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Study on the quantitative relationship between urban landscape pattern and surface temperature

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Urban heat island (UHI) is one of typical climate characteristics in urban areas, which is largely attributed to land use and land cover patterns. This paper derived land use/land cover conditions corresponding to 2004, 2006, and 2008 from the remote sensing data using linear spectral mixture model, and identified the relationships between urban landscape patterns and surface temperature all year round utilizing the ordinary least squares (OLS) and geographically weighted regression (GWR) models, respectively. Results showed that the UHI in Shenzhen are notable during the year, and the GWR model performed better than OLS model in simulating the quantitative relationships between landscape patterns and surface temperature. The impervious landscape metrics, largest patch index, mean patch area, mean Euclidean nearest neighbor distance, and the vegetation landscape metrics, largest patch index, patch density, mean patch area, normalized Difference Vegetation Index and leaf Area Index have more potential to predict surface temperature. Our study demonstrated that avoiding too much concentrated impervious surface as well as reducing its neighboring degrees and improving urban green space in area, NDVI and LAI can effectively alleviate the UHI.

Review of Agroforestry innovations and adoption in sub-Saharan Africa

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Approaches to analyzing Agroforestry adoption tend to follow the vast literature on adoption of Agricultural production technologies, most of which focus on new or improved production inputs such as Green revolution inputs for conventional Agricultural crops. No matter how elegant efficient, productive Agroforestry ecologically sustainable, agroforestry systems can contribute to sustainable land use only if they are adopted and maintained over long time periods. The period since the early 1990s has witness an explosion of research on the adoption of Agroforestry innovations in the sub-Saharan Africa. Achieving the full promise of Agroforestry requires a fundamental understanding of how and why farmers make long-term land-use decision and applying this knowledge to the design, development and marketing of agroforestry innovation. This paper reviews the theoretical and empirical literature that literature that has developed during the past decade analyzing agroforestry adoption from a variety of perspectives and identities needed future research in sub-Saharan Africa. Additional research needs like identifying better understanding of the role of risk and uncertainty. Insights into how and why farmers adapt and modify adopted systems, factors influencing the intensity of adoption, village-level and spatial analyses of adoption, the impact of disease such as Aid and malaria. As in traditional Agricultural adoption , the major influences on adoption concern household preferences ,resource endowments ,market incentives, biophysical factors and risk and uncertainty follows the predictions of economics theory. This paper recommend that it is to begin to collect longitudinal data on Agroforestry adoption that will allow analysis of the temporal nature of agroforestry adoption including the rate and time at which a technology will be abandoned.

The Research Of Grassland Landscape Evaluation Of Resilience And Land System Optimization Under The Multiple Objective

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The semi-arid region in Northern China is a typical ecotone, it is very sensitive to global climate change. Because of the irrational agricultural development in the past, the ecological environment is increasingly vulnerability. Under the pressure of global climate change, the vulnerability of ecosystems in the region is increasing. Human-environmental systems' ability to resist disasters continue to weaken. It showed the characteristics of the local governance and overall deterioration. And the region sustainable development faces great challenges in the future. The research mainly uses the model to simulate evaluation and experimental methods of field investigation. Through the study of climate change and human activities' impact mechanism and process on typical steppe landscape, understanding the relationship between human-environmental systems and society-economy-environment under the multiple objective, to meet the diverse needs of humanity on ecosystem services, exploring the land system optimization program on landscape and regional scale, promoting regional sustainable development, achieving the best overall interests of the human and environment system through the human activities orderly, rather than the best local interests. It makes human adapt to the changes in the environment in the context of global change, which is of great scientific value and practical application for human sustainable development.

Climatic influence on corn sowing date in the Midwestern United States

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This study has investigated climatic influence on corn sowing date in the Midwestern United States, by comparing the survey data of corn cultivation with meteorological records in nine states for the last 36 years (1979–2014). The results show that the year-to-year changes in the sowing date are significantly affected by springtime air temperature and precipitation in the nine states, but there exist large state-to-state differences in the degree of sowing date-meteorology relationship. We found the 36-year climatological warm period (with daily-mean temperatures ³ 10°C) plays an important role in the state-to-state differences. For the states with the longer climatological warm period, the influence of the air temperature (precipitation) was generally weaker (stronger). This observed counteractive relations should be taken into account for crop modeling, so that the impact of climate change on agriculture can be better assessed.

Spatio-temporal dynamics of multiple cropping intensity in Huang-Huai-Hai region during 2000-2012

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Multiple cropping systems have effectively improved the utilization efficiency and production of cropland, by increasing cropping frequency in one year. Meanwhile, it has also significantly altered biogeochemical cycles. Therefore, exploring the spatio-temporal dynamic of multiple cropping intensity is of great significance for ensuring food and ecological security. In this study, the multiple cropping index of the Huang-Huai-Hai Plain, an important agriculture region with multiple cropping systems, was extracted using multi-temporal MODIS remote sensing data. Then the spatial dynamic of multiple cropping intensity was analyzed during 2000-2012. Results showed that the multiple cropping index in Huang-Huai-Hai Plain has increased from 152% to 156% in the last 12 years with significant spatial variation, that is, 25% of cropland increased in multiple cropping index, while 16% of cropland decreased. Topography is a primary factor in determining the spatial pattern dynamics of multiple cropping index, which is more stable in hilly regions than in plain areas. An increase from 158% to 164% of multiple cropping index occurred in the plain area while there was almost no change in the hilly region of single cropping. The most active region of multiple cropping intensity change was the intersection zone between the hill region and plain area, where cropland with decreasing multiple cropping index was mostly concentrated, and cropland with increasing cropping intensity index was also mainly distributed. On the contrary, cropland both in the hinterland plain and foot of hilly region had relatively stable multiple cropping intensity. Moisture is another important reason for explaining spatial dynamics of multiple cropping index. That means multiple cropping index decreases mostly in regions with scarce rainfall and ground water. According to the Nanyang basin of the Huang-Huai Plain, with favorable hydrothermal conditions, there was a substantial increase of multiple cropping index from 178.41% to 190.72%. Besides, an increase occurred both in the hilly area and plain area in this region. In space, landscape patterns of multiple cropping systems tended to homogenize reflected by a reduction in the degree of fragmentation and an increase in the degree of concentration of cropland with the same cropping system. It is mainly owing to the current circumstance of restrictions imposed by physical conditions on agricultural production, impacts of farmers' livelihoods change and advancement of agricultural technology. This feature also allows us to recognize that agricultural technology and farm household management scales may be major causes of spatial dynamics of multiple cropping intensity.

China's Land-use Changes And Driving Forces During The Past 300 Years: A Historical Perspective

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Understanding the processes of historical land-use change is crucial to the research of global environmental sustainability. It remains a daunting challenge for land system science and few studies have focused on long-term land-use change and its driving forces at the regional level—mainly due to lack of reliable historical data. With relatively reliable and complete historical records, China offers an ideal exemplar for these kinds of studies. Here we compile and synthesize historical land-use change (mainly cropland and forest) and various biophysical, political, socioeconomic and technical datasets over the past 300 years, from the Qing dynasty to modern China (1700-2010). The analysis reveals a clear transition period between the 1950s and the 1980s: before the 1950s, cropland expanded while forested land diminished, which was also accompanied by increasing population; after the 1980s land-use change exhibited new characteristics: changes in cropland, forest and population decoupled from each other as a result of agricultural intensification and globalization. Chinese political policies also played an important and complex role, especially during the 1950s-1980s transition period. Overall, climate change plays an indirect but fundamental role in the dynamics of land use via series of various cascading effects such as shrinking agricultural production proceeding to population collapse and outbreaks of war. The expected continuation of agricultural intensification this century should be able to support increasing domestic demand for richer diets, but may not be compatible with long-term environmental sustainability.

Review of Agroforestry Adoption and Innovation in sub-Saharan Africa

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This paper recommends that it is time to begin to collect longitudinal data on Agroforestry adoption that will allow analysis of the temporal nature of agroforestry adoption including the rate and time at which a technology will be abandoned.

Changes in the Termite Assemblage Structure Associated with Agricultural Practices in the Lamto Region, Central Côte d'Ivoire

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Termites play key roles in plant decomposition and soil bioturbation in tropics, and are good bio-indicators with regard to their sensitivity to habitat modification. This study investigated their assemblage structure across a sequence of land-use types in the rural area surrounding Lamto Scientific Reserve. With a standardized method, data were collected on termites from different habitats (unexploited forest, cleared forest, burned forest, teak plantation, cocoa plantation, *Jatropha* plantation, crop field and fallow). Compared to forest, the mean termite species richness slightly declined in cleared forest, burned forest, teak plantation and cocoa plantation, but significantly in *Jatropha* plantation, crop field and fallow. The abundance of fungus-growers was the highest in all land use types although it significantly varied between habitats. Soil-feeders steeply declined in all modified sites, certainly because of canopy openness. Wood-feeders showed clear responses to disturbance, with low abundances in monospecific- and modified sites without tree materials. It was concluded that changes in the termite assemblage structure result from forest conversion to agricultural systems. To help mitigate the loss of termites when forests are disturbed, we recommend to: (i) promote the association of cropping and silvicultural systems that reduces changes in microclimate and maintains the original termite assemblage with the associated ecosystem services; (ii) leave dead wood on the ground after forest clearance or burning to accelerate the recovery of the termite assemblage; and (iii) increase forest and silvicultural patch size to sustain the survival of forest-dependent species.

The Future Earth Knowledge-Action Network on the water-energy-food nexus: agenda-setting approach and first outputs

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Future Earth is a 10-year international research initiative that aims to provide knowledge to accelerate our transformations to a sustainable world. Future Earth's Knowledge-Action Networks were launched in 2016 to provide collaborative frameworks that facilitate integrative sustainability research with the aim to generate the multifaceted knowledge required to inform solutions for complex societal issues. These frameworks are central to the goal of addressing the eight major societal challenges to sustainability identified in Future Earth's research agenda in 2014.

Delivering water, energy and food for all in a sustainable and equitable way is one of these challenges to which Future Earth intends to contribute through its Knowledge-Action Network on the Nexus. This initiative aims to foster the generation of knowledge needed to understand how interactions between water, energy and food are shaped by environmental, economic, social and political changes and how the synergies and trade-offs among them can be better planned and managed.

An agenda-setting process was initiated in 2016 with the goal to collaboratively define a research agenda for the Nexus Knowledge-Action Network. The process has been designed to be in line with Future Earth principles that emphasise greater interactions among disciplines and between research and societal actors as key approaches to improve the contribution of science on the solution of societal issues. This presentation will highlight the co-design approach adopted for the agenda-setting exercise as well as its first outputs.

The Variation of NPP and LUCC From 2001 to 2012 in China and Their Correlation

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Terrestrial net primary production (NPP) plays an important role in ecosystem process and the mean NPP varies greatly among different land cover types. But there are few detailed studies on how the land use and land cover change (LUCC) related to NPP variation on a temporal and spatial trend over China. Here we collect China's land cover and NPP data in the 2001-2012 period and these two part data come from MODIS products MCD12Q1 and MOD17A3 respectively. Analysis work shows that in the twenty years China's mean annual NPP is around 2.70 PgC, which is mainly produced in the mixed forest(31.1%) and the croplands(24.5%). Not every land cover type area change is correlative with the interannual NPP change in China and the R^2 of study on deciduous needleleaf forest is the highest ($R^2=0.5411$). As to these area study on land cover type can produce NPP, There is a significant correlation between the area of each land cover type and the NPP happened in the corresponding region ($R^2>0.67$) except deciduous broadleaf forest ($R^2 = 0.41$). Besides, There shows no correlation between area and NPP change in the same study on grassland ($R^2 = 0.08$). That maybe results from the area of grasslands almost stayed the same during the study period.

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Land surface heat flux construction over northern China by integrating gridded flux data sets with in-site measurements

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The surface energy budget (SEB) over northern China greatly influences the climate in China, and the East Asian monsoon. However, current estimates of SEB from models are subject to large errors, and ground-measured data sets within this region are limited in temporal length and geographic coverage.

This study attempts to determine the SEB over northern China by integrating information from three sources: (1) ground-measured data sets from ChinaFLUX, and the co-observation program over northern China; (2) four reanalysis data sets including NCEP/DOE, MERRA, ERA-Interim, and Japanese 25-year Reanalysis; (3) off-line land model NOAH outputs .

A comparison of gridded flux data with the observations suggests that the gridded flux data interpolated to the measurement sites can be seen as a linear function of the observations. For one certain gridded flux dataset, there is little difference in linear relationships between the gridded data and the observations over different types of surface, which is an important statistical regularity for the dataset construction. The cross-validation results showed that the accuracy of the constructed dataset is improved. Besides, the impact of the resample scale has been assessed to be small by applying the proposed data construction method to several grid sizes in order to investigate the sensitivity of the constructed and original data sets to the chosen spatial resolutions. It is found that the constructed flux dataset can reasonably reproduce the expected temporal-spatial pattern of surface heat flux, suggesting the potential for application of the constructed data sets in climatic and environmental research.

Mapping land use land cover change and prediction of future extension of bowé in Benin (West Africa)

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Desertification and land degradation are worldwide problems affecting soil, vegetation and thereby livelihood of the rural population. *Bowal* (plural *bowé*) is a particular form of degraded land that occurred in tropical region and leads to ferricrete exposure unusable for farming. *Bowé* are more frequent in farmland and degraded savanna. Land use land cover change analysis was used to map the land cover of 1975, 1990 and 2010. The changes observed during these periods (1975-1990, 1990-2010 and 1975-2010) were considered to predict occurrence of *bowé* towards 2050 with the Markovian chain. The results showed considerable change in land use land cover maps of the three periods (1975, 1990 and 2010). The land cover on which *bowé* occur (farmland and degraded savanna) have persisted, and increased at the rate of 0.0542 ha/year, 0.0952 ha/year during the periods 1975-1990, 1990-2010 respectively; while the natural vegetation (forest, woodland and tree savanna) have decreased at the same rate. The future scenarios also predict the same trend. A total of 26% (1286346 ha) and 31% (1293693 ha) of the area cover with natural vegetation would be converted to farmland and degraded savanna towards 2050 if we assume the dynamic recorded respectively from 1975-1990 and 1990-2010. Thus *bowalization* would persist and increase towards 2050. Promotion of the best practices developed by the farmers to prevent and cope with *bowalization* would help to refrain land degradation in this zone.

Study on Ecology Efficiency in Rapid Urbanization Area

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With the rapid development of urbanization in China, spatial problems such as deterioration of ecological environment, unbalanced development between the urban and rural areas are getting increasing serious, becoming the major obstacles of sustainable development. How to obtain the biggest economic and social benefits with the minimum ecological loss is an important basis for optimizing development of national spatial territory. Taking Hubei province as the study area. These is a link-up between land use and eco-economic benefits from the perspective of ecological efficiency. We consider the NDVI as the ecological variable by utilizing cross-sectional data in county scale. Based on SFA(Stochastic Frontier Analysis), we not only make measurement on ecological efficiency, environment performance index and total factor productivity but also quantitate the relationship between the land use ecosystem service which aims to analyze the interactive mechanism and balance their conflict . Research results can provide reference for socio-economic development and sustainable development of territorial resources.

Analyzing the spatial relationship between urbanization, food production, and irrigation water requirements in Jordan

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Countries in the Middle East use a large fraction of their scarce freshwater water resources to produce cash crops, such as fruit and vegetables, for international markets. At the same time, these countries import a large amount of staple crops, such as cereals, required to meet the nutritional demand of their populations. This makes food security in the Middle East heavily dependent on world market prices for staple crops. Under these preconditions, increasing food demand due to population growth and detrimental effects of a changing climate on the production of agricultural commodities present major challenges to countries in the Middle East that try to improve food security by increasing their self-sufficiency rate of staple crops. We applied the spatio-temporal land-use change model LandSHIFT.JR to simulate how an expansion of urban areas may affect the production of agricultural commodities in Jordan. We furthermore evaluated, how climate change and changes in socio-economic conditions may influence crop production. The focus of our analysis was on irrigated and rainfed production (crop yield and area demand) of fruit, vegetables, and cereals. Our simulation results show that the expansion of urban areas and the resulting displacement of agricultural areas does result in a slight decrease in crop yields. However, this results in almost no additional irrigation water requirements due to the relocation of agricultural areas, i.e. there is the same amount of “crop per drop”. Taking into account projected changes in socio-economic conditions and climate conditions, a large volume of water would be required for cereal production in order to safeguard current self-sufficiency rates for staple crops. Irrigation water requirements are expected to double until 2025 and to triple until 2050. Irrigated crop yields are projected to decrease by about 25%, whereas there is no decrease in rainfed crop yields to be expected.

To evaluate the influences of land use and land cover changes on regional climate over East Asia and China with satellite-based data

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With the rapid economic development in East Asia, and especially China, over the past few decades, the land surface has been significantly impacted. It is challenging to evaluate the influence on regional climate due to land use and land cover (LULC) changes, and to reduce the uncertainties at regional and local scales. Using satellite-based LULC data for the years 1980, 1990, 2000 and 2010, the Weather Research and Forecasting (WRF) regional climate model is adopted to explore the impact of LULC changes on surface air temperature (SAT) and the precipitation over East Asia, as well as subregions in China. Simulated results with satellite-based LULC data show that SAT and precipitation biases can be decreased to a certain degree. In terms of the general effect of LULC changes between 1980 and 2010, the precipitation decreases across the simulated domain. In subregions of China, significant subregional characteristics are apparent, especially with respect to East Asian Summer Monsoon (EASM) related precipitation, which is decreased in northeastern China, while increased in the south and mainly occurs during EASM southward retreat. In terms of the radiative forcing (RF) at the surface and top of the atmosphere, the values are negative over East Asia, which results in decreased SAT. SAT and radiation budget changes in China, which present obvious subregional characteristics that are distinct from those of East Asia, are also detailed discussed. Furthermore, the impacts on regional climate show obvious seasonal, interannual and decadal variations. Although the impact of LULC change on SAT and the radiation budget in global terms is small compared to other factors, and even less on regional scales, the importance on local scales and the corresponding components is worthy of attention.

Land surface temperature retrieval from Landsat8 TIR data for city regions

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Land surface temperature(LST) is playing an important role in the land surface physical process. The recent successful launch of Landsat-8 satellite with the Thermal Infrared Sensor (TIRs) which has two TIR bands makes it possible to use a split window algorithm (SWA) to retrieve LST and allow the comparison of different retrieval methods. In this study, according to the characteristics of land use of study area, NDVI threshold method is chosen to retrieve land surface emissivity(LSE) . In addition, SWA and mono-window algorithm (MWA) are applied to retrieve the LST of study area, and comparisons between them are made to explore the difference of their performances. The results indicate that the retrieved LST of the two algorithms have a good consistency in spatial distribution and frequency distribution overall. But there is a more centralized distribution and a higher average value in the results of SWA than that of MWA. The correlation analysis of sampling points show a R^2 of 0.972 and a root mean squared error(RMSE) of 0.723°C, indicating a strong relationship between the two algorithms. Both of the two algorithms can provide accurate retrieved LST, but SWA may be a better choice in urban climate and environmental studies in terms of the number of input parameters, parameter sensitivity and the quality of retrieved LST.

Quantifying the factors contributing to the differences of micro-meteorology over a pair sites in lower reaches of Yangtze River

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There is robust evidence that anthropogenic land use changes, such as urbanization, expansion of agriculture, deforestation and afforestation, have significant impacts on climate system. As an important meteorological parameter to investigate these effects in land-atmosphere interaction, the surface temperature (T_s) depend on the condition of climate as well as land surface. And the lower reaches of Yangtze River is a region where the interaction between human activities and monsoon climate is most intensive around the world. In this study, we not only calculated the difference of T_s between cropland, suburb, urban area and natural grassland in Nanjing from Mar. to Aug., 2013, but also quantified contributions of land surface factors including radiation, aerodynamic resistance, and Bowen ratio to this difference. Results indicate that (1) monthly T_s obviously increases from crop, grass, suburb to urban area; (2) differences of land surface factors between cropland, urban area and grassland are large, unlike that of the suburb which is similar to the grassland; (3) the contributions of radiation, aerodynamic resistance and Bowen ratio to T_s are positive; (4) under the same climate background, the influence of turbulence, especially evaporation are more important than radiation on T_s .

Agricultural expansion in the Amazon: is it plausible?

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The Amazon hosts one of the largest stocks of arable land in the world. However, little is known about the available extent of agricultural land in conformity with legal, agronomical and environmental requirements. This study aims to identify potentially available areas for agricultural expansion in the Brazilian Amazon considering the extent of (i) legally available forested lands and (ii) previously converted lands with suitable productive capacity and free of land-use conflicts. This analysis was carried-out by integrating georeferenced information on land-use, soil-fertility, terrain-slope, biomass, protected-areas and land-use policies (e.g. Brazilian Forest-Code) into a conditional decision support procedure, based on Boolean-inference techniques. Our results showed that 11.69% (493,103.03 km²) of the Brazilian Amazon would be potentially available for agricultural expansion by 2010. This area was dominated by forests (59.37%), followed by previously converted lands (40.63%). However, the usage of these areas would have direct political and environmental implications. It is expected that the conversion of available forests would detract recent achievements of the Brazilian Plan for Prevention and Control of Deforestation-PPCDAm, which has reduced deforestation by 79% from historical rates. Moreover, the conversion of these areas could result in a committed emission of 13±1 PgCO₂eq to the atmosphere, which, is equivalent to the total emissions from land-cover change registered in Brazil during the 2000–2010 period. To minimize environmental impacts, agricultural expansion in the Brazilian Amazon should be restricted to already converted areas. This land-cover class totalizes 200,000 km², which could support agricultural expansion without promoting the advance of deforestation.

Brazilian food commodity production: Incentives, agricultural modernization and environmental implications

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The global market for food commodities makes national players intrinsically connected. On the other hand, local decisions, such as new economic policies or cultural shifts (e.g., the increased demand for beef), can foster significant changes across long distances, not as an exogenous cause, but as an endogenous one. This study analyzes the incentives for soy and maize production in Brazil and their trade and environmental implications. Land use and land cover change analyses; census-based data at mesoregion and municipality levels (e.g., commodity price, fertilizers); policy analysis (e.g., farm credit); and stakeholder interviews guide our methodological approach. Technological modernization pushed soy and maize production to the Cerrado biome, where agricultural expansion is replacing pastures and native vegetation. In fact, this biome still has approximately 15 million hectares of lands with high agricultural aptitude, currently covered by natural vegetation, indicating the need for systematic assessments to monitor potential environmental impacts (e.g., land degradation, deforestation), as well as socioeconomic implications (e.g., income distribution). In this context, the balance between nitrogen biological fixation - extensively used in soy production - followed by nitrogen fertilization - needed for maize production - within a two-crop non-tillage system, is a key indicator to measure. In the last two agricultural years (2013/2014 and 2014/2015), 21.8% and 21.3% of the total farm credit were applied to soy and maize production, respectively. Brazilian financial support for farmers and agricultural modernization is a strong example of a telecoupled outcome connected to global demands for food commodities.

Determining Robust Impacts of Land-Use-Induced Land Cover Changes on Surface Temperature over China and surrounding regions: Results from the First Set of LUCID Experiments

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The project Land-Use and Climate, Identification of Robust Impacts (LUCID) was designed to address the robustness of biogeophysical impacts of historical land use–land cover change (LULCC). LUCID used seven atmosphere–land models with a common experimental design to explore those impacts of LULCC that are robust and consistent across the climate models. The biogeophysical impacts of LULCC were also compared to the impact of elevated greenhouse gases and resulting changes in sea surface temperatures and sea ice extent (hereafter SST/CO₂). Focusing the analysis on China and surrounding regions, the climate models involved in LUCID show, however, significant differences in the magnitude and the seasonal partitioning of the temperature change. The LULCC-induced cooling is directed by decreases in absorbed solar radiation, but its amplitude is 30 to 50% smaller than the one that would be expected from the sole radiative changes. This results from direct impacts on the total turbulent energy flux (related to changes in land-cover properties other than albedo, such as evapotranspiration efficiency or surface roughness) that decreases at all seasons, and thereby induces a relative warming in all models. The magnitude of those processes varies significantly from model to model, resulting on different climate responses to LULCC.

Comparison of the land surface turbulent flux parameter schemes in semi-arid region of China

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Arid and semi-arid regions account for about 40% of the Chinese territory. The uncertainty of land surface parameters extremely restricts the improvement of land surface model over above regions. Based on the eddy covariance observation data from typical underlying surface in semi-arid regions of China, i.e., farmland, forest and grassland, total up to 15 field sites, aerodynamic roughness length (z_0) is retrieved by three methods. The results show that there is no much difference among different method retrieved value of z_0 . The sites from the same plant functional type have similar z_0 , and the average value increase in the order of grassland-farmland-forest. We also compared seven parameterization schemes for calculating the excess resistance to heat transfer (k_B-1). k_B-1 performs apparently diurnal variation and Y07 scheme reproduces it best. Last, above parameters are introduced in Common Land Model to calculate turbulent heat fluxes, the results show that the revised parameters improve the model performance significantly. This study is expected to help the better understanding of the land-atmosphere interaction in semi-arid region by combination of field observation and modeling.

Analysis of Beijing-tianjin-hebei ecological land use change in recent years

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Ecological land not only has the service function for provide human with physical ecological product, and has very vital significance for maintaining regional ecological balance. This study is based on the < Current land use classification > (GB/T 21010-2007), on the basis of widely solicit opinions from relevant experts, according to the standard of land ecological function. We define forest land, natural grassland, river, and other 14 land use type secondary class as ecological land. On the basis of strictly defined ecological land range, with the land use data from 2009 to 2014, this study analyzed the ecological land use structure, spatial distribution, quantity change and transition of ecological land and other land use types of space-time evolution characteristics in Beijing, Tianjin and Hebei. Main conclusions are as follows:

- (1) There are 9.171 million hectares of Beijing, Tianjin and Hebei in 2014, mainly constitution of forestland, grassland and water. Ecological land is mainly distributed in the north and west along the route, ecological coverage rate of southeast is low.
- (2) Ecological land is decreasing of Beijing, Tianjin and Hebei in recent years, there were a total reduction of 113300 hectares from 2009 to 2014, the average annual reduction is 22700 hectares, the reduction ratio is 1.22%.
- (3) Due to the urbanization develop, a large number of forestland and grassland are occupied for construction in this region. And the increase of the population is needed to expand cultivated land area of demand for food, which make the region ecological area is shrinking, the land ecological environment worsening.

Synergetic development of human and natural systems on the Tibet

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The region environmental change was effected by the human system (HS) and natural system(NS). Nowadays, we cannot found an ecosystem that is free of human influence, even for the fragile and vulnerable area, such as on Tibetan Plateau. Where the climate change have got plenty research, However, human disturbances producing much stronger impacts regional climate and ecosystems simultaneously. In this paper, the coupled natural and human concept investigates the interactions between the NSs and HSs and their respective processes at different scales in effort to better understand and predict environmental change, human action, and the relationship between them. By applying the natural and human (CNH) concept, our study objective is to understand the relative roles of both natural and social driving forces in these dynamics. We expect that human influences on the CNH system exceed those of the biophysical changes and that their relative significances vary in space, time, and biophysical settings (e.g.,biome). Specifically, we hypothesize that increased grazing intensity, will decrease the vegetation coverage, following decrease surface albedo and positive the temperature increasing. The magnitude of the grazing effects on land cover change (LCC) varies among biomes and is regulated by a combination of land use, and social, economic, and physical conditions. So we used the structure equation models (SEM) to quantify HS and NS's correlation. A comprehensive understanding of these processes and their consequences is critical for assessing the impacts of land surface process feedbacks to the regional and global climate.

Progress in climate change on the pattern of grain production and allocation of land and water resources in Northeast China

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Northeast China is an important commodity grain base to the national food security. During the past decades, climate change has brought about influences on the spatial distribution of heat and water resources and then changed the pattern of grain production in Northeast China. This article reviews the literature both on the climate change on the pattern of grain production and allocation of land and water resources in Northeast China. With the trend of temperature increasing and rainfall decreasing, there have been great changes on the pattern of grain production, including the north boundary of rice planting and corn planting extending to Huma county in Heilongjiang province and the east boundary of corn planting extending to the east mountain in Liaoning province; in addition, wheat cropping region has been back up north while maize seedling period shortens, mature period postpones and the growing season increases based on global climate change; For allocation of land and water resources with climate change in Northeast China, water resources shortage and land degradation are main factors restricting grain production, and some indicators are used for measuring the spatial allocation of land and water resources in Northeast China. Finally, this article puts forward some future research directions, including study on coupling effect between spatial pattern change of grain production and allocation of land and water resources based on scale of grid in Northeast China, which will provide operational planning for the pattern of grain production based on spatial balanced allocation of land and water resources.

Land Use Change of Western Jilin in Recent 100 Years

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Large-scale reclamation in western Jilin Province began in the late 19th century. The land use change trajectories in western Jilin in nearly 100 years can be divided into six phases: the end of the Qing Dynasty (19th century -1911), the Republic of China (1912-1930), the period of Japanese puppet army's occupation (1931-1945), around the founding of the PRC (1946-1954), the Great Leap Forward and the Cultural Revolution (1955-1977) and since the reform and opening up (1978-2013); the proportion of farmland and grassland in western Jilin in the early days of new China was 1:1, it was 3:1 in 1976 and it up to 5.6:1 in 2013; meanwhile, the alkali-land increased and the marsh seriously declined led to an increasingly disordered land use structure. To further investigate the transforming relationship between various types of land use, this study focused on the land use change between 1976 and 2013. The results showed that there were 309,200 ha of non-arable (mostly were grassland, woodland and marsh) land transformed to arable land. With social and economic development, the expansion of construction land occupied 31,700 ha of cultivated land. According Land use transition probability matrix between 2000 and 2013, the land use structure in 2030 was simulated by using system dynamics model and found that ratio of farmland and grassland will become 14: 1. In addition, the land use degree composite index in 2013 reached 239 which had an increase of 4.6 over 1976 and it would reach 247.6 in 2030. Human activity (population density) and climate (temperature and precipitation) change had a significant impact on land use change.

Cropland abandonment, re-cultivation and the effects on corridors in the steppes of Kazakhstan

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Agricultural expansion and intensification are a major factor for the disappearance of wild places, with generally negative outcomes for biodiversity. But human pressure is also decreasing in some regions when croplands are abandoned and rural outmigration results in the abandonment of rural settlements. This is particularly so in Eurasia's steppes, where after 1991 human pressure decreased substantially, and as such may have resulted in the appearance of new 'wild areas'. Our goal was to identify such potential new 'wild areas' by mapping areas of cropland abandonment using Landsat image composites for a study region in northern Kazakhstan. We then combined the information of cropland abandonment with secondary statistics for livestock and human population density to identify new wilderness areas. Further, we assessed how these wilderness areas may increase the conservation value of the existing protected area network through an increased connectivity among them. Our results suggest that high rates of cropland abandonment (36%), declining livestock numbers (-70%), and decreasing human population density resulted in an effective rewilding of the Kazakh landscape between 1990 and 2000, and led to an increasing connectivity between existing protected areas. However, our results also suggest a trend of re-cultivation of abandonment croplands since 2000 and declining connectivity, suggesting that the window of opportunity for broad-scale conservation planning may close soon in the future.

Climate and crop yield relationships over the past 90 years in Hungary and the estimation of floodplains' flood defence service

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The number one objective of the European Water Framework Directive (WFD) is to restore the good status of water bodies. For Hungary, where one quarter of agricultural lands lie in the most drought-prone zone and their majority are endangered by excess surface water, the implementation of the WFD is of particular significance. This study shows two descriptive statistical analyses. First, I tested the relationship between the variances of precipitation, temperature and yields of the three main grains over the past 90 years by multiple linear regression. Regression coefficients between 30 year long time series indicated a significantly increasing exposure of cropland farming to meteorological variances over the past three decades. The second analysis compared the investment costs per reservoir capacity units of two restored aquatic ecosystems with those of six artificial flood protection reservoirs. Every project was financed by the EU (2004–2008) and implemented in the Great Hungarian Plain where the occurrence of serious drought events and excess surface water inundations is the most frequent at a national scale. Investment costs of reservoir capacity per unit of artificial reservoirs exceeded those of the two restored wetlands 5–10 fold. These results offer a chance to harmonize the interests between land users of deep floodplains who may serve the community by reserving, infiltrating and evaporating water and other actors who are interested in drought and flood prevention or environmental protection.

Coupling Community Land Model (CLM4.5) with Weather Research and Forecast Model (WRF) and its application to northern Scandinavia

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Land surface processes play an important role in climate variation and its future changes. Detailed depictions of land surface processes are pivotal for climate models to capture climate variability and its potential impacts. Regional climate models have been widely used to quantify the impact of land surface processes on climate changes. However, most of the regional climate models are developed from weather forecast models which lack in the dynamics of land surface properties, therefore hampering their applications to fully understanding the interaction of land cover changes with climate. To improve the representation of land surface processes and their interaction with climate in a regional climate model, we are coupling the Weather Research and Forecasting Model (WRF version 3.7) with the most recent version of Community Land Model (CLM4.5). CLM4.5 includes comprehensive description of the dynamics of land surface properties, such as dynamical vegetation and carbon-nitrogen cycle, compared to the default land surface model of WRF (i.e., Noah-MP). Test experiments with the coupled WRF-CLM4.5 will be performed over northern Scandinavia in this study, and the output from the test runs will be presented. The coupled WRF-CLM4.5 is a contribution to our ongoing project on Land-Atmosphere Interactions in Cold Environments (LATICE), and will be employed to quantify the impacts of land use and land cover changes in the high-latitude region in the future.

Assessment of thematic classification based on GF-1 image: A Case Study of Lower Mekong Region

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Among all global environmental changes, Land Use and Land Cover Change (LUCC) is the most significant one in the areas of combined effects of natural and human activities. LUCC monitoring has been one of the most important procedures for the research of nexus of water, food and energy. GF-1 was the first launch of a high-resolution satellite in China. How to make better use of the GF-1 image has become an important topic in China's satellite application research. There were fewer studies about the application of GF image over Southeast Asia. In order to assure the application of GF image, it is very important and necessary to make an accuracy assessment. Taking the example of the Case Study of Lower Mekong Region, this paper carried out a research of land cover classification by GF-1 image.

Impacts of land use and climate change on crop production in agro-pastoral transitional zone of North China

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As an important food production area, the agro-pastoral transitional zone (APTZ) plays a role in regional food security. However, the past few decades have witnessed dramatic land use and climate change in APTZ. In order to quantify the impacts of land use and climate change on crop production, the well-established GIS-based Environmental Policy Integrated Climate (EPIC) model was adopted in our study. By using the control variable measure and linear regression model, the impacts of land use and climate change on the production of three major crops were analyzed. Results show that land use changes led to the decline of wheat production while increased the productions of maize and rice for the period of 1980 to 2010. At the regional scale, climate change had negative impacts on the yield of wheat and maize and positive impacts on rice yield. However, impacts of climate change on crop yield had spatial heterogeneity at the grid scale. For wheat and maize, there were clearly positive response of yields to the precipitation and relative humidity. For rice, the yield declined with the relative humidity and wind speed while increased with the minimum and maximum temperature. It has great significance to analyze the impacts of land use and climate change on crop yield for the regional food security. In addition, it can provide reference for adjusting the crop planting areas and adapting to the future climate trend change.

The reaserch of landuse change and soil of erosion in Typical karst basin

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A study of soil of erosion of three cha he basion located in typical Karst ecological fragile area is taken by using GIS、Erdas and RUSLE Modle based on the date of TM image、DEM 、rainfall and siol.The study computes the amount of rael soil erosion and potential erosion and assesses the capability of soil conservation and the spatial distribution of soil erosion.Landuse change is one of the direct reasions of soil erosion,different landuse types have different impact on the soil of erosion.The paper puts forward the suggestions of economic development and ecological protection of three cha he basion based on the research of relationship between different landuse type and soil of erosion.

Spatial Analysis of anthrax in Khenti, Mongolia

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Anthrax is a natural infectious diseases was investigated in this research using satellite and GIS data. Study area is Khenti province of Mongolia. There is case that humans and animals affected by the disease anthrax in the area. Anthrax is caused by the bacterium *Bacillus anthracis*. *Bacillus anthracis* has stored in the soil for hundreds of years and are the conditions favorable breeding. The anthrax disease breeds in the mountain black brown soil, usual dark brown soil and meadow soils. The result describes that the Anthrax case occurred for soil contained soil neutral and acidic with pH 5.0-7.5. GIS analysis show that Anthrax can be found for soil where surface temperature up to 15 °C. Remote Sensing and GIS is good tool to Identify the factors influencing the spread of anthrax.

Simulation of virtual water of major agricultural products in Altay Prefecture, China

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Altay Prefecture is a typical agroecological zone in arid desert oasis. As the main area of exporting agricultural products, Altay Prefecture has serious water shortage and huge water consumption. Moreover, a large number of virtual water outflow threatened water resources security and food security seriously. This paper simulated the virtual water of main agricultural products based on Penman formula combining CROPWAT software from 1985 to 2013 in Altay Prefecture, and analyzed the structure of supply and demand as well as water resource carrying capacity. The results show that: 1) From the view of water consumption, helianthus annuus and livestock products are high water consumption products; wheat and soybean belong to the medium; corn, potato, sugar beet, vegetables, muskmelon and alfalfa are low water consumption products. 2) Virtual water outflow mainly in medium and high water consumption products. Crop production in high water consumption has increased, while it reduced in medium and low water consumption. Crop virtual water has significant regional differences. 3) Virtual water production is 872~2731 million m³, while consumption is 195~384 million m³. Virtual water production products is much larger than that of consumption. The virtual water outflow severe crowding out local ecological water. As a result, we put forward measures to improve the utilization efficiency of water resources in Altay Prefecture: Adjust the agricultural structure and develop characteristic advantaged industries; Develop agricultural water-saving potential to ensure food security; Use virtual water trade to supplement the inter-basin water transfer; Implement the strategy of virtual water management through innovating system.

Energy Consumption Analysis of the Drinking Water Supply Modes in Rural Areas of Northwest China

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Energy is vital to providing potable water, because the power systems are needed to collect, transport, treat and distribute the drinking water. In some rural areas, fresh water is scarce and drinking water must be brought in from a long distance, the energy consumption is extremely high, therefore, design of operating mode plays an important role in decreasing energy consumption, stabilizing production and achieving more economic benefits. Based on the example of Yangchuan drinking water project in Zhuanglang County of northwest China, the energy consumption of different rural drinking water supply modes were comparatively analyzed in semi-arid loess plateau region, and the effective water supply methods was put forward.

Impact of land and climate change on food security challenges on sub-Saharan Africa

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Land and Climate change have direct impact on food production across the globe. Global food systems are inherently linked to climate and land in a large number of complex ways.. Food distribution and other system with transportation, storage and purchasing of food all being key components of the process between production and consumption. Land and Climate is expected to affect the prices of food. Many component of food system like transport and infrastructure are likely to be more vulnerable to changes in extremes rather than shifts in the mean climate. River, land, coastal flooding and extreme wind events cause damage to infrastructure, affecting transport and sales of food. This paper declares that direct consequences of land warming such as increased heat stress and increase in mean sea level are inevitable. land Warming is expected to increase global average precipitation, long-term precipitation changes at regional scales and are far more difficult to confidently predict especially in the next few years to decades when year to year variability factor is considered in sub-Saharan Africa. The paper concluded that there is a need of making food production sustainable while controlling greenhouse gas emission and conserving dwindling water supplies, as well as meeting the Millennium Development Goal of ending hunger. Moreover, we must avoid the temptation to further sacrifice Earth's already hugely depleted biodiversity for easy gains in food production.

Heavy metal concentrations and distribution around the Qinghai-Tibet Plateau-A review

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The Qinghai-Tibet Plateau, known as the third polar and roof of the world, serves an important role in evaluating long-term ecologic conditions and environmental status and changes of the surroundings over time. Supported by One Hundred-Talent Plan of Chinese Academy of Sciences (CAS), this study summarizes major concentrations in water and soil around the Qinghai-Tibet Plateau based on the previously published data. The soil heavy metal contamination degree and the water heavy metal hazard index were respectively evaluated. The contamination degrees of two sampling areas around the Qinghai-Tibet Plateau showed extremely high levels with soil mCd (modified degree of contamination) values exceeding 20. The hazard indexes of two important rivers have reached unacceptable level (>1). Heavy metals, especially Hg, were also frequently detected in fish of the Plateau. The potential risk might be beyond our expectation. Therefore, it should be an urgent and top priority to identify and confirm possible pollution sources around the Qinghai-Tibet Plateau to guarantee the ecological safety and food safety of this area.

Quantification of climatic influences on the recent changes in forest spring phenology over Northern Hemisphere

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Facing climate change, deciduous forests in northern hemisphere experienced an enormous change in their seasonal trajectories from mid- to high-latitude. Recent studies reported that the start date of growing season (SOS), which is an indicator of beginning of biological spring, was severely advanced in 1980s and 1990s, but this advancing trend of SOS was weakened or even reversed by changes in temperature conditions at some regions after late 1990s. In this study we tried to diagnose and quantify a contribution of other climatic variables as well as temperature on the abrupt change in SOS trend over northern hemisphere. Using satellite-retrieved NDVI and multi-linear regression with climatic explanatory variables (temperature, radiation, and precipitation), we examine the relationship among the SOS and climatic variables over temperate and boreal forests in northern hemisphere. Although most of the SOS variation is explained by heat accumulation, but winter chilling and radiation also act a secondary role to modulate the SOS timing in high latitude regions. These results suggest that the winter chilling and radiation are should be considered to describe details about the large-scale response in SOS to the climate changes.

Risk Tolerance and Adoption of Conservation Agricultural Practices by Indian Tribal Farmers.

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In Odisha, India, the adoption rate of innovative technology is low as the farmers are generally risk averse. In Odisha, traditional agricultural practices include multiple plowings for land preparation and mono-cropping. This system is not sustainable where the practices result in soil erosion and low yields. Conservation Agriculture Production Systems (CAPS) have been proven to work in other countries. CAPS is based on three principles: minimal tillage, year-round cover cropping, and optimal crop rotation. Finding early adopters to practice CAPS will help achieve higher adoption rates, as they can influence other farmers. A survey for farmers in Rudhiapada, Badamahulidiha, Geridhina, Rajabata Sahi was developed to uncover socio-economic determinants of early adopters. Sixty-six tribal farmers were surveyed to determine whether they are willing to try a new technology. To determine the significant characteristics for identifying early adopters a logistic regression model was developed. The model incorporates a dichotomous dependent variable of willing to try new technology or not sure, with seven explanatory variables of age, gender, education, villages (3) and farm size. Results showed that farmers from villages (Rudhiapada, Badamahulidiha), male and older have a higher probability of becoming early adopters. Contrary to most studies, younger farmers are early adopters. Since most of the farmers that are older are not educated, they rely on NGOs to introduce technologies. Geridhina and Rajabata Sahi have less contact with NGOs thus they are ambivalent about trying new technologies. This highlights the importance of NGOs and the trust placed on them.

Impacts of Civil War Driven Land Use Change on Hydrology and Climate

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Spatiotemporal patterns of vegetation are a critical control on water, energy, and biogeochemical cycles. Civil-conflict is a known cause of land cover/land use change (LCLU), prompting both direct and indirect alterations on vegetation and land use. LCLU is often considered a static variable in many climate models, and human-land interactions are often not accounted for. Civil war in Mozambique (1977-1992) affected the ecology of the region as large herbivore populations decreased due to poaching and farming later rebounded. Modifications of vegetation affect hydrologic conditions as biophysical parameters change, which can cause redistribution of the surface energy balance. The Gorongosa National Park (GNP) in Mozambique is a unique place to study these potential feedbacks between LULC and hydrometeorology because of recent conservation efforts seeking to rehabilitate the wildlife. In this study, we explore the role of LULC change that was, in part, driven by civil-conflict on regional hydrology and climate. We categorize LULC change in GNP from 1977 to present using Landsat imagery, then use these maps to parameterize the Weather Research and Forecasting (WRF) model. To quantify hydrometeorological changes, we mixed input LULC maps and atmospheric forcing data from different time periods during and after the war. This approach allows for intercomparison between the modeled output scenarios allowing us to explore the sensitivity of regional hydroclimate to both vegetation and potential errors in LULC classification. Initial results show potentially significant land cover change from 1977-present and corresponding sensitivities to different LULC schemes suggested by the WRF model.

A typology of resource use adaptation among rice-farming households in Asia

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The research explores the possibility of creating a meta-typology of rice-farming households in Asia based on case studies in four countries (Laos, Cambodia, Bangladesh, India) for which separate household typologies had been developed. The analysis applies (a) Dorward's livelihood systems approach and (b) Giampietro's impredicative loop analysis in order to scale up local-level household information for higher-level design of adaptation options and policy interventions.

Results visualise the transformation of the land-water-food-energy nexus as farming households adapt to their changing environments. It shows that farmers require either specific interventions attuned to their resource base or strong policy support as they shift their livelihood strategies. The method of analysis applied shows that up-scaled typologies developed from empirical data can serve as powerful tools at the science-policy interface.

Global land production and water use efficiency in facing land use and climatic Changes in the 20th and 21st centuries

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Much concern has been raised regarding the impacts of climate and land use changes on water resource and land production. However, it is short of investigation on the quantitative understanding and assessment of how land use and climate change have affected global Net primary Productivity (NPP), evapotranspiration (ET) and global Water Use Efficiency (WUE) in the terrestrial biosphere. By using the Dynamic Land Ecosystem Model (DLEM) driven by spatially-explicit information on land use, climate changes, we assessed the spatial and temporal patterns of global NPP, ET and WUE across the global land surface in the past and future. Our study shows the following major results: 1) For contemporary period (1980-2010), both global NPP and ET increased as a result of multiple environmental changes. WUE increased because NPP showed a larger increase than ET. 2) Global NPP and ET show substantially interannual, decadal and spatial variations due to climate variability. Climate extremes induced by ENSO largely affect spatial and temporal variations in global NPP and ET. 3) For the projected period (2011-2099), our simulated results show that global NPP would have a slight increase under the B1 scenario, while a decrease at the end of 21st century under A2 scenarios. 4) Global ET shows a significant increasing trend under A2 scenario, particularly in the second half of the 21st century, comparing to a slight increasing trend under B1 scenario. 5) Global WUE would decrease greatly under A2 scenario, especially after 2050s, while WUE would remain relatively stable under B1 scenario.

Impact of Deforestation on Food and Water in North Korea : Focus on Agro-environment and Water availability

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Deforestation in North Korea is becoming a synonymous with the environmental change occurring in the Korean Peninsula, North Korea has been converting forests to mostly cropland, necessitating research on deforestation with a focus on agro-environment and water availability of forests and croplands. This research estimates the agro-environmental variables of North Korea's total croplands using GEPIC (GIS based EPIC) model to analyze three land cover types over the past 30 years. To identify the change in quality of agriculture, this study uses total soil nitrogen, organic carbon loss, and root zone soil water as the agro-environmental variables having an impact on crop productivity. And also to identify the change in water quantity of forests and cropland, this study use forest water yield from InVEST model and cropland runoff having an impact on natural land water availability. By using land cover maps belonging to the past three decades, this research found that 75 % of converted forests became cropland, and 69 % of converted cropland came from forests; thereby confirming that there exists a significant correlation between deforestation and cropland expansion. A quantitative comparison of the converted cropland expanded through deforestation with the original cropland revealed a definite negative change in organic carbon loss, water erosion, and runoff regardless of crops. The reason for such a change might be attributable to the topographical characteristics of cropland converted from forests. The forest water yields for the past 30 years clearly demonstrate a decrease in time series by deforestation. On the contrary to this, the cropland runoffs for the past 30 years clearly demonstrate a increase in time series by deforestation. Deforestation of North Korea clearly confirmed decreasing cropland productivity and water availability. It can make a more risky environment in food production and water resource at the era of climate change.

Using TMA of MODIS-NDVI data to map double and single rice-cropping system in Hunan, China during 2000-2015

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The distribution of rice cropping system is a foundation for agriculture land management, food security and agriculture response to climate change. Mapping the distribution of rice area is often depended on remote sensing technology. Long term and large scale rice cropping-system mapping needs to consider the spectral, temporal and spatial resolutions of different remote sensors. MODIS-NDVI time series data offers a unique combination of subpixel heterogeneity to apply to rice area estimation. While phenology-assisted crop mapping is promising, relying on frequently observed images, the accuracies are often low, with mixed pixels in coarse-resolution imagery. In this study, a temporal mixture analysis (TMA) with 250m MODIS-NDVI time series data were employed to estimates subpixel fractions of double and single rice cropping area throughout the growing season. This approach was evaluated in Hunan Province, China during 2000-2015. The resultant MODIS-derived paddy rice map was evaluated, using National Land Cover Dataset(NLCD) and the census dada of rice planting area in 2000-2015. There were reasonable agreements in area estimates of rice cropping system between MODIS-derived map and NLCD and census data at county levels. The area of double rice cropping system has 1.30×10^6 ha, 1.39×10^6 ha, 1.78×10^6 ha and 1.27×10^6 ha in 2000, 2005, 2010 and 2015 respectively. The area of single rice cropping system has 5.88×10^5 ha, 7.71×10^5 ha, 1.09×10^6 ha and 8.77×10^5 ha respectively. The results of this study demonstrate the importance of subpixel heterogeneity methods and the significant temporal change in cropping systems, which could better assist agriculture decision-making.

Feminization in NTAE production: case of coffee plantation in southern Laos

Saithong PHOMMAVONG

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The aim of this poster is to present gender relation in employment opportunities in the coffee plantation in southern Laos. The study applied qualitative study for data collection and analysis method including observation, interview, focus group discussion (FGD) and in-depth interview (IDI) in 4 villages in Champasak and Salavan provinces Lao PDR during 2014-2015. Findings show, NTAE production, coffee plantation offers as an arena as public sphere for female to work outside of domestic chores. Female have opportunities to work outside home for various positions mostly light works. There are different divisions of tasks between female and male in coffee plantation. Male are working on specific tasks that female can't do mostly heavy takes. Payment is difference between male and female for monthly wage. Labor law specifies non-discrimination toward tasks and wages. Some recommendations are to unlocked the necessary conditions and barriers that impede fair relation. What can you do to improve this unequal labor and wage structure?

Drying surface by warming induced increase in atmospheric evaporative potential

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Many assessments argue that understanding on land surface dryness changes is crucial for mitigating and adapting impacts of climate changes. In recent studies, land surface dryness changes are contrasting to the traditional paradigm of hydrological change in warmer climate “dry gets drier, wet gets wetter” because changes many climate variables show different attributions on the land surface dryness. In this study, we estimate relative contributions of dominant climate parameters on land surface dryness changes over East Asia, consists of various hydroclimate regimes from humid to arid regions, by using climate records of 189 weather sites for the period of 1961-2010. Since the year of 1984, trends in the land surface dryness are changes from negative to positive over monsoon climate regions (east of 100°E). Mechanisms of changing dryness trends are different according to hydroclimate regimes. The increase in the dryness are mainly caused by the decreased precipitation in arid regions. On the contrary, in humid regions, the increase in the saturation vapor pressure following warming and resulting increase in evapotranspiration mostly influences on the increase in the surface dryness though precipitation increases. Our results suggest increasing atmospheric water-holding capacity, a secondary impact of warming, plays a considerable role in determining trends in land surface dryness over the humid monsoon area even though sufficient moisture supplies from increased precipitation.

Land Policy and Development Plans in Ethiopia

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After the postwar period, after 1941, land policy and development plans have been considered an important part of the development plan of the country and yet the government did not have the power (nor the will) to implement an effective land reform that could break the existing structure apart. This situation was the base of the coup of 1960 and of the students' movement that supported the idea of 'The land to the tiller'. The failure of the imperial government to give a satisfactory answer to these requests had a major role in explaining the 1974 revolution and the subsequent developments that persist in Ethiopia till today.

This essay examines the main features and dynamics of rural land policy and the development strategy of the central government in its subsequent development plans. As land policy and development plans are complex, the sources, both primary and secondary, have been carefully examined and interpreted using themes identified both from literature and interviews in order to reconstruct the land policy and development plans of the country, the past and the present.

Competition for land-based ecosystem services at multiple geographic scales

Effects of crop distribution patterns change on agro-ecosystem service function in Northeast China

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Researches on dynamic changes of landscapes and land use types by using remote sensing techniques have been hot. However, the vast majority of studies have taken farmland as a “single” land type, the spatial distribution and variation of different crops inside the farmland have been neglected, and the agro-ecosystem service function have been thought as only food product supply function. This paper explored the extraction methods of large scale crop acreage and distribution pattern based on remote sensing. Furthermore, effects of crop distribution patterns change on agro-ecosystem service function were analyzed. Based on MODIS - NDVI data during the crop growth period of 2005 and 2010, by analyzing the planting structure, phenological calendar and NDVI time series curve characteristics, different area extracting models were established and were used to extract the spatial distribution of main crops (spring maize, soybean and paddy) by using RS, GIS techniques in Northeast China. Meanwhile, the changes of agro-ecosystem producing function, social security function, agro-ecosystem regulating function, soil conservation function, water conservation function, environmental purification function and leisure and entertainment functions were counted and analyzed based on different methods. The results showed that the overall areas extraction accuracies were more than 90% compared with statistical data. Agricultural producing function increased greatly in western and Northeastern counties. The tendencies of agro-ecosystem service function changes had great connection with the crop pattern changes. The effects of crop distribution patterns change on agro-ecosystem service function were obvious.

Competition for land and its impact on ecosystem services

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Land is the critical resource and provides food and fodder to feed the Earth's population of >7.2 billion, and fibre and fuel for a variety of purposes. It provides livelihoods for billions of people worldwide. It is finite and provides a multitude of goods and ecosystem services that are fundamental to human well-being. Human economies and quality of life are directly dependent on the services and the resources provided by land. Land delivers a variety of provisioning, regulating, cultural and supporting services. Implementing policy to deliver one service from land may directly or indirectly affect other services provided by land in positive or negative ways.

Competition for land, in itself, is not a driver affecting food , farming, forestry and other land use, but is an emergent property of other drivers and pressures. Modelling studies suggest that future policy decisions in the agriculture, forestry, energy and conservation sectors could have profound effects, with different demands for land to supply multiple ecosystem services usually intensifying competition for land in the future. There are co-benefits and trade-offs associated with any land use decision, and all policies are likely to lead to winners and losers among the people who rely upon the land for their livelihood.

In this presentation I will provide an introduction to the ecosystem services provided by land, before provided a range of examples of where optimising land for one purpose, impacts upon other services, at scales from local to global. I conclude by examining the knowledge needed to allow stakeholders become in decision making, and to all policy to be developed that maximises co-benefits and minimises trade-offs in an equitable manner.

The energy - land nexus in Indonesia - how to balance renewable energy and ecosystems services protection

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Indonesia has experienced an increase of its energy demand, while the share of renewable sources has remained stable (6%). However, Indonesia is committed to increase the production of renewable energy. The government has established a 23% target for renewable energy by 2025. In that respect, Indonesia has abundant resources to meet these targets, but there is – inter alia - a lack of proper integrated planning, regulatory support, investment, distribution in remote areas of the Archipelago, and missing data to back the planning.

To support the government of Indonesia in its sustainable energy system planning, the geographic explicit energy model BeWhere is applied. The model incorporates the existing fossil fuel-based infrastructures, and evaluates the optimal costs, potentials and locations for the development of renewable energy technologies (i.e. wind, solar, hydro, biomass and geothermal based technologies), as well as the development of biomass co-firing in existing coal plants. An optimally adapted renewable energy mix is identified. The development of the optimal renewable energy technologies is carried out with special focus on nature protection and cultural heritage areas, where feedstock (e.g. biomass harvesting) and green-field power plant sites will be limited – depending on the protection type and renewable energy technology.

Study results provide indications to the policy makers on where, how and which technologies should be implemented, and what kind of policy support would be needed in order to increase and meet the Indonesian renewable energy target and to increase the energy access for all.

A socioecological perspective on global land-use competition: Biophysical modelling based on HANPP and social metabolism

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Growth of world population and GDP are expected to result in increases of agricultural output by 70-100% until 2050. On top of that, efforts to substitute biomass for fossil fuels on a grand scale could at least double humanity's present biomass demand. Scenarios results suggest that bioenergy use could rise by factors between 2 and 5 over its present volume of ~50 EJ/yr in the next decades. But three quarters of the entire global land area (except Antarctica and Greenland) are currently used for human purposes, and the remaining areas are unlikely to contribute much as they are either unproductive (alpine or arctic tundras and deserts) or ecologically highly valuable (pristine forests). Raising biomass production will hence involve intensified land-use competition and/or an intensification of land use. Intensification may reduce land demand by raising biomass production per unit area and year, but it often has considerable ecological costs (e.g. emissions, water demand). Competition for land occurs when several agents demand the same good or service produced from a limited area. It implies that when one agent acquires scarce resources from land, less resources are available for competing agents. Possible negative effects of increased competition for land include pressures on biodiversity, rising food prices, land conflicts and GHG emissions. This presentation will show on how the socioecological metabolism approach can help analyzing land-related limits and functions in particular with respect to production and consumption of biomass and carbon sequestration. The metabolism approach has yielded databases (such as global HANPP and biomass flow data) and a biomass balance model (BioBaM) that can be used to analyze land-use competition. Recent studies of land-use competition in 2050 based on the BioBaM model that help to better understand biophysical option spaces as well as trade-offs and synergies between changes in demand (e.g. diets), agricultural technology (e.g., yields and livestock feeding efficiencies) and bioenergy (energy crops, residues) will be reported. Ongoing work to better understand the full GHG consequences and other ecological pressures resulting from different future land-use and biomass demand scenarios will also be discussed.

The change of live pattern change in Hulun Buir and the analysis of ecological effects

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The change of live pattern change in Hulun Buir and the analysis of ecological effects

WANG qing^{1,2} ZHANG Shuwen² CHANG Liping², YANG Jiuchun² 1.Collage of Earth Science, Jilin University, Changchun,china; 2.Northeast Institute of Geography and Agroecology, Chinese Academy of Science, Changchun, China. Abstract :Land use affects global change .The human factor is also one of the main driving forces of the land use change .Population is a major driving force of ecological footprint. Hulun Buir is typical farming-pasturing interlocked.The land use pattern is mainly nomadic and farming .Once in the constraints of climate and pasture conditions,the Mongols live on nomadic manner.Because of the specification of nomadic way ,they have to change place which are not fixed and disperse to suit for grazing.With the development of the economic and the damage to the grassland ,herders choose to rear livestock in pens or grazing nearby .Thus,herders have possess fixed abode so called settlement.Nomadic way,taking advantage of critical point of consumption and regeneration of the grassland resources. First,Make use of land use, slope, roads and other data to make the spatialization of 2005, 2010, 2015 demographic data by the ways of geographical weighted regression.Then allocate the population to the 100m×100m pixel according to the probability coefficient .Convent the settlement newly increased to point data .Buffer the point data and choose the best distance affect by settlement.Finally ,calculate the population number ,fragmentation and value of ecosystem services in buffer zone .Studies shown ,the change of living ways have lead the increase of the population density and fragmentation and the reduce of the value of ecosystem services .Once forming fixed settlement , the appropriate facilities will increase, and settled grazing will cause damage to the surrounding pastures, enormous pressure on the environment.

Understanding ecosystem service tradeoffs using a two-stage approach to investigate values of water benefits in the Big Horn Basin, USA

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Whether driven by natural or human forces, changes in the endowment of natural resources will result in perceptions of ‘winners’ and ‘losers’. Although it’s not possible to completely eliminate tradeoffs through policy-making and management, understanding how ecosystems support a broad range of beneficiaries, and what drivers of change impact the provision of ecosystem services, may result in more equitable and justifiable management and policy. This study demonstrates application of a two-step approach to valuation which (1) informs of perceived tradeoffs among residents for a broad range of water-based ecosystem services derived from federal lands in Wyoming and Montana, USA; and (2) develops ecosystem service valuation across targeted segments of residents to allow tradeoff analysis among the most relevant benefits.

This two-stage approach first employed Q-methodology, a qualitative method used to identify the major orientations of residents based on tradeoffs among ecosystem services. Using factor analysis, this stage distilled the diverse opinions of 96 stakeholders to reveal 4 major perspectives. Based on results from the first stage, a choice modelling survey was developed and mailed to a representative sample in the study area, which elicited valuation estimates for agricultural, angling, biodiversity, and motorized winter recreation benefits. This quantitative approach yielded household non-market value estimates for marginal changes in the levels of ecosystem services, and provided an understanding of how the perspectives identified in the first phase were distributed across the population. In tandem, we achieved a holistic understanding of tradeoffs among different ecosystem services to inform public lands policies.

Making land systems science matter: examples from the field

Ruth DeFries

Columbia University, New York, United States

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The future of land use in China

Jun Chen

National Geomatics Centre of China, Beijing, China

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GLOBE Training: Global Representativeness Analysis for Meta-Study Research

Advancing global land mapping and monitoring

Matt Hansen

University of Maryland, College Park, MD, United States

-

Grazing, Livestock, Land-use change and the Sustainability Nexus

The effect of precipitation variability on global pasture for livestock-dependent global food security

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Naturally vegetated rangelands encompass approximately two-thirds of the Earth's land area, a considerably larger proportion than that devoted to crop production. The capability of these areas to support livestock is important for global food security, particularly in regions that rely heavily on extensive grazing. However, rangeland ecosystems may be particularly vulnerable to climate change. Precipitation heterogeneity has been linked to the ecosystem dynamics of rangelands through its impact on livestock carrying capacity and degradation potential. Here, we establish the extent to which global pastures are tied to precipitation variability by mapping the relationships between precipitation (CRU data) and NDVI (GIMMS data). We then present a global analysis of the inter-annual coefficient of variation of precipitation (CV) over the last century and identify areas that are currently vulnerable or are becoming increasingly vulnerable to changes in precipitation variability. We use this information to highlight regions where livestock intensification may not be viable or may negatively impact both rangelands and the livelihoods of the people who rely upon them. CV is widely used to quantify precipitation variability and in this study we establish that it can also serve as an important climate change risk metric for global pastures.

Ecosystem Dynamics in the Returning Rangeland to Grassland programs, China

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Grassland in arid, semi-arid and alpine areas has been experiencing severe degradation in recent decades. To enable restoration of grassland vegetation and sustainable development, the Returning Rangeland to Grassland (RRG) programs was initiated in 2003. Based on the remote sensing images, meteorological data and ground observed data, this study utilized data fusion, ecological model simulation and scaling transformation to construct the regional macro ecosystem structure, ecosystem quality and dynamics in regions hosting RRG programs. Fractional vegetation cover (FVC), leaf area index (LAI) and net primary productivity (NPP) were utilized to indicate ecosystem quality. We examined the spatiotemporal characteristics of ecological structure and ecosystem quality in regions where the RRG programs were implemented from 2000 to 2010. Additionally, we analyzed the ecosystem evolution characteristics and the driving mechanism of the ecosystem change. Grassland ecosystems were dominant in the study area. The ecosystem structure was stable, but grassland experienced local change in farmland, wetland and desert locally. FVC showed a slight increasing trend for grassland; LAI tended to fluctuate but tended to also increase; NPP increased, ranging from 218.23 gC/(m² ×a) in 2000, to 226.30 gC/(m² ×a) in 2010, a 3.70% increase. Ecological conditions differed in spatially; overall there was improvement but with areas of localized deterioration. The spatiotemporal variations of ecosystem were mainly controlled by the ecological restoration projects, climate change and human activities. The RRG programs restored degraded grassland and promoted natural grassland protection. The warming-wetting trend observed over this time promoted the restoration of vegetation. Human activities such as overexploitation resulted in conversion of grassland into farmland in some area.

Food consumption pattern, diet transition and food-land-water nexus in China

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Rapid urbanization and increased affluence in China have greatly changed food consumption pattern from starch-based to diversified food which mixed meat, milk, eggs, fruit and vegetables with rice and wheat. More than a quarter of all the meat produced worldwide is now eaten in China, and currently China consumes nearly half of world pork, and it is still rising. In order to feed the increasing number of livestock, land for rice or wheat is gradually transformed to maize, which consumed more water. Considering more land and water is needed to produce meat than grain, the large scale increasing of non-starchy food consumption have great impacts on China's land and water scarcity. There also is a mismatch of the places of food production and demand which exacerbate the imbalances of land and water scarcity in China. The rising of food demand is at the price of heavy fertilizer and pesticide use, which affect the sustainability of land and water. Diet transition in China also have great impacts on land use in other countries from globalization and food import. Analysis the process, trend and driving forces of the changing food consumption pattern, projecting food demand in future and preparing for the challenges to meet China's food security, is not only important for food security in China, but also critical for the world food security as a whole. This paper uses China's land use data and national and provincial statistics on food consumption from 1960s to 2010s, study the change of food consumption patter and the trend of diet transition, then use Bayes model to explore the future scenarios. Considering the population change and urbanization, this paper provide suggestions to address the dilemma of how to achieve China's food security and meet land and water sustainability.

Mapping the distribution of grazing livestock in Kazakhstan

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Pastoralism is a dominant feature in the Kazakh landscape, a landscape which is itself dominated by the Eurasian Steppe that stretches from Ukraine to Mongolia. Livestock production has always been an integral part of Kazakh rural society, however after the dissolution of the Soviet Union, livestock numbers and production dropped precipitously (70% reduction in grazer numbers), and though numbers have rebounded in the last 15 years, grazing livestock are still only 55% of 1990 numbers. Increasing livestock production is one of the focal points of the Agribusiness 2020 program for agricultural development in Kazakhstan. However, little information exists on the extent of lands currently utilized for livestock production, and the intensity with which they are being utilized. This information is critical for planning development in grazing livestock production, and in estimating the carrying capacity of Kazakh grasslands. Rajon (district)-level statistics, land cover, grassland productivity, and settlement-level socioeconomic information were used to create high-resolution, annual maps of livestock distribution and grazing intensity. Grassland productivity was estimated using net primary production, and livestock grazing demand was estimated using a feed input-output model based on feed energy content. This is a vast improvement on the currently existing global-scale livestock distribution, better illustrating the variability in livestock distribution, and providing temporal resolution for inter-annual analyses and future projections. These maps can be used to identify areas of grassland degradation due to overgrazing, as well as to reveal areas with potential for sustainable expansion.

**How Farming Energy Flows interact with Land Systems? Towards Energy—
Landscape Integrated Analysis**

Sustainable Farm Systems? Applying Energy—Landscape Integrated Analysis in past and present Western agricultures: Some comparative results

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ELIA is a method that combines the network analysis of energy flows driven by farmers in agroecosystems, and their capacity to store energy within, with the landscape patterns seen as the energy-information imprint. After being applied to the land cover land-use changes and the corresponding transformation of socio-metabolic fluxes experienced in the Vallès County, in the province of Barcelona (Spain), from 1860 to the present (Marull et al., 2016), it has been replicated in other ten case studies across Europe and North America. In each case, the land cover heterogeneity or polarization is correlated to the spatial-explicit pattern of energy flows and the level of complexity/information held in the prevailing farm systems. A key point of this analysis is the capacity of each agroecosystem to harness energy through the farming energy reinvestment effort, which generates greater internal energy loops that are well balanced with external energy flows. The results will be presented, and will be used to address the question whether there appear some general trends considering all these cases from a socio-ecological long-term perspective. This approach will contribute to our understanding of the underlying relationships between the socio-metabolic flows driven by different farm systems and their spatial imprint on the landscape patterns and ecological functioning. This way of integrating the material-energy flow analysis used in ecological economics, and the quantitative landscape ecology applied to assess the farm-associated capacity to host biodiversity in different landscape patterns, will provide useful data to contribute to the ongoing land-sharing/land-sparing debate in biological conservation.

Socioecological transition in the Cauca Valley, Colombia (1943-2010): Towards an energy-landscape integrated analysis

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Agroecosystems are facing a global challenge amidst a socio-ecological transition that places them in a dilemma: increasing land-use intensity to meet the growing demand of food, feed, fibres and fuels, while avoiding ecosystem services loss. We applied an Intermediate Disturbance-Complexity approach to the land-use changes of a Latin American intercultural landscape (Cauca river valley, Colombia, 1943-2010). It accounts for the joint behaviour of human appropriation of photosynthetic Net Primary Production (HANPP), used as a measure of disturbance, and a selection of land metrics that account for ecological functionality as a proxy for biodiversity. Then we delved deeper into the local land-use in order to identify the main socioeconomic drivers and ruling agencies at stake. The results show that traditional organic mixed-farming have tended to disappear as a consequence of sugarcane intensification, which in turn has caused profound changes on the properties of the landscape, both structural (landscape patterns such as fragmentation) and functional (landscape processes such as ecological connectivity). The analysis confirms the intermediate disturbance-complexity hypothesis by showing a hump shaped relationship, where the highest level of landscape complexity (assessed as land cover heterogeneity-connectivity) is attained when HANPP disturbance peaks at 50-60%. The study shows the usefulness of transferring the concept of intermediate disturbance to bio-cultural landscapes. They also suggest that the conservation of a mixed farming able to keep a positive interplay between intermediate disturbances and a complex land-use pattern, which is endowed with a rich bio-cultural heritage, becomes a crucial resource for a sustainable future.

Long-term Energy-Landscape Integrated Analysis (ELIA): application to the Barcelona Metropolitan Region (1850-2010) at different spatial scales

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The role of agricultural landscapes in biodiversity conservation and ecosystem services is an emerging topic. It requires a deeper research on how species richness is kept in different land-use patterns, according to the level and shape of the ecological disturbance that farmers carry out across the land matrix. To that aim, we have developed an Energy-Landscape Integrated Analysis (ELIA) that brings together the accounting of socio-metabolic energy flows driven by farmers in agroecosystems and the assessment of the ecological functioning of their cultural landscapes. The ELIA model is applicable at different spatial scales, from regional to local. Through GIS it assesses in each cell of a grid drawn in the land matrix studied: a) the complexity of internal energy loops; and b) the information held in the whole network of energy fluxes; in order to then, c) correlate this energy-information interplay with the functional landscape structure. This spatial-explicit model assumes an Intermediate Disturbance-Complexity (IDC) hypothesis in the agroecosystem functioning, which is aimed at assessing how different levels of anthropogenic disturbance on ecosystems affect the capacity to host biodiversity depending on the land-matrix complexity. Hence, ELIA modelling can reveal how and why different agroecosystem managements lead to key turning points in the relationship between the farming energy profile and the landscape ecological performance. The results obtained can be used as a tool for strategic environmental assessment of land-use planning, and will be very useful for designing more sustainable farm systems worldwide in future.

Minimising agriculture's post-carbon footprint

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The spread of agriculture is a major cause of biodiversity loss. Over the last 60 years agricultural production has intensified, resulting in more produce per area, largely through the use of petrochemical fertilisers. In a post-carbon world, more land may be required to maintain productivity without these fertilisers, threatening biodiversity. We mapped the global change in deforestation and biodiversity loss during the global financial crisis (GFC) during which the oil supply was constrained. We found an increase in deforestation associated with the GFC which tended to coincide with the areas of highest biodiversity. A review of the hotspot areas of increased loss indicated that commercial agriculture was primarily driving the changes, and these countries were also most sensitive to the price of fertiliser. To gauge the possible future threat, we mapped the potential global requirements for cropland without mineral nitrogen (N), and found that the remaining suitable land would be unable to meet food requirements, leading to food insecurity in much of the world, and threatening most of the remaining biodiversity. We then mapped a best-case scenario for the footprint of future crop production using sources of renewable N which might replace mineral N. Some of the most promising options include using a concentrated solar-powered Haber-Bosch process, marine azolla production and human waste reuse. Spatial prioritisation shows where each of these would displace the least biodiversity for the least cost. We conclude that conservation science needs to engage with these agricultural practices in order to conserve biodiversity.

Reconciling food security and biodiversity conservation in Uganda – a baseline and scenario analysis

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Global food production systems are based on resource intensive land management practices which have contributed significantly to global environmental changes, i.e., land use and land cover change (LUCC), loss of biological diversity and disruption of the nitrogen cycle. The impacts are likely to increase in the future due to socio-economic and climate changes.

A range of high resolution (30 arc-seconds) LUCC scenarios is computed for Uganda until the year 2050 driven by different climate and socio-economic scenarios. LUCC impacts are assessed on the extent of biodiversity priority sites and soil nitrogen depletion rates. Different land-zoning strategies are investigated if they can mitigate LUCC impacts on biodiversity.

The results show that it is feasible to meet future food production demands (between +183% and +193 % of crop and +66% of livestock production) but cropland must expand between +28% and +44 % and crop yield must increase between +103% and +122%. These changes cause tradeoffs; natural habitats decrease between -47% and -65% and potential soil nitrogen depletion increases between +205% and +230%.

Land-zoning can help steering the expansion of agricultural land onto less species-rich, but still productive areas while preserving biodiverse areas. Between +85% and +100% of the currently un-protected Key-Biodiversity-Areas (KBAs) can additionally be incorporated into the national Biodiversity Strategy and Action Plan without undermining future food security. In contrast, without prioritizing biodiversity conservation, between 33% and 52% of the current protected area network and between 86% and 93% of currently un-protected KBAs could be converted into managed land.

How is regional climate affected by large (regional or global) scale changes in land uses and cover?

Deforestation changes land-atmosphere interactions across South American biomes

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Increasing evidence is showing the relevance of land cover change on the regional mean climate. However, the mechanisms that explain these interactions remain a challenge in land-atmosphere interactions science. This challenge is particularly significant in understanding the role of deforestation on the mean climate, climate extremes and aridity. These last, barely addressed by the literature.

In this paper we focus on the effects of deforestation on land-atmosphere interactions in non-Amazonian South America (3 million km²). We run a 3 ensemble climate model nudged with the ERA-Interim reanalysis and stretched to 25 km resolution for present (2005) land cover relative to realistic historic vegetation distribution. Results show a significant change in land-atmosphere interactions across different biomes as expressed by an increase in surface temperature and decrease in soil and atmospheric moisture, among other variables. We found geographical and seasonal climate responses to deforestation linked to changes in heat fluxes, roughness length but also to the distance from coast and the presence of mountains such as the Brazilian plateau and the Andes mountains. For example, dry season temperature changed between $\sim 0^\circ$ and 1.4° , which is higher to the increase in temperature attributed to increased CO₂. Also both soil and atmospheric moisture decreased up to 6% and evapotranspiration increased up to 200% in the same season.

Other results are that the degree of change in vegetation structure determines whether extreme daytime temperatures and aridity will increase or decrease, particularly during the dry season.

Requirement of accurate urban fraction data for improving regional climate modelling

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As one of the main characteristics of land use change in China, the fast expansion of urban built-up areas could contribute to local and even regional climate change. In this paper, Beijing-Tianjin-Hebei region, one of the most typical areas experiencing drastic urban expansion, is selected as the study area to discuss the impacts of different urban fraction data on accuracy of regional climate modelling. Simulation results using urban fraction data of default USGS, MODIS in WRF model is compared with that using urban fraction data based on Landsat TM/ETM+. It is showed that air temperature modelling results using MODIS is more accurate than USGS for better representation of recent urban fraction and other land cover types, and results using Landsat TM/ETM+ is the most accurate for more accurate spatial details of urban land cover. In addition, distinguish of urban land cover types for commercial areas, high residential or low residential areas is helpful for improving climate modelling. Accurate estimation of fraction data of different urban types would improve climate simulation at local and regional scales.

How does land use and land cover change impact monsoon Asian climate and its variability?

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Land use and land cover change (LULCC) is primarily characterized as forest conversion to cropland for the development of agriculture. Previous climate modeling studies have demonstrated the LULCC impacts on mean climate and its long-term trends. This study investigates the diurnal and seasonal climatic response to LULCC in monsoon Asia through two numerical experiments with potential and current vegetation cover using the fully coupled Community Earth System Model. Results show that LULCC leads to a reduced diurnal temperature range due to the enhanced (reduced) diurnal cycle of the ground heat flux (sensible heat flux). Daily minimum surface air temperature (Tmin) exhibits a clear seasonality over India as it increases most in the premonsoon season and least during the summer monsoon season. Similarly, a strong anticyclonic anomaly is present at 850 hPa over India in spring and over eastern China in autumn, but weak changes in circulation appear in winter and summer. In addition, the LULCC results in significant changes in the variability of the 2 m air temperature, as characterized by an enhanced variability in India and a reduced variability in northern China to eastern Mongolia in autumn and winter. Possible land-atmosphere feedback loops involving surface albedo, soil moisture, evapotranspiration, atmospheric circulation, and precipitation are offered as biogeophysical mechanisms that are responsible for the region-specific LULCC-induced diurnal and seasonal response.

Forest cover change and biophysical climate feedbacks in Southeast Asia

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Forest cover change can have a strong biophysical influence on regional climates, mitigating or accentuating the effects of global climate change. Forest loss in Southeast Asia has accelerated over recent decades, driven by economic development pressures. Here we review the nature and extent of changes in forest cover and the implications of these changes for potential biophysical regional climate feedbacks. Over the past 60 years, many countries in the region have lost around 30–50% of their remaining forest cover. The greatest percentage of forest loss since 2000 has occurred in lowland rainforests and peat swamp forests. In Borneo between 1973 and 2007, average rainfall declined by nearly 800 mm/year, and temperatures increased by around 0.5°C. These changes are linked to deforestation which modifies forest structure, leaf area index, evapotranspiration rates and heat fluxes. Global climate predictions indicate that Southeast Asia will become hotter by up to 3°C. Rainfall patterns will vary, with western areas becoming drier and eastern areas becoming wetter. Predicted increases in the extent of deforestation, particularly for palm oil, and forest degradation due to timber extraction suggest that regional biophysical climate impacts may be much greater than global climate change associated with increased concentrations of CO₂.

Land use and land cover change emissions between 1901 and 2012 constrained by biomass observations

Wei Li, Philippe Ciais, et al.

Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Gif sur Yvette, France

Land use and land cover change (LULCC) emissions estimated by global biosphere models exhibit a relatively large spread, primarily due to the difficulty of constraining the components of this flux across different ecosystems, in particular of the biomass stocks impacted by deforestation. Here, we analyze the relationship between the initial biomass and the cumulative LULCC emissions from 1901 to 2012 simulated by nine dynamic global vegetation models. Then, we combine the biomass data sets based on inventories and satellite observations to constrain the modelled LULCC emissions. A significant positive linear relationship was found between the cumulative LULCC emissions and the simulated initial biomass (in 1901) across all nine models, and between their simulated initial and present biomass. These two relationships are used as emergent constraint, applying observed biomass data sets to reassess cumulative LULCC emissions. Compared to the original global cumulative LULCC emissions between 1901 and 2012, that could be uniformly distributed between models, ranging from 94 to 273 Pg C, we propose a biomass observation constrained global estimate of 155 ± 50 (1- σ Gaussian error) Pg C, and the probability of a higher improved global estimate than prior is 81%. A significant reduction of 10.5 Pg C ($p < 0.01$) in cumulative LULCC emission was found in North America after biomass constraint, and large discrepancy also exists in South and Southeast Asia between the original results and the improved estimates under different constraining biomass data sets. This study shows that constraints of cumulative LULCC emissions can be achieved by using observation-based biomass data sets

Human modification of rainfall through large-scale land use and land cover change

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Large-scale changes of the Earth's land surface alter the climate in various way. In this research, we quantify and analyse the changes to the regional-global atmospheric water cycle (i.e., terrestrial moisture recycling) from anthropogenic driven modifications in land cover and land use.

We simulate evaporation and moisture recycling in potential, historical, and current land cover and land use scenarios by coupling a global hydrological model (STEAM) with a moisture tracking scheme (WAM-2layers). Moreover, we investigate where and when rainfall change occurs, assuming that changes in moisture recycling translate into changes in rainfall.

Although modifications in global and annual average rainfall are minor, changes can be important regionally and during specific seasons. In particular, reduced vegetation may shorten the dry season length, and decrease the dry season rainfall more than the mean annual. Furthermore, we attribute downwind changes in precipitation to land use change processes, primarily deforestation and irrigation. Finally, the effect on rainfall from transpiration ratio shift following different types of land use change is analysed.

This study contributes to the understanding of human influence of precipitation, and reveals how land use change in some upwind regions potentially affects agricultural development in downwind regions by altering the total rainfall as well as the dry season length. Land decisions are tightly connected to water availability, thus, regionally, it is crucial to consider the atmospheric water cycle and its interactions with land and water resources governance.

Things I like about trees

Test Account

University of Experimentation, Bern, Other

they are tall and they drink water from the earth

Comparison of land-atmosphere interaction at different surface types in the mid- to lower reaches of Yangtze River Valley

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The mid- to lower reaches of Yangtze River Valley is located within the typical monsoon zone. Rapid urbanization, industrialization, and development of agriculture have led to fast and complicated land use and land cover changes in this region. To investigate land-atmosphere interaction in this region where human activities and monsoon climate are highly interactive with each other, the micro-meteorological elements, land surface energy budget, and near surface turbulent fluxes exchange at four pair sites over different underlying surface types varying from urban to rural are analyzed systematically based on the in-situ observations. Results indicate that despite under the same climate background, the differences of surface characteristics like albedo, aerodynamic roughness length, and Bowen ratio due to different land use/cover change exert unneglectable influences on the radiative components and surface energy allocation, and cause the obvious differences of micro-meteorological elements subsequently, especially during the dry periods, the proportion of LE/R_n keeps increasing from spring to summer, which is contrary to H/R_n ; the differences in radiative fluxes are mainly reflected in upward shortwave radiation that is related to surface albedo and upward longwave radiation due to the differences of surface temperature. Results obtained from this study can not only fill in the blank of the field observations, but also help us have a better understanding of land-atmosphere interactions and its climatic/environmental effects due to land use/cover changes in this region.

What is the sensitivity of regional climate modeling to land use and land cover changes?

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By modifying the Earth's natural landscapes, humans have introduced an imbalance in the Earth System's energy, water and emission fluxes via land-use and land-cover changes (LULCCs). Through land-atmosphere interactions, LULCCs influence weather, air quality and climate from local to global scales. Therefore, in the context of climate change, LULCCs play a role locally/regionally in altering atmospheric conditions. In addition to the global climate change impacts, future LULCCs will possibly induce further changes in the functioning of terrestrial ecosystems and thereby affect mitigation and adaptation strategies.

Nowadays, numerical land-atmosphere modeling allows to assess LULCC impacts at different scales. However, most scenarios of climate changes used to force impact models result from downscaling procedures that do not account for LULCCs. Hence, to assess the sensitivity of regional climate modeling to LULCCs, we apply a coupled land-atmosphere model over France. To depict future LULCCs in France, we use the RCP 4.5 scenario from the IPCC AR5 report. To provide initial and boundary conditions to the coupled land-atmosphere model, we use ERA-INTERIM re-analyses (period 1980–2009). Results are discussed in terms of the impact of land-atmosphere interactions on: (a) mean and extreme atmospheric conditions (e.g., surface temperature, precipitation): and (b) ecosystem services that the land-atmosphere system provide to humans (e.g., apparent temperature, heat index).

This study aims to quantify the impact of LULCCs on regional climate and as well to push further scenario development to build compelling LULCC scenarios.

Exploring Future Biogeophysical Signal of Land Use and its Uncertainties.

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Using the NOAA/GFDL fully coupled Earth System Model ESM2Mb we investigate the biogeophysical response of simulated climate to future scenarios of land use and land cover change (LULCC) while allowing the dynamic vegetation to respond to both LULCC and climate change. Previous studies using ESMs with prescribed vegetation indicated that LULCC could lead to significant regional climate responses. Here we demonstrate interactions between vegetation dynamics and LULCC and effects of such interactions on changes in land surface characteristics. The ESM2Mb model structure allows to examine in unique ways the sub-grid effects of LULCC on regional and global climate patterns. In addition to providing specific information about climate response to LULCC on different land use types, the sub-grid output allows to separate local and non-local effects of LULCC.

We also compare our findings with those based on differencing near-surface climate from experiments perturbed and unperturbed by LULCC and assess contribution of unforced climate variability to such differences. We analyze surface turbulent and radiative fluxes and land properties which contribute to those changes, such as albedo and surface roughness, and the implication of these changes for the resulting response of near-surface temperature. We compare our results with the results from a set of simulations with other models.

Examining the influence of perturbation scale of albedo enhancement over crop areas on regional temperature extremes

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Land radiation management (LRM) involves the modification of agricultural practices, including no-till management or selective crop planting, to enhance surface albedo and change the surface energy balance to reduce surface temperature. LRM has been proposed as a possible mechanism for mitigating regional temperature extremes associated with future climate change. However, at what scale of implementation does LRM become effective in reducing regional temperature extremes? Using idealized fully coupled simulations from the Community Earth System Model we examine both the effects of spatial scale and magnitude of albedo enhancement on regional temperature extremes for the major global agricultural regions. We implement the albedo enhancement firstly over all crop regions by increasing snow-free surface albedo over cropland by 0.02, 0.04, 0.08 and 0.10 to examine the sensitivity of regional temperature extremes to the magnitude of albedo change. Then we examine the scale of implementation by varying spatial extent of the albedo enhancement from isolated grid cells of a crop region to the entire crop region. These experiments aim to identify which level and scale of LRM implementation is sufficient to have a statistically significant effect on regional temperature extremes through changes in the surface energy balance.

Predicting the responses of forest distribution and aboveground biomass to climate change under RCPs scenarios in southern China

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In the past three decades, our global climate has been experiencing unprecedented warming. This warming has and will continue to significantly influence the structure and function of forest ecosystems. While studies have been conducted to explore the possible responses of forest landscapes to future climate change, the Representative Concentration Pathways (RCPs) scenarios under the framework of the Coupled Model Intercomparison Project Phase 5 (CMIP5) have not been widely used in quantitative modeling research of forest landscapes. We used LANDIS-II, a forest dynamic landscape model, coupled with a forest ecosystem progress model (PnET-II), to simulate spatial interactions and ecological succession processes under RCPs scenarios, RCP2.6, RCP4.5 and RCP8.5 respectively. We also modelled a control scenario of extrapolating current climate conditions to examine changes in distribution and aboveground biomass (AGB) among five different forest types for the period of 2010-2100 in Taihe County in southern China, where subtropical coniferous plantations dominate. Our results show that climate change will significantly influence forest distribution and AGB. Evergreen broad-leaved forests will expand into Chinese fir and Chinese weeping cypress forests. The results also demonstrate that forest total AGB increases rapidly first and then decrease slowly on the temporal dimension. The results suggest that, even though the fluctuation patterns of total AGB will remain consistent under various future climatic scenarios, there will be certain responsive differences among various forest types. By the year 2100, the total AGB in Taihe County under RCP4.5 will reach its highest level.

Observational evidence for the influence of agricultural land use change on extreme summer temperatures

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Agroecosystem productivity is sensitive to extreme temperatures, but agricultural land use change can influence regional climate. Here we present three observational analyses that characterize regional-scale interactions between land use and summer temperatures extremes. First, we characterize shifts in MODIS-derived land surface temperature, albedo, EVI, and estimated evapotranspiration in areas of the US following recent land cover change from 2008-2012. Second, we analyze how weather station 95th percentile summer temperature trends relate to agricultural land use over the last century, using USDA agricultural inventory data on irrigation, crop area, and crop productivity. We extend this analysis to seven major cropping regions using historical datasets of crop productivity and irrigation since 1961. All three analyses indicate a substantial influence of agricultural land use on regional climate, and extreme temperatures appear particularly sensitive to alterations in surface evapotranspiration characteristics. Recent land cover change in the Southern Great Plains, for example, shows that conversion of grass to maize resulted in roughly a doubling of peak EVI and estimated ET, with peak land surface temperature (over a 16-day period) declining $\sim 5^{\circ}\text{C}$. Over longer historical periods, we find that intensification of summer crop productivity in the US, not simply expansion of croplands, is most strongly associated with cooling of air temperature extremes for both irrigated and rainfed lands. Cooling is not sustained in rainfed areas during drought, consistent with intensification increasing potential evapotranspiration. Similar results are found for other major summer cropping systems, including in the Canadian Prairies, Argentina, and East Asia.

Please note I was not able to add more than 7 authors. Missing authors are Stefan Siebert (University of Bonn) and Deepak Ray (University of Minnesota).

Spatiotemporal Changes of Built-Up Land Expansion and Carbon Emissions Caused by the Chinese Construction Industry

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China is undergoing rapid urbanization, enlarging the construction industry, greatly expanding built-up land, and generating substantial carbon emissions. This study reconstructed the calculating framework of carbon emissions in the construction industry. We calculated both the direct and indirect carbon emissions from energy consumption (anthropogenic emissions) in the construction sector and analyzed built-up land expansion and carbon storage losses from the terrestrial ecosystem. According to our study, the total anthropogenic carbon emissions from the construction sector increased from $3,905 \times 10^4$ to $103,721.17 \times 10^4$ t from 1995 to 2010, representing 27.87% and 34.31% of the total carbon emissions from energy consumption in China. Indirect carbon emissions from other industrial sectors induced by the construction sector represented approximately 97% of the total anthropogenic carbon emissions of the sector. These emissions were mainly concentrated in seven upstream industry sectors. Based on our assumptions, built-up land expansion caused 3704.84×10^4 t of carbon storage loss from vegetation between 1995 and 2010. Cropland was the main built-up land expansion type across all regions. The study shows great regional differences. Coastal regions showed dramatic built-up land expansion, greater carbon storage losses from vegetation, and greater anthropogenic carbon emissions. These regional differences were the most obvious in East China followed by Midsouth China. These regions are under pressure for strong carbon emissions reduction. In temporal dimension, the rate of built-up land expansion increase gradually, and there is an obvious growth of carbon emissions in the construction sector.

Identifying Gaps and Improvements in Global Agricultural Monitoring

Global Agricultural Monitoring Systems: Current Gaps and Possible Solutions

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Global Agricultural Monitoring (GAM) systems are designed to provide up-to-date information regarding food production to different actors and decision makers, from farmers to governments. These systems deliver critical data in order to activate policies, local agricultural practices and, if needed, emergency plans dealing with forecasts of poor harvests or adverse climatic conditions, thereby supporting global food security. Remote sensing is one significant source of comprehensive and timely information for supporting agricultural monitoring, and new higher resolution sensors with more frequent revisit times (e.g. Sentinel 2) have come online recently. Yet there are still numerous gaps in the basic information needed to support better agricultural monitoring, crop modelling and yield gap analysis. The aim of this paper is to present the current state of large scale GAM systems and identify the main gaps in their information based on a combination of literature review and expert interviews. We then provide recommendations that could address these gaps and improve these systems for stakeholder at all levels. This includes recommendations for improving baseline information (e.g. better global crop masks, crop type maps, crop calendars, etc.), improving statistical data on agricultural production, area and yield at national and sub-national level, as well as increasing the amount of in-situ yield data currently available, e.g. through novel technologies and crowdsourcing.

A Global Cropland Map for 2010

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There is a lack of accurate data on the spatial extent of global cropland and major crop types. Such baseline data are critical inputs to agricultural monitoring and rural development and investment at multiple scales. Cropland extent is available from generic global land cover products such as the GLC-2000, MODIS or GlobCover but these products do not agree with respect to the overall amount of cropland or their spatial distribution. Specific cropland products are available that are aligned to national and sub-national crop statistics but the uncertainty in these products remains high. To tackle these issues, a global hybrid cropland map for the year 2005 was created jointly by the International Institute for Applied Systems Analysis and the International Food Policy Research Institute (IFPRI) using many different national and regional cropland maps, available national and sub-national statistics and crowdsourced data collected through Geo-Wiki. This paper will present a new hybrid global cropland map for 2010, using more up-to-date land cover maps as inputs, a new methodology that involves geographically weighted regression (GWR), and a more extensive crowdsourced dataset, used by GWR in the map development process. The map is also validated using a combination of crowdsourced and expert-collected data. This map will be contributed to GEOGLAM, the Group on Earth Observation's Global Agricultural Monitoring flagship initiative, to serve as the most accurate baseline information on cropland extent. The map will also be a primary input to the development of crop type distribution maps for the year 2010 by IFPRI.

Development of a hybrid cropland map using a synergy approach

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The information of cropland spatial extent plays a major role in food security and global change research. It is available from land cover dataset, e.g., GlobeLand30, CCI-LC, and MODIS Collection 5. However, uncertainties and inconsistencies are generally occurred among these maps because of different classification systems and methodologies. In order to solve this issues, this study employ a method of Hierarchical Optimization Synergy with Dataset Agreement (HOSDA) to develop a global cropland map by using existing cropland maps and cropland area statistics. At global scale, five cropland maps in circa 2010, including GlobeLand30, GlobCover2009, CCI-LC, MODIS Collection 5 and MODSI Cropland, are used for synergy mapping. After data preprocessing, an initial synergy map is established based on the agreement and accuracy of the existing cropland maps, and then the initial map is calibrated by using statistics in national and sub-national levels. The accuracy of the map is assessed by samples collected by Geo-wiki. Using this approach, a new global cropland percentage map with 500 m spatial resolution for the base year of 2010 has been developed. The new map is expected to have a higher accuracy compared with the original cropland maps and better consistency with cropland statistics.

A remote sensing multi-scale approach for agricultural systems zoning

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Agricultural systems zoning maps provide valuable spatial information for GLAM and allow effective planning of the best adapted agricultural practices to the agricultural potential of each zone. Our purpose is to present a new remote sensing approach for objective and repeatable agricultural systems zoning at regional scale.

Firstly, a principal component analysis transformation was applied to an annual dataset (2015 period) of MODIS (MODerate Imaging Spectroradiometer) normalized difference vegetation index (NDVI) images. A series of segmentations were performed on the first three principal component images, which contain the essential information on the physiognomy and phenology of the vegetation cover. An unsupervised evaluation method was used for identifying the optimum segmentation which successfully delineates homogeneous zones in terms of agricultural activity at regional scale. Secondly, cropland, crop type, cropping frequency and management levels of grassland maps were produced at a field scale through object-based analysis of a Landsat8 2015 high resolution mosaic image and spectral and textural variables derived from the MODIS NDVI time series, and validated with in situ data. Finally, a bottom-up spatial analysis of the extracted land use information at field scale allowed definitive classification and characterisation of the regional scale zones in terms of agricultural systems.

The main agricultural systems zones of the Brazilian state of Tocantins, an agricultural expansion region, were successfully mapped with the developed approach and evaluated with expert-based collaborative zoning maps of the region. This study shows the potential of remote sensing techniques to provide valuable baseline spatial information for supporting GLAM.

Framing global cropland dynamics during 2000-2010

Wenbin Wu, Qiong Hu, Miao Lu, Di Chen

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Croplands cover 1.53 billion hectares (about 12% of Earth's terrestrial surface), with great implications for global food production, food security and the environment. There has been much research to investigate the spatio-temporal changes of croplands at local scale or in specific small regions, few study was performed at the global level. This presentation aims to introduce the latest research on detecting and monitoring the dynamics of global croplands during 2000-2010. The China's 30 meter resolution land cover dataset (GlobeLand30) was used and multiple indicators including total areas of change, conversion-in/out areas, cultivation index, multiple cropping index and other landscape index at different levels were calculated to depict the quantitative and spatial characteristics of changes in global cropland over the past decade. The preliminary results show that global cropland increases by 7.83 million mu during 2000-2010, which is mainly due to the reclamation of grassland and deforestation. South America and Africa have the largest changing rate in terms of cropland area. Those countries such as India, Argentina, Eastern European, USA and Northern China have relatively high cultivation index, which are the important regions for producing global grains. Moreover, countries near the equator (e.g., Philippines and Nigeria) or surrounded by ocean (e.g., Malaysia and Bahamas) are found to have high multiple cropping index largely due to the abundant heat and water resources. The regions with high cultivation index but low multiple cropping index may have some potential to increase global food production by increasing the cropping intensity. These results may provide some helpful information to better understand the agriculture development and the multi-dimensional interactions of the coupled human and natural systems.

Bias calibration of cropland pattern change categorization using Landsat imagery

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Monitoring the spatial patterns and temporal changes of cropland provides important information for advanced regional agro-ecosystem management. As the development of remote sensing technology applied in agriculture monitoring system, productions of crop maps and cropland pattern change based on image classification has been one of the most important data sources for food policy and economic plan and therefore be more and more cared by administrators and users. Accurate cropland pattern change categorization is needed with considering to overcome restrictions such as crop phenologies, planting conditions, remote sensing data source, and performances of various classifiers. Taking into account spectral characteristics and spatial structure information of crops, this paper discussed a spatio-temporal analysis of cropland pattern change in the Bond county of Illinois over the last five years (between 2010/08 and 2015/08). A bias calibration method for categorization was proposed with quantification and prediction of the biases of category memberships before and after the spectral classification based on the techniques of variogram and kriging algorithms from geostatistics. Landsat ETM+ and Landsat 8 OLI imageries were used for the multi-temporal crop mapping. Two Cropland Data layer(CDL) products from the US Department of Agriculture (USDA) were used to generated the reference layers of land cover and cropland pattern change. Accuracy assessment and error statistics showed the proposed categorization method has an effectively increased accuracy compared with traditional methods. Change analysis described the spatial dynamics of cropland, the exchanges and spatial trend of changes by comparing the gain and loss between crops or cropland.

Integrated perspectives on long-term land-use trajectories

Land use change and its effects on water supply and sediment retention services in Tibetan Plateau for 1900s-2000

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By changing the structure and processes of ecosystems, land use and land cover change (LUCC) affects the provisioning capability of ecosystem services (ES). LUCC in Tibetan Plateau (TP) and its influence on ES are hot topics. Firstly, we estimated the cropland, forestland and grassland area of TP at provincial level for 1900s, 1930s, 1950s, 1980s and 2000. Then the spatially explicit reconstruction models of LUCC were designed based on in-depth analysis of TP land use history. Subsequently, the provincial area datasets were transformed into spatial datasets with 1 km resolution based on the above-mentioned models. Finally, using InVEST model, we assessed the changes of water supply services (WSS) and sediment retention services (SRS) under the influences of LUCC. The results show that the dramatic change tendency for 1950s-1980s was the most obvious characteristic of LUCC in TP over the past one hundred years, which resulted from the intensified human deforestation and over-grazing activities. The cropland expanded obvious in the Yellow River-Huangshui River Valley and the valley of Brahmaputra River and its two tributaries. The spatial extent of forestland shrunked significantly in the southeast of TP and grassland degraded obviously in northwest of TP. Owing to the degradation of forestland and grassland, WSS value decreased for 1900s-1980s and slightly increased for 1980s-2000. In terms of SRS, most regions of TP stay in a low erosion level. Decreasing tendency for 1900s-1980s and slightly increasing tendency for 1980s-2000 were found because of cropland expansion and forestland degradation.

Understanding the long-term resource nexus implications between Swaziland and South Africa

Marc Pienaar, Graham Von Maltitz, Shakespear Mudombi

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Most land with a high productive potential and available water resources are already allocated to existing uses. The changing socio-economic and political landscape in southern Africa has a high dependency on bilateral resources and trade to promote growth and uphold economic and political agreements in the region. It is now clear that land user's engagements in collaboration with expert support from multidisciplinary and multi-sectoral stakeholders are necessary to support profitable yet sustainable agricultural production, energy production, industry, biodiversity as well as rural and urban human needs. This involves hugely complex tradeoffs between food production, export crops, energy production, forestry production, biodiversity conservation, re-creation and generation of tourism revenue, and potentially new biofuels among other uses. The challenge is to find innovative ways to deal with land productivity, while also promoting good governance, economic growth, and development opportunities at the local level. This paper examines the benefits and drawbacks of land use changes in northern Swaziland, including the potential for biofuel production, and what the long term resource nexus implications are for bilateral water and energy resources between Swaziland and South Africa.

Two-decade change in pattern of farming–pastoral ecotone in China

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The farming-pastoral ecotone (FPE) is the mosaic border of the traditional farming and pastoral regions, where is sensitive to climate change and human disturbance. Understanding change in FPE pattern and its mechanism is urgent for both researchers and decision makers to evaluate applied “farmland to grassland” policies and explore its ecological effects. In this study, we investigated the two-decade change of FPE pattern in China and its driving forces using local indicators of spatial association (LISA) approach along with the 1-km land use data at an interval of 5 years during 1990-2010. The results show that the derived ecotones all present a banded distribution along the Hu Huanyong Line to the east of which more than 90 percent of the Chinese population are located during the study period. The FPEs in the northeastern and north central subareas rather than the southern subarea are similar to that defined by annual precipitation, indicating that the ecotone distribution is constrained by precipitation in these two zones. However, the barycenter points of three subareas show remarkable spatial and temporal differences in the last two decades. It is also found that both the upper and lower borders of northeastern and central subareas tend to move up. The combined impacts of climate, human activities, and policies were also investigated to explain the spatiotemporal change in FPE.

Does Natural Resource Dependence Help or Hurt? Evidence from Nepal on Whether Forests Contribute to Poverty Traps

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There is tension in the international development and natural resource policy arenas on whether dependence on natural resources in rural areas increases poverty or reduces it. On the one hand, many poor households receive higher incomes from livelihoods, such as agriculture and livestock production, on lands once dedicated exclusively to natural resources. On the other, there is increasing evidence showing environmental degradation reduces the horizon over which benefits from such activities can be expected. Converting forests into agricultural land, for example, can increase incomes temporarily, but eventually the loss in ecosystem services attributed to forest depletion may reduce benefits and even cause negative returns. This paper centers on this debate by estimating how forest dependence in rural Nepal leads to poverty traps. We find that in some cases forest dependence creates poverty traps or exacerbates existing ones, while in others forest dependent households fare better than those depending on alternative livelihoods. We tease out a causal relationship under various conditions by leveraging a unique 5,000-household panel dataset collected in 23 districts of Nepal between 2012–2015. We first construct a poverty transition matrix of households over time and then estimate a parametric empirical equation representing poverty dynamics through asset differences. We use household fixed effects and include as an important covariate participation in Nepal's Multi-stakeholder Forestry Program (MSFP), a program aimed at helping households diversify income and decrease extractive forest uses. Results from this research can aid policymakers looking to increase environmental sustainability while also reducing rural poverty.

Landscape filtering effects in globalisation processes

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Industrialized agriculture production in the globally integrated world is less determined by transportation costs and local biophysical restrictions than less integrated forms of farming. However, farming remains fixed in space and its spatial organisation is crucial for productivity, the impact on the environment, farmers's conditions and the future of societies. The purpose of this paper is to investigate the local restructuring of farms in a highly economic globally integrated country and how the farmers has responded to the de-regulation and globalization processes which has effected them the last decade. The study is based on satellite image analysis and interviews with farmers to acquire knowledge of their decision-making deliberations over the last 25 years.

This paper propose an approach to analyze satellite images that combine three different strands of research; ontologies of land use in geography, local spatial contextual analysis, and actor sensitive functional time-space analysis of farming. The result show that the local land use regime in the study area has been radically altered over the studied 25-year period and that the farmers adapted space in different ways in different parts of the study area depending on spatial configuration, which has had a significant impact in the identified change trajectories. The spatial configuration is interpreted as both an effect of, and a filter in, landscape transformations. The results shows six characteristic landscape trajectories, three on farm level and three on landscape level, all of which can be related to the global integration of Swedish agriculture.

Land-use legacies from a century ago affect rates of contemporary land change

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Contemporary land-system change is rooted in centuries of socio-ecological interactions, against which contemporary drivers of land change play out. Yet, although historic land use can affect ecosystems long into the future, the effects of land-use legacies for contemporary land change remain poorly understood. Here, we assessed the effect of 19th century land-use legacies for contemporary agricultural abandonment and forest disturbance (harvesting and natural disturbances) for the Carpathian region in Eastern Europe. We mapped agricultural and forest dynamics since 1860s using historic maps and satellite imagery, and modeled contemporary agricultural abandonment and forest disturbance in relation to legacies of land use at three points in time during the Habsburg (1860s), the Interwar (1930s) and the Socialist (1960s) eras. Controlling for agro-ecological, accessibility and socio-political variation, we quantified the persistence and strength of land-use legacies. We found evidence for important path dependency in land systems: Across the Carpathians the odds of forest disturbance were 50% higher in areas that were without forest in the 1860s compared to areas forested then. The odds of agricultural abandonment were 46% higher in areas that were not farmed in the 1860s, compared to farmed areas. We observed strongest legacy effects when comparing different historic political regimes. Our results provide quantitative evidence for land-use legacies and path dependency in land systems, and highlight the need for farsighted land-management decisions because these decisions will affect land change for centuries into the future.

Changing drivers – changing pressures? Two centuries of land-system change in Europe

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European land systems are good cases to investigate the long-term socio-economic drivers of land-use trajectories as, compared to many other world regions, they are used very intensively for agriculture and forestry today and have been used at high intensity for many for centuries. Based on historical narratives, recently seven broad European land-management regimes have been described and allocated to historic time periods from 1800 to 2010. These regimes (e.g., “Era of peasantry”, “Intensification”, “Industrialization”) are characterized by coinciding technological, institutional, and economic drivers of land-use change at the national level. To what extent the delineation of this land-management regimes also holds when looking at biophysical features of land systems has not been investigated in depth. To address this research gap, we combine annual data on land-use change, biomass flows and HANPP (human appropriation of net primary production, an indicator for the pressure land use exerts on land systems) in nine European countries for the past ~150 years with the information on land-management regimes and socio-economic drivers in the individual countries. In order to investigate if biophysical changes in the land systems follow distinct patterns within individual land-management regimes, we formally analyze trajectories of change (e.g., annual change rates in forest area, annual change rates in crop yields). In addition, we investigate the relevance of economic and demographic change in explaining historic land-use trajectories. Our study contributes to discussions on the extent to which national-scale changes in land management influence the socio-economic metabolism and the environment.

A socio-metabolic reading of land-use transition in Spain (1900-2010)

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This work presents a new reconstruction of Spanish land-uses performed at provincial scale (50 provinces in Spain), including a disaggregation by croplands and by forest management categories (high forests, coppice and open forests), for the 20th Century. This allow us to deepen in the forest transition debate analyzing woody area changes including a diversity of forest categories, but also including woody crop areas. Woody crops (mainly olives, vineyards and other fruit orchards) occupying the Mediterranean areas of the country have historically grown in substitution of forests and today represent another key issue in the Spanish land-use evolution: olive area in South-Spain represents the largest tree crop concentration in Europe, while showing a continuous process of intensification (we offer analysis of this change at municipal level for this particular crop).

Secondly, this work aims to put in relation the land-use data obtained with the biophysical evolution of Spanish economy, using Social Metabolism methodologies. Material Flow Accounting methodology has been applied to reconstruct biomass and material flows (extraction, trade and consumption) from 1900 to 2010. Our hypothesis is that the Socio-Ecological Transition to industrial economy helps to explain the major land-use changes in Spain: before industrialization, an increase of cropland and deforestation process; after industrialization, a reforestation process with changes in forest uses (high forest instead of open forest), and a decline of cropland but with a clear territorial specialization. We argue that intensification of agriculture, development of new industrial consumption products and massive imports are the main driving-forces of land-use changes.

Change analysis of spatio-temporal distribution of high-,medium-and low-production rice land in Northeast China during 1990-2010

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According to the lack of research in dynamic change of rice area, this study aimed to detect the spatio-temporal changes of different productivity level of rice land at a high spatial resolution. Here we investigate the dynamic changes of high-, medium- and low-production field recognized by its rice land productivity (5' resolution) generated from the SPAM (Spatial Production Allocation Model) and GlobeLand30 cropland distribution data (30-m resolution) during 1990-2010 in Northeast China. The results show that most of the high-production field were in middle of Liaoning province and eastern of Jilin province, and low-production field was mainly located in Heilongjiang province. The ratios of low-production field were 89% and 60.5% with the highest proportion at 1990 and 2000 in Northeast China, with a decline by 28.5%. The high-production, medium-production rice land have increased by 7.8% and 20.7% during the past 20 years, respectively. This study suggest that the average productivity of rice land has increased in Northeast China, especially for the medium-production rice land. However, the low-production rice land is still occupying a high proportion. It needs to be further studied how to improve the productivity of low-production rice land and whether the improvement is necessary for some low-production rice land in the condition of limited water resource.

150 years of agricultural land use and soil nitrogen fluxes in the United States Great Plains

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This paper will estimate total soil nitrogen (N) fluxes for the entire U.S. Great Plains between 1860 and 2010. Relying on agricultural census data for some 1000 counties in 12 U.S. states, this analysis traces N inputs, outputs, and balances for each location across a century and a half as the region rose from an agricultural frontier to become the nation's breadbasket and a major food exporter to the world. The chronology begins with large soil N losses from 1860-1950 as settlers opened new land for agriculture and extracted more soil nutrients each year than they returned. Between 1950 and 1970 crop nutrient management was in transition, as synthetic fertilizer applications replaced older manure and legume management strategies. By the late twentieth century farmers applied excessive N fertilizer, causing soil, water, and air pollution between 1970 and 2010. The paper will quantify total N outputs to the environment for an area equal to 20 percent of the continental U.S. over 150 years.

Towards an understanding Forest Transition of China: a historical and systematic perspective

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The forest cover in China had been steadily declined over the more than 4000 years of civilization history, mainly due to the expansion of agriculture, until around 1980s when forest cover hit the lowest point and began to increase. This land use trajectory from net deforestation to net reforestation is dubbed as forest transition (FT). The FT pathways framework has been widely employed to understand the forest transition based on the main causes. This framework however is often misused in a way that the complex forest transition is over-simplified; additionally, the qualitative nature of this framework is deficient in exemplify the dynamic process and the complex interactions among political, socioeconomic and biophysical factors. To bridge the gap, we collected over 300 years of historical data on political events, population, forest cover area, agricultural land area, technical factors, and climate data in China to put the forest transition in a historical context; we further use system thinking and simulation approaches to model the nonlinear interactions and feedbacks among various factors shaping the land-use dynamics. A conceptual causal loop diagram has been constructed to visually depict the forest transition process in China. We then built and calibrated the system dynamics model of for China based on statistical data and empirical knowledge. The modeling results provide a comprehensive and systematic explanation of the forest transition in China. Additionally, the model allows for the exploration of “what-if” scenarios of various economic development and government policies.

Understanding long-term land use trajectories by combining low resolution satellite trends and spatial modeling

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Satellite images acquired frequently and covering large areas are essential for detecting landscape changes. However, these images generally have coarse spatial resolutions. Extracting useful information from the images is complicated since each pixel regroups various signals of different nature and scale. This issue is particularly important in West African regions, where agricultural landscapes are fragmented and usually composed of small plots.

We hereby present a method based on multi-scalar modelling of past landscape dynamics that improves the extraction of information from coarse resolution satellite images. The study area is the Tuy Province in West Burkina Faso, where the main crop system is based on a cotton-cereal rotation. The cropping systems dynamics was modelled with the Ocelet Modelling Platform. The multi-scalar model simulates crop production and land use and land cover changes over the last fifteen years. The model was validated at local scale with information derived from high resolution Landsat images.

Model spatial outputs (i.e. cropland change maps, daily crop development status) were then used to decompose the spatio-temporal signal of coarse resolution images time series. This allowed the identification of factors responsible for different spectral and temporal responses at different scales. Important changes were found to be due to population migratory movements, increase in farm size, variation in crop prices and climatic events. This approach opens new opportunities for the understanding and monitoring of landscape changes using time series of coarse resolution satellite images.

Land system change in an Austrian valley since 1861: Studying carbon dynamics and its implications for the climate system

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European landscapes have changed tremendously over the past centuries, not only in terms of their aesthetic appearance, but also in terms of being a source or sink of atmospheric carbon. We investigate land system change in the Stubai-valley, an alpine valley in the Austrian central Alps from 1861 to 2009, in order to highlight the relation between socio-economic shifts and carbon dynamics. Drastic agricultural abandonment followed by forest expansion was responsible for a growth of biomass carbon stocks by a factor 7 over the study-period. Yet, secondary forest succession did not fully compensate for net primary production (NPP) and carbon stock losses that have occurred along with agricultural conversion before our study-period. This is particularly visible in terms of a persisting gap between actual and pre-agricultural NPP that still amounted up to ca. 50% of natural NPP in 2009. Our results indicate a time-lag between the period in which land use changes occurred and the time at which such changes play out in a new climax vegetation. Land use change has been a slow and ongoing process since 1861, accompanied by a polarization of areas into low and high land-use intensity. Our findings are crucial for the understanding of carbon dynamics in and beyond the Stubai-valley, i.e. at the regional to the global scale. This is particularly true considering that mountainous regions are regarded key areas for terrestrial carbon sequestration in the coming decades. This work is part of the ClimLUC-project, funded by the Austrian Academy of Science (ÖAW)

Land management plan by Land degradation classification in Mid-Latitude

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The Mid-Latitude zone can be broadly defined as part of the hemisphere between 30° - 60° latitude. In terms of demographics and level of economic development, approximately 50% of population live in this region where there appears land use problems in relation to economic development and poverty solution.

Along with climate change, ongoing land degradation and deforestation has been observed in many regions of the Mid-Latitude ecotone. Land degradation seems to be concentrated in specific locations, such as in Central Asian region, whose land has been susceptible to continuous degradation with the disturbance of additional human activities and extreme weather condition. In this context – we conducted trend analysis of land degradation focusing on Mid-Latitude region, with the aim to use its findings in the process of setting out environmental planning. The area, where land degradation seems prevalent, could be detected with the use of remote sensing techniques. The Mid-Latitude ecotone could be classified into following categories; green zone, buffering zone, degradation zone, and others. Classifying Mid-Latitude into 3 zones, as mentioned above, enables us to have better understanding on the adaptation action plan which is expected to prevent further degradation from the region. We can set different plans by different land class such as restoration plan for land degradation zone, and sustainable land use plan in green zone, and residential plan based on environmental resilience principle in buffering zone.

Introducing this study is expected to invite a number of stakeholders in scientific dialogue which will facilitate the spread of the latest concept, methodology and trend in land restoration approach, all in all is put to actualize sustainable development of environment and society.

The impacts of strategic spatial planning on land change in European urban regions

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Strategic spatial planning, territorial governance and land system change have been widely explored in the literature. However, little attention has been paid to the conceptual and practical linkage between these three areas of inquiry. The main purpose of this study is to contribute to fill this gap. More specifically, it aims to scrutinise - how do strategic spatial plans affect land change in urban regions. The hypothesis of departure is that - governance arrangements, such as “coordination of policies”, “cooperation between regional actors” and “vision-building” - influence strategic spatial plans - from the designing phase to its practical implementation. The governance settings that take shape during strategic planning, will generate an impact on land use, for example, over new housing developments, the edification of an industrial site or the development of infrastructures. To describe these governance arrangements, a set of components, such as “coordination”, “agenda-framing”, “accountability” and “legitimacy” has been elaborated. These components will be operationalised through a set of indicators, such as “goal-alignment”, “strategic-cooperation”, “representability of interests” and “freedom of association”. The working hypothesis will be tested by taking 10 urban regions in western Europe as case studies. The primary data sources will be a documentary analysis of strategic plans and semi-structured interviews with regional actors and organisations. We are expecting to contribute to clarify, for example, how having a clear “leadership” at the regional level is reflected in strategic spatial plans and it impacts land change. These insights are crucial for effective land use modelling and scenario analysis.

Historical Drivers and Impacts of Land-Use Change Trajectories along a Pioneer Front in North-Western Cambodia

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The peace negotiation for political and territorial reintegration of the Khmer Rouge that legitimated autonomous administration in their stronghold areas in 1998 was landmark of dramatic landscape and agrarian changes. Focused on four upland districts along a pioneer front of north-western Cambodia, this presentation aims at analysing historical trajectories of land use/cover changes using a chronological series of Landsat data (from 1979 to 2016) and identifying key drivers for these changes using demographic data and qualitative information from local actors and other relevant stakeholders. Peace restoration, land saturation in lowland areas and consecutive massive migration towards upland areas, and booming regional market demand for cereals emerge as key drivers of land use/cover changes. Massive forested land has been converted to farmland thanks to the high profitability of hybrid maize in the early 2000s. The surface area covered by annual upland crops (maize and cassava) has expanded dramatically in just a decade, and farming systems have been in rapid transition from subsistence (upland rice) to market-oriented and intensive annual crops (soybean, maize and cassava) and tree crops (longan and mango). This general trajectory has however been uneven in space and time due to two simultaneous land colonization processes: one driven by former Khmer Rouge families expanding eastward from their strongholds at the Cambodian-Thai border towards accessible and fertile forested uplands and another one by migrants from neighboring and densely populated lowlands.

Urban green space, trend and driving forces in world cities

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Green spaces support the sustainability of cities (Rydin, 2010; Hall, 2006; Chiesura, 2004). United Nations stated that, all city-regions should achieve a tree canopy of at least 25% of land area, and meet WHO's suggested minimum of 9 m² open space per resident by 2030 in its indicators on sustainable development goals (SDGs). However, statistics show declining urban green spaces worldwide with African situation been critical (Chen, 2014; McDonald et al., 2010; Fuller & Gaston, 2009). Rapid urbanization has changed green space into build up areas in order to hold the increasing population in a lot of cities in developing countries. Moreover, with its multi-function of urban green spaces, government from local to national become take it more seriously. Green space displays different pattern and process in different countries. It covers nearly 40% of land area in Shanghai, however, less than 10% coverage in many African cities (Adjei Mensah, 2014, MaConnachie et al., 2008). We propose that the pathway of urban green space is in a Kuznets curve which are correspondent to the stages of urban development and use data from ten cities all over the world to explore the process of urban green space change.

Long-term medieval and early modern dynamics of land cover and land-use in the Pilis area (Hungary)

Jozsef Laszlovszky

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Long-term medieval and early modern dynamics of land cover and land-use in the Pilis area (Hungary)

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The main goal of this paper is to discuss the most important human and nature interaction elements of the historical landscape of the Pilis area. This hilly forest area is a historical landscape in the central part of Hungary and its present land-cover and land-use system is controlled by the local National Park and Biosphere Reserve. The area has been investigated by systematic archaeological-topographical survey methods and some of the most important medieval sites has also produced relevant data for environmental archaeological analysis. The combination of medieval written sources (mainly charter evidence) with a detailed study of landscape archaeological features offers a unique opportunity for an interdisciplinary, long-duree research on the historical land cover and land-use pattern. Some archaeological sites of the area also contribute to our understanding of the scale of industrial production (iron and glass) in the pre-industrial (medieval) period. These activities were directly connected to the dynamic changes of forest cover and to the exploitation of natural resources. The emergence of major urban centers around the Pilis area can also be studied from the point of view of drivers in land cover changes. At the same time changes in the land-use system can also be seen as indicators for the changing character of medieval royal power. The reconstructed mosaic character of the land-cover pattern of the medieval period offers a relevant starting point for the protection of the present historical landscape and for a more environmental friendly land-use system in the future.

Interactions between food security and land use in the context of global change: the Belmont Forum perspective (I)

A Comparative Analysis of the Trade Balance between China and Brazil based on Resource Flow Perspective - Case Study of Soybean Flow

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Global change and globalization have accelerated the natural resource flow all over the world in recent years. However, the ecological elements flow hidden behind the agricultural products trade has been the study hotspot in recent years as the aggravation of global warming and the resource scarcity globally. For China, the agricultural products trade has been an important strategy to remit its water and land scarcity. On the other hand, the increasing import of China's agricultural products, especially the huge amount of soybean import, has been the focus of global academic circles, and also has been the important issues of China's food security. Compared with lower growth of soybean production in China, Brazil soybean production increased rapidly and it makes Brazil become the world largest exporter of soybean. However, most studies focused on the soybean, integrated effect of soy products has not yet been studied. Therefore, the purpose of this paper is to compare the differences of import and export of all soybean products between China and Brazil, quantify the relationship between China soybean import and Brazil soybean export; analyze the change reason of soybean production during the past two decades in China and its ecological and socio-economic impacts based on the resource flow theory, and support the scientific basis for the policy makers to make the sustainable trade strategy and resource and environmental diplomacy. The method such as material flow analysis, the multi-attribute theory, statistical analysis and GIS spatial analysis will be used in this study. The impact of the soybean trade flow and its impact from the global, country and region scale will be discussed, respectively.

Food Security Impacts of Industrial Crop Expansion in Sub-Saharan Africa: insights from project FICESSA

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There is a recent trend to allocate large tracts of land in Sub-Saharan Africa for the production of industrial crops such as sugarcane, jatropha, oil palm and cotton used for non-food purposes including bioenergy and fibre.

These land conversions are often financed through direct foreign investments (FDIs) and are justified as an engine of economic growth and rural development. Yet they are often undertaken in countries of Sub-Saharan Africa that are barely food secure.

This presentation will highlight some of the early findings of the Belmont Forum-funded project FICESSA. In particular it will discuss the radically different:

- (a) land use change mechanisms experienced in areas of industrial crop expansion across Africa
- (b) effects on the food security of those involved in industrial crop value chains (e.g. smallholders, outgrowers, plantation workers) and control groups not involved (e.g. adjacent communities).

The presentation will draw from extensive fieldwork in operational industrial crop projects across Africa, including Ghana (jatropha, oil palm), Guinea (oil palm, rubber), Malawi (jatropha, sugarcane, tobacco), Mozambique (jatropha) and Swaziland (sugarcane, cotton).

Acknowledging the important differences between crops, modes of production and local socioeconomic and environmental circumstances, some common impact mechanisms will be identified as a first step towards proposing recommendations that can improve the food security outcomes of industrial crop expansion in Africa.

Food acquisition vs. production in Brazil: an analysis of food security scenarios restricted by land availability regarding environmental regulations

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This work is part of Postdoc project coupled to DEVIL (Delivering Food Security on Limited Land) project focused on the challenge of delivering food security on limited area. Also it includes part of the results of the first PhD project developed at CCST/INPE focused on food security. The World Health Organization (WHO) recommends a daily consumption of 400 g of vegetables, an amount consumed in 2008 by only 18% of the Brazilian population. In this work we present an analysis of food acquisition (including vegetables) vs. demand scenarios in Brazil, built-up upon census data of food acquisition retrieved by longitudinal surveys, agricultural production and population growth estimates. Preliminary scenario analysis for 2030 indicate that vegetables consumption is still far from WHO recommendations, as agricultural census indicate enough production of vegetables, but not equally available regionally. Results indicate a large inequality between acquisition and production within Southern-Southeastern and North-Northeastern parts of Brazil, which can be linked to socioeconomic issues constraining access to more nutritious food, industrial incorporation of food *in natura* into processed food, cultural issues and also logistic set-backs. Further scenarios of food consumption rather than vegetables are under development. When analyzing food production restricted by environmental regulations (Forestry Code), preliminary results indicate sufficient land availability without the need of land cover change over original vegetation or protected areas, even if production of vegetables is increased. However, following population demands for 2060, public policies that tackle cultural issues and food availability regarding distribution and economic access are still needed to meet food security.

Greenhouse gas mitigation potentials in the livestock sector

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The livestock sector is the largest anthropogenic land user. It supports about 1.3 billion producers and retailers, and contributes to 40-50% of agricultural GDP. We estimated that between 1995 and 2005, the livestock sector was responsible for greenhouse gas emissions ranging between 5.6-7.5 GtCO₂eq/yr. If current projections of increases in consumption of animal source foods are correct, these emissions could potentially double in the future. The technical mitigation potential of livestock systems ranges between 0.1-7.8 GtCO₂eq/yr, which is up to 50% of the mitigation potential of the agriculture, forestry and land use sectors. Technical options that sustainably intensify livestock production, that promote carbon sequestration in rangelands, or that reduce emissions from manures account for 2.4 GtCO₂eq, while modelled scenarios of reduced livestock product consumption provide a range up to 7.8 GtCO₂eq. The economic mitigation potential of these options is low due to numerous trade-offs and constraints to their adoption. More research and investment are needed to increase adoption rates of technical mitigation practices, and for establishing the levels of consumption of animal source foods that are sustainable, and that do not have negative impacts on livelihoods, economic activities and our ecosystems.

Land allocation with coordination of urban expansion, cultivated land protection and ecology conservation

Weiwei Zheng, et al.

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China is in the stage of rapid urbanization, in which Urban expansion, Cultivated land protection and Ecological conservation are the principal contradiction of land-use in this stage. In view of this contradiction, taking Wuhan city as an example, this paper bases on partitioned & asynchronous CA, carries out the layout optimization of land use, attempting to achieve balanced development of Urban expansion, Cultivated land protection and Ecological conservation. The results suggest that (1) asynchronous evolution speed is determined through the rate of ecological service value per unite area of each land types and carrying out optimal allocation of regional land resources relies on partitioned & asynchronous CA, which will, under the premise of meeting the needs of urban expansion and food security, reduce the damage of the value of ecological services as a result of urban expansion as far as possible; (2) Under the dual constraints of the scale of urban expansion and food security, the occupation of the value of regional ecosystem services by the optimization of urban land expansion accounts for only 47% of the loss of the actual ecosystem services value. The optimization model which proposed in this text can significantly improve the coordination of Urban expansion, Cultivated land protection and Ecological conservation; (3) "share pie expansion mold" is the main cause which results the excessive loss of ecological service value of land system in the process of urban expansion.

Assessing the climate impacts of Chinese dietary choices using a telecoupled global food trade and local land use framework

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Global emissions trajectories developed to meet the 2°C temperature target are likely to rely on the widespread deployment of negative emissions technologies and/or the implementation of substantial terrestrial carbon sinks. Such technologies include afforestation, carbon capture and storage (CCS) and bioenergy with carbon capture and storage (BECCS), but mitigation options for agriculture appear limited. For example, using the Global Calculator tool (<http://www.globalcalculator.org/>), under a 2°C pathway, the ‘forests and other land use’ sector is projected to become a major carbon sink, reaching -15 GtCO₂e yr⁻¹ by 2050, compared to fossil emissions of 21 GtCO₂e yr⁻¹. At the same time, rates of agricultural emissions remain static at about 6 GtCO₂e yr⁻¹, despite increasing demands for crop and livestock production to meet the forecast dietary demands of the growing and increasingly wealthy global population. Emissions in the Global Calculator are sensitive to the assumed global diet, and particularly to the level and type of meat consumption, which in turn drive global land use patterns and agricultural emissions. Here we assess the potential to use a modified down-scaled Global Calculator methodology embedded within the telecoupled global food trade framework, to estimate the agricultural emissions and terrestrial carbon stock impacts in China and Brazil, arising from a plausible range of dietary choices in China. These dietary choices are linked via telecoupling mechanisms to Brazilian crop production (e.g. Brazilian soy for Chinese animal feed provision) and drive land and global market dynamics. ‘Spill-over’ impacts will also be assessed using the EU and Malawi as case studies.

Conservation agriculture practices as climate smart technology for sustainable food security in Keonjhar, India: A transdisciplinary approach

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In regions of India, like Odisha, low agricultural productivity and high poverty rates leave millions, especially tribal societies in rural areas, undernourished. The situation is further exacerbated on rainfed regions. Conservation agriculture (CA) strategies and practices (reduced tillage, year-round cover crop and optimum rotation) have been developed and promoted to reduce climate change risk, improve soil quality and low yields around the world. In order to enhance and promote CA adoption in Odisha, a transdisciplinary approach was undertaken to engage stakeholders to co-design, co-produce and co-disseminate locally appropriate CA practices for ownership, legitimacy and collaboration of the project. The goal of this project was to identify entry points for improvement of farmers' economic livelihoods through CA. The objectives were to: 1. Evaluate the effect of CA practices on system productivity and profitability; 2. Evaluate the effect of CA practices on regulatory ecosystem services (soil quality); 3. Compare farmer preferences for CA practices; and 4. Provide recommendations for stakeholders regarding CA practices suitability. There were four treatments identified: full tillage with maize and no mustard residue cover after mustard (farmer's practice); full tillage intercropping maize with cowpea with mustard residue cover; reduced tillage with maize only with mustard residue cover; and reduced tillage intercropping maize with cowpea with mustard residue cover. Results showed that CA practices improves the economic livelihoods of farmers by reduced tillage, intercropping with cowpea and practising cover crop year round. The farmers testified to the media that CA has ameliorated the adverse impact from the recent drought.

The impact of urbanisation on food demand in Africa: Findings from a meta-analysis

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Food insecurity in Africa remains high and forecast to increase, particularly in Sub Saharan Africa, as a result of growing population levels (FAO IFAD and WFP, 2015). One factor which influences the pattern of food demand and therefore land use (at local and global level) is the process of urbanisation.

Urbanisation influences the demand for food in three ways. First urban households typically have more diverse diets than rural households who depend more on own produce and staple foods. Second, the opportunity cost of time for women in urban locations is typically higher than in rural areas leading to greater dependence on foods cooked outside the home. Third, urban lifestyles are typically more sedentary than rural lifestyles leading to different calorie requirements.

Drawing on a meta analysis of 1,768 food-income elasticities, 324 nutrient-income elasticities, and 103 calorie-income elasticities extracted from 66 studies and covering 48 countries, the paper explores evidence of the impact of urbanisation rates on the demand for food across Africa. Country-level urbanisation data were taken from the World Development Indicators dataset (World Bank, 2015).

As expected the results suggest that countries with higher urbanisation rates have a smaller overall demand for calorie-rich foods and nutrients as they grow. Other geographical variables are also found to influence the demand for food, suggesting that the predicted convergence of food consumption patterns remains some way off. In the context of increasing rates of urbanisation, the paper considers the implications of the findings for both local and global land use systems.

Sugarcane impacts on the water budget and scarcity in the Krishna River Basin, southern India

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Sugarcane has expanded rapidly across south Asia, but its role in the water budget and water scarcity at the river basin scale has not been quantified. The Krishna River basin has experienced rapid sugarcane expansion, streamflow depletion, and downstream water scarcity. Here we report a water balance for the Krishna River basin, southern India, in both normal and drought years, and separate the contribution of sugarcane to the water balance. The impact of sugarcane on streamflow is quantified with a simple annual water budget in both normal and drought years, to determine the sensitivity of sugarcane production to drought, and its impact on downstream users during drought. The water productivity of sugarcane is also calculated and compared with other crops. We find that 1) sugarcane cultivation is resistant to drought due to its location in the headwaters, upstream of other users 2) downstream rice-gram double cropped areas are highly sensitive to drought, and that during drought years basin-wide ET is reallocated to upstream sugarcane irrigated regions.

A sweet deal? Sugarcane, water and agricultural transformation in Sub-Saharan Africa

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Globally, the area of sugarcane is rising rapidly in response to growing demands for bioethanol and increased sugar demand for human consumption. Despite considerable diversity in production systems and contexts, sugarcane is a particularly “high impact” crop with significant positive and negative environmental and socio-economic impacts. Our analysis is focused on Sub-Saharan Africa (SSA), which is a critical region for continued expansion, due to its high production potential, low cost of production and proximity, and access, to European markets. Drawing on a systematic review of scientific evidence, combined with information from key informants, stakeholders and a research-industry workshop, we critically assess the impacts of sugarcane development on water, soil and air quality, employment, food security and human health. Our analysis shows that sugarcane production is, in general, neither explicitly good nor bad, sustainable nor unsustainable. The impacts of expansion of sugarcane production on the environment and society depend on the local context, quality of scheme, nature of the production system and farm management. Despite threats from climate change and forthcoming changes in the trade relationship with the European Union, agricultural development policies are driving national and international interest and investment in sugarcane in SSA, with expansion likely to play an important role in sustainable development in the region. Our findings will help guide researchers and policy makers with new insights in understanding the situated environmental and social impacts associated with alternative sugar economy models, production technologies and qualities of management.

Modelling feedbacks across scales and levels in telecoupled global food trade and local land use

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The links between global food systems and local land use span many spatial scales and organizational levels. Viewed through the lens of the telecoupling framework, local interactions between people and their environment can have consequences far away due to global trade and other flows. Previous approaches to modelling food systems and land use have generally been either top-down (e.g. partial-equilibrium models such as IMPACT) or bottom-up (e.g. agent-based frameworks such as CRAFTY). Linking existing models taking these differing approaches is challenging given disparities in levels of aggregation and epistemology. The gaps between global and local will likely need to be filled by representation of intermediate organizations, decisions and flows.

Here we discuss the identification of appropriate levels of aggregation and possible impacts of alternative representations of different components of food and land use systems. To bridge gaps between top-down vs bottom-up modelling approaches, it is important to consider intermediate activities between global and local levels of agents such as traders, institutions and companies managing agricultural inputs (e.g. fertilizers, seeds) and products (e.g. storage, distribution). These activities influence local farmer decision-making, national policy, and global markets. Examining how such intermediate activities can be represented to bridge or align existing modelling approaches should enable more robust modelling of feedbacks across levels between global food flows and local land use. It will also help identify causes and effects of telecouplings that shape food security and environmental sustainability across local to global scales.

Room to grow: is global crop production keeping up with potential?

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Feeding the world without destroying the environment is the biggest challenge of our time, and the extent to which crop production can be increased will determine if we can feed a growing population without land use change. Yield gaps, defined as the difference between current yields and realistically attainable yields, have been identified as a useful framework for analyzing the global agricultural system and identifying areas and methods for targeting interventions. However, published yield gap studies have been static, regional, or very coarse. Here, we assess yield gaps at a global scale for several major crops over the time period 1965 to 2008 and determine temporal and regional patterns in yield gaps. We find that yield gaps are remarkably consistent at the global scale, but that there is substantial regional variation; current yields and attainable yields are both growing at a commensurate rate, but not in the same regions, and with different profiles for different crops. Yield gaps are generally increasing in less developed countries. The absolute increase in yield gaps suggests that global crop production can continue to increase for the foreseeable future.

Land use implications of pathways to future nutrition security – a comparison across scenarios

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A range of potential pathways toward future nutrition security have been suggested, involving options such as sustainable intensification, yield gap closure, dietary change and waste reduction among others. As well as diversity among potential pathways to nutrition security, there are differences among the models used to explore these future pathways. Models used to explore such futures include multi-sector integrated assessment models, land surface models, food system models, economic models, and combinations of all of the above. Also differing between the models are the assumptions made about future technology roll-out, yield improvements and land availability. The models also differ in their spatial resolution with some operating at the level of large global regions, while others operate on fine spatial grids. In this paper we present a preliminary analysis of changes in agricultural land area and land use to 2050 from a community inter-model comparison exercise using a wide variety of different models, scenarios and assumptions. We group the scenarios into pathway families and explore the differences between and within these families. We discuss the outcomes in terms of future research needs, and the implications for future food system transition pathways.

Using a causal loop diagrams as a mechanism for understanding the linkages between land transformation to biofuels and food security

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Using a causal loop diagrams as a mechanism for understanding the linkages between land transformation to biofuels and food security

Graham Von Maltitz

CSIR South Africa

Africa has been targeted for industrial crop expansion, for both biofuel and other cash crops. This is in response to the perceived land availability. However, much of the targeted land is currently used for small-scale, low input food production. The prevailing paradigm is that large-scale production of industrial crops will negatively affect local and national food security. This is not a necessary outcome as there may be a number of mechanisms where alternative outcomes may be possible.

Linked to the Belmont Forum funded project FICESSA, we used a method based on mediated modelling and the use of causal loop diagrams to capture insights from both the diverse project team members as well as from select representative of the stakeholder community. The approach captured the diverse ways in which industrial crops may impact (positively and negatively) on food security and the likely feedback loops. This information was used to develop the research protocols for the project. A number of different production models were considered ranging from large industrial plantations to cash crop production on smallholdings.

The process proved to be a powerful mechanism for ensuring that there was a commonality of underlying assumption between team members. It also proved to be a powerful mechanism of sharing the research ideas with stakeholders and ensuring that stakeholder concerns were being captured in the research design. The approach will be further refined and tested with local stakeholders and case study data in two case studies.

Attributing tropical deforestation to specific commodities

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Agricultural expansion is the biggest driver of tropical deforestation, resulting in impacts on biodiversity, carbon storage, and many other ecosystem services. Policies and market-incentives have decreased deforestation in some regions, but this progress has been offset by increased forest loss in other regions. As companies and NGOs work to create sustainable supply chains, it is critical to understand how to attribute deforestation in a particular area to a set of commodities. Traceability back to specific farms may not be realistic for many major commodities. However, a simple bookkeeping model can be used to assess connections between specific commodities and deforestation at the scale of administrative units. Identification of changes in extent of forests, agriculture, and production of specific commodities can provide insights to fill this information gap.

Using global level agent-based modelling approaches to evaluate future food security and land use requirements within a changing environment

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The challenge of feeding ten billion people by 2050 is exacerbated by the need to reduce the impact of food production on GHG emissions, to adapt to the environmental change that will occur, to move to healthier diets, and to reduce the adverse impacts of food production on biodiversity and the provision of ecosystem services. The DEVIL (Delivering Food Security on Limited Land) project aims to examine some of this complexity by developing food system and land use models to use with spatial datasets.

Agent-based modelling is an approach that has been receiving attention by the land-use modelling community as it offers a way of incorporating the influence of heterogeneous decision-making entities into natural resource systems models in a mechanistic and spatially explicit way, taking into account social interaction, adaptation, and multiple scales of decision-making. In this paper, we present a global level agent-based model being developed within the DEVIL project to explore some of the feedback loop interactions between land use change and food security dynamics. Each agent represents a country with the goal of meeting nutritionally balanced dietary demands by its population for food commodities, based on the FAO food balance sheets. Different strategies are employed to achieve this goal by manipulating the control variables of land use allocation, commodity type, production, import, export, amounts used for feed, seed, food, waste, and other uses. Strategies are evaluated for their robustness in achieving domestic food security. Initial results will be presented.

Global Food Security and Land Use in the Telecoupled Anthropocene

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In the Anthropocene, global demand for food increases while human impacts on the environment (the foundation for long-term food production) grow. This challenge is further complicated by powerful “telecoupling” (socioeconomic and environmental interactions over long distances such as through international food trade). Food needs were historically satisfied by local producers but are now more and more met through global trade. As a result, land use is increasingly shaped by distant forces, such as demand for food from places far away. There has been significant progress in understanding food security and land use dynamics through location-specific empirical case studies and modeling. However, much remains poorly understood, particularly about telecouplings, for example, the impacts of global food trade on land use in distant places among and beyond trade partners. To address these important knowledge gaps, we apply the integrated framework of telecoupling to conceptualize global food security and land-use dynamics. We consider food security and land use to be inherently connected through flows (e.g., food, capital) across multiple spatial, temporal, and organizational scales. The flows are made possible through interactions among various agents (e.g., producers, traders, consumers, and policy makers). These interactions arise from a variety of economic, political, social, climatic, and ecological causes. Telecouplings also result in profound effects on human well-being, ecosystem services, biodiversity, and many other aspects of the environment around the world. Operationalizing this framework can provide essential quantitative information for developing more effective policy on food security and environmental sustainability in the telecoupled Anthropocene.

Food System Governance, Food Security and Land Use in Southern Africa (SAFGOV)

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The role of private companies and other non-state actors is of growing importance in food security and land use issues in southern Africa. These include major ‘up-stream’ actors in the food system, including those engaged in food processing, marketing, intraregional trading, and the food aid sectors and environmental NGOs. In essence, the governance arrangements among these actors determine how these interactions play out, but the situation is complex and these arrangements are poorly understood; a new research initiative is needed to determine current governance arrangements and how these could be enhanced to help deliver better food security and land use outcomes.

To this end the Belmont Forum 1-year ‘Community Building’ project SAFGOV drew on research skills from SA, NL, UK and US to build an international community of researchers closely linked to a range of stakeholders across South Africa’s public and private organisations to identify research needs. The maize case study showed that while the role of private companies in food security is fundamental, and demand from large-scale purchasers drives production, there is a lack of harmonization between various governmental policies across levels and ministries, and between state and non-state actors in South Africa’s food security policy. Further, the South African government’s new food security strategy does not allow sufficient interaction with some key stakeholders from the private domain or other policy sectors concerned with wider land use issues.

The paper will summarise the SAFGOV’s objectives, process, participants and resulting plans for follow-up research in southern Africa.

African Food, Agriculture, Land and Natural Resource Dynamics in the Context of Global Change

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Recent changes in the global agro–food–energy system have led to renewed interest in investment in agriculture and a rush to acquire land among international and domestic investors. The broader socio-economic and ecological impacts of these land use changes are not always clear and many assessments focus mainly on short-term effects at the local level, without relating them to the wider agrarian and socio-economic transformations that are now underway. Against this backdrop, the objective of the Belmont Forum-supported AFGROLAND project is to analyze how large-scale investments in land and agriculture impact on natural resources (soil, water, vegetation), food security, governance and rural economies in African countries. The project adopts an interdisciplinary approach (including geography, political science, agronomy, economics) and uses qualitative and quantitative methods to conduct within- and cross-country analyses of these dynamics in Kenya, Madagascar and Mozambique. This presentation is based on the first round of fieldwork. The results indicate that large-scale land investments yield varying ecological, social and economic outcomes both within and across the study areas. Within study areas, important sustainability trade-offs (e.g. water scarcity vs. income) and synergies are identified. Comparative analyses across study areas indicate that more sustainable outcomes seem to be attributable to historical land uses, to the land property rights regime, and to the adopted business models. These results contribute to a better understanding of the multi-scale impacts of global agro-food-energy system changes, and they indicate leverage points for managing sustainability trade-offs and synergies in the global land rush.

Environmental consequences of the Brazil-China soy trade

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In the beginning of the 60's the area planted with soybean in Brazil was only 0.24 million ha, fifty years later this area increased to approximately 24 million ha, an impressive 100 fold increase. On the contrary, during the same time period, the area planted in soybean in China decreased from approximately 10 to 7 million ha. In order to supply the growing demand for animal feed, China increased its soybeans imports from Brazil. China alone consumes approximately 30% of the Brazilian soy production. Therefore, by the lens of telecoupling China transferred the environmental externalities of soybean production to Brazil. The main objective of this paper is to discuss the environmental consequences of the expansion of soybean in Brazil, and the environmental benefits that China has gained by importing soybean from Brazil. Through census-based and land use/cover data analysis, the study will conduct an investigation in municipal and region levels in the major Brazilian soy producer regions between 1990 and 2015. The variables forest cover, GDP, use of fertilizers and pesticides, productivity, crop area, soy exportation, incentives (e.g., farm credit) and land use changes will be assessed. In China the telecoupling research will focus on the regions that suffered major decreases in soy production at the same period and economic and environmental variables will be assessed. In our previous results, the expansion of soy in Brazil, mostly traded in China revealed intrinsic connection with forest dynamics in both countries.

Food Systems and Natural Resources: A Major Assessment Report by UNEP's International Resource Panel

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A comprehensive scientific assessment of the current status and dynamics of natural resource use in food systems and their environmental impacts has just been published by UNEP's International Resource Panel.

The Report looks at food as a crucial connection point (a 'node') where various societal issues coincide, such as human dependence on natural resources, the environment, health and wellbeing. It covers all the resources needed for the primary production of food, as well as for other food system activities (e.g. processing, distribution). It notes that food system activities have already led to 33% of soils being degraded, 20% of fresh water aquifers being overexploited, a 60% loss of biodiversity, while over 80% of the minerals used in primary production are lost from farm to fork. Food system activities overall contribute about a quarter of total GHG emissions. It notes the importance of both sustainable and efficient use of land as part of more favorable resource efficiency, i.e. also water, biodiversity, minerals, etc.

The Report considers not only the set of food system activities, but also the range of actors engaged in them and the outcomes of their activities in terms of food security, livelihoods and human health. It identifies opportunities for 'Resource Smart Food Systems' responding to policy- and business-relevant questions, noting that a more efficient use of natural resources is essential to reduce the total environmental impact of the food system. This is especially so given the projected increase in food demand over coming decades, driven by the combination of increases in population, wealth and urbanisation. If unchecked, dietary trends by 2050 will be a major contributor to an estimated 80% increase in greenhouse gas emissions from food production and associated global land clearing alone. The Report therefore also highlights the need for changes not only in food production, but also for consumption (e.g., lower food losses and waste, lower meat consumption) as a further means to reduce pressure on natural resources; and the fact that there are powerful actors downstream in the food chain, such as retailers and food companies, able to help implement such changes.

The Full Report, a Summary, a Fact Sheet and an Infographic can all be downloaded from:

<http://www.unep.org/resourcepanel/KnowledgeResources/AssessmentAreasReports/Food/tabid/133335/Default.aspx>

The 1.5 hour Mini-Session will present the Report and hold a structured discussion around the outcomes and options for developing 'Resource Smart Food Systems'.

Global nitrogen trade reveals the food and environmental challenges

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Nitrogen is essential for agricultural production and is embedded in the global trade of agricultural products. However, the extent of global nitrogen trade and its impacts remain largely unknown. Using global agricultural trade data and the integrated framework of telecoupling (socioeconomic and environmental interactions over distances), we analyzed the nitrogen flows over time and their environmental and socioeconomic impacts. Results indicate that from 1961 to 2009, global nitrogen trade increased from 3 to 36.6 Tg (embodied in fertilizer, edible food and feed). The percentage of countries and population relying on imported N consistently increased from 40% and 20% to 65% and 50% respectively. Meanwhile, we found an increasing price gap between nitrogen producers and consumers. The nitrogen supply per capita did not improve but nitrogen use efficiency (output/input) decreased significantly. Most nitrogen traded in food and feed end up in the sewage system, which could be recycled onto cropland or discharged to the environment, but are typically ignored when calculating nitrogen budget. Although most developed countries reduced nitrogen fertilizer inputs, the total nitrogen load (fertilizer + bio-fixation + nitrogen in imported food) in agricultural land have not significantly reduced after the 1980s. In the developing countries, the nitrogen load per ha arable land has continued to increase. Increased nitrogen load and reduced nitrogen use efficiency have many negative impacts on the environment and long-term food production. Better managing nitrogen flows and improving nitrogen use efficiency are critical to improve food security and reduce environmental impacts across the telecoupled world.

The right to land use: navigating competition for a scarce resource and knowledge needs

Ward Anseeuw

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Interactions between food security and land use in the context of global change: the Belmont Forum perspective (II)

Belmont Forum/FACCE-JPI Roundtable: Food Security and Land Use Change - Investigators, Funding Agencies, Users and Stakeholders

Gilberto Câmara, Reynaldo Victoria, Alexandre Roccoatto

FAPESP - São Paulo Research Foundation (Brazil), São Paulo, Brazil

The interactions between food security and land use, both now and over the next few decades, are of paramount interest to policy, science and society at large. Since many nations are grappling with the research challenges presented by this complex agenda, a Belmont Forum/FACCE-JPI Collaborative Research Action was launched in 2013, aiming to add value to individual nations' efforts. The ultimate goal of the Call for Proposals was to rapidly evolve the knowledge base that is needed to develop innovations and support decision-making towards sustainable land use planning and practices, i.e. innovations, strategies and policies targeted at enhancing food security as well as preserving the environment.

Through this round-table session, the Call organizers and Belmont Forum scientific representatives wish to promote a thorough discussion among investigators from the selected multinational projects, representatives from the funding agencies and users/stakeholders regarding the ongoing projects achievements and possible future actions.

Engaging with stakeholders in project FICESSA

Alexandros Gasparatos

University of Tokyo, Tokyo, Japan

The Belmont Forum project FICESSA conducts research at the interface of industrial crops, land use change and food security. Apart from original science, FICESSA's vision is to produce knowledge that will be directly used by key stakeholders to improve the food security outcomes of industrial crop production in Sub-Saharan Africa.

The relevant stakeholders for FICESSA are highly diverse ranging from the actual companies that operate industrial crop projects, to farmer associations, national/international policy makers, government boundary organisations that assist farmers, NGOs, certification agencies and consultancies that consult all of the above stakeholders.

This presentation discusses some of the stakeholder engagement activities of FICESSA. It will focus in particular on how interaction with stakeholders can offer insights both for the design of research instruments and the analysis of results.

Regarding the former the presentation outlines the experience obtained during a mediated modeling exercise conducted in London (May 2015). This workshop with stakeholders identified the causal links between industrial crops, land use change and food security, and laid the foundations for the development of the main FICESSA research instruments.

Regarding the latter, the presentation will highlight the results of a workshop in Swaziland (March 2016) that brought together local stakeholders to identify the potential causal links between sugarcane production and food security in one of the FICESSA case study areas. This helped identify the appropriate variables to be explored during the analysis of primary data collected at the same time in the region by the FICESSA team.

Stakeholder engagement rountable - ABC telecoupling

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Stakeholder Engagement Rountable - ABC Telecoupling

The project's core questions implicate a broad range of stakeholders across several continents, including the producers and consumers of agricultural commodities, such as corn and soy, as well as those who facilitate and regulate transnational trade. The geographic breadth of the project, relative to the time and resources available, precludes the engagement of meaningful numbers of individuals, leading to a strategy of engaging stakeholders from organizations representing the interests of the various groups. Furthermore, by design, the research sites in Brazil, China, the UK, and the US vary considerably in terms of production and consumption of the key commodities, as well as in the facilitation and regulation of trade, and the consequent social and environmental consequences. This variation necessitates a tailored approach in which country-level stakeholder panels are constituted, each enjoying representation on the project's Stakeholder Council, to be convened at the project's annual meeting. As a first step in achieving the project objective of co-designing a computational simulation model to examine scenarios useful to stakeholders, it is crucial to elicit those stakeholders' understanding of the structure and function of the system being analyzed. To this end, the project is employing a mental modeling approach to record stakeholder understanding of the key components and relationships in the production-transport-consumption system. Representing this information in a systematic fashion enables comparison of the ways in which scientists and stakeholders perceive the system, and ensures that model output provides insights that each finds meaningful.

Policy-Science interface for advancing Food-Water-Energy Nexus (FEW) in Developing Countries

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The real engagement of decision makers in the Food-Energy-Water (F-E-W) nexus came with the WEHAB framework for Action on Energy launched during World Summit on Sustainable Development in Johannesburg in 2002. Today there are many policies trying to promote the Nexus. To succeed, a Green Economy approach or the SDGs, we must go beyond sectoral solutions and actively address the water, energy and food security nexus, in-line with human rights-based approaches and consider an integrated solution that embraces the entire suite of economic policies of relevance to sustainable development. The policy synergies that consider co-benefits from harmonized governance systems will involve the exchange of information and knowledge leading to learning, and ultimately influencing decisions on including the nexus approach in their agenda. The presentations will nudge down the important role that decision-makers and other stakeholders can fulfill in assessing the nexus potential, threats and opportunities for action in the context of Africa. We will explore how scientists, policy-makers and other stakeholders should link up and jointly develop knowledge to enrich policy and decision-making processes. The presentation will address to the following questions.

1. What are the benefits of F-E-W nexus to be attained at different scales?
2. How can we , and food
3. What opportunities and tools exist to advance the nexus agenda?

An example of practical nexus programs will be used as an illustration of actionable knowledge that are policy-relevant in developing countries in West Africa.

Land system and food security in facing of climate change

A warmer policy for a colder climate: Can China both reduce poverty and cap carbon emissions?

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Reducing global carbon dioxide (CO₂) emissions is often thought to be at odds with economic growth and poverty reduction. This paper studies whether China, the world's largest single nation emitter, can cap CO₂ emissions for the 2015-2030 period and still sustain growth and reduce the urban-rural income gap. Using an integrated assessment modeling approach, we find that with CO₂ emissions held at 2015 levels, China can still slightly increase its GDP and reduce the urban-rural income gap by a third by 2030. As a result, the Chinese economy becomes less dependent on exports and investments, as household consumption emerge as a stronger driver behind economic growth, in line with current policy priorities. The resulting accumulated greenhouse gas emissions reduction 2016-2030 is about 60 billion ton CO₂e. The policy initially leads to a modest warming due to reduction in sulfur dioxide (SO₂) emissions. However, the net effect is eventually cooling when the effect of reduced CO₂ emissions dominates due to the long-lasting climate response of CO₂. The net reduction in global temperature for the remaining part of this century is about 0.03 ± 0.02 degrees, corresponding in magnitude to the cooling from avoiding one year of global emissions.

Sustainable agricultural intensification through fixing the broken urban-rural nitrogen cycle in China

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Agricultural systems in China could not fully meet the basic food demands for the increasing population before the 1980s, but had low environmental impact because the nitrogen cycle between food production and consumption had been well maintained. The widespread use of synthetic fertilizers thereafter has significantly improved yields, but the traditional nitrogen cycle has been broken into one-way flow, and resulted in severe pollutions. We applied a biogeochemical model, Crop-DNDC (DeNitrification and DeComposition) to simulate the growth of rice, maize, and wheat and the nitrogen balance for the period 1955-2014. Considering the negative impacts of fertilization (NH_3 , N_2O , N leaching and runoff), the research objective is to present quantitative results for the following questions:

1. What is the contribution of the synthetic nitrogen fertilizers to the food production over the past 60 years?
2. Compared with the available nitrogen supplies, what is the optimal requirement for current croplands?
3. If the urban-rural nitrogen cycle is reconstructed in China, how much synthetic nitrogen is needed for sustainable agriculture?

Based on the quantitative evaluation, policy options will be discussed to address the approaches of genetic intensification, ecological intensification and economic intensification to rebuilding the urban-rural nitrogen cycle and long-term sustainability (Conway 2012).

Climate extremes with large impact on food production through inter-regional linkages in the present and a warmer climate

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Climate extremes like droughts, floods, cold spells and heat waves have a considerable impact on food production. The societal impact is even larger when important food producing regions are struck by simultaneously occurring adversary weather conditions.

In this study we systematically analyse climate extremes, obtained using large ensembles of climate simulations using state-of-the-art global climate models, that have large impacts on food production. We study the physical origin of the extremes, their inter-regional linkages, their predictability and how climate change affects their magnitude and probability.

Such simulated extremes can serve as testcases to explore the type of risks faced by the current food producing infrastructure and as such provide research material to study the effectiveness of adaptations to mitigate these risks.

Shift in China's agro-climatic resource inventory under climate change

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China's demand for grains has been growing rapidly and the growth is expected to continue in the coming decades. This leads to a great concern on future supply potentials of Chinese agriculture under climate change and the extent to which China would have to depend on world markets. An array of research results indicate that food crop's yield will reduce by the 2050s, suggesting quite adverse implications for China's food security. However, these assessments focus on single crops only and neglect the improved multi-cropping opportunities induced by climate change. Here we provide an additional dimension of climate change impacts by focusing on the shift in China's agro-climatic resource inventory. Based on an assembling of 30 General Circulation Models (GCMs) under 4 Representative Concentration Pathway (RCP) scenarios in the CMIP5, the result shows that the extents of the multi-cropping classes in current cropland will move northwards and/or northeast-wards. This shift of multi-cropping zones creates significant increases in multi-cropping opportunities, which is an important factor that dominates the overall changes in crop production potential. And this significant increase in the production potential of China's agro-climatic resource base calls for technological and policy preparedness so that any newly emerging multi-cropping opportunities can be readily utilized in the decades to come. As more than 70% of China's current food production comes from irrigated fields, securing future irrigation water supplies and improving irrigation water use efficiency will be essential for exploiting future enhanced temperature regimes especially in north and northeast China.

The analysis on the temporal-spatial distribution, change regulation and trend simulation of food crop in China

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According to the basic theories and methods in land evaluation, it will find a mode to evaluate the spatial-temporal change of food crop, based on the county panel data from 1996 to 2016 in China. With the analysis on the result of the change in history, it will find the warning boundary of the spatial-temporal change for food security. And with the help of analyzing the factors affecting the spatial-temporal change of food crop separately, it will find the different type of the change. Considering the natural, social and economic factors and policy affecting the change, introducing discrete and virtual variable, it will establish a mode on the factors affecting the change based on the method of AHP, grey correlation analysis and data envelopment analysis etc. With analyzing the data in the whole country, it will sort the factors according their importance, calculate the elasticity coefficient and find the changing trend. Based on the theory and method on land system simulation, it will design the different simulation scenarios, establish different simulation method and find the different results of them. Then it will simulate the trend of spatial-temporal change of food crop in the whole country and discuss the early warning mechanism and strategy according the purpose of food security and ecological security.

Contributions of climate change on the boundary shifts of farming-pastoral ecotone in northern China since 1970

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The boundary of farming-pastoral ecotone is very sensitive to climate change, which can cause large variations of precipitation, and the ecological environment of this region is extraordinarily fragile and sensitive to human activity. However, previous studies have given few descriptions about the contributions of climate change on the boundary shifts of the ecotones. Here, climatic and land use data of the farming-pastoral ecotone (FPE) in northern China since 1970 were used to describe the boundaries of the FPE based on both climate and land use, respectively. The responses of land use boundary of FPE shifts to climate change in different periods were explored through centroid and different directions of boundary shift analysis. Moreover, a contribution model was used to determine how much of the boundary shifts can be explained by climate change. The results showed that the most violent fluctuation of climate boundary was 51.2 km, occurred during the 1970s-1980s. Meanwhile, the land use boundaries moved similarly and slightly to the climate boundaries, indicating the lagging response to climate change. With regard to the boundary shifts of the northwest segment of the Greater Hinggan Mountains, 11-44% was caused by climate change in the east-west direction from 1970s to 2000s. While the contributions were 9-80% in the north-south direction for the northwest segment of the Inner Mongolian Plateau since 1970s. The climate change, which caused the change of suitable cropland areas, substantially influenced the boundaries of the FPE in northern China over the past decades.

Extreme weather impacts on maize yield: the case of Shanxi province in China

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Extreme weather can have negative impact on crop production. In this study, we statistically estimate the impacts of extreme drought, heat waves and cold days on maize yield based on household survey data from 1993 to 2011 in ten villages of Shanxi province, China. Our study shows that growing degree days (GDD) is not a plausible indicator to represent the positive effect of temperature on maize growth in Shanxi as it captures too much of the extreme heat days. Hence, this analysis adopts moderate degree days (MDD) where the extreme heat days is excluded. Furthermore, the maize growth might become more sensitive to high temperature, as the upper threshold temperature seems lower over time in our case. Finally, we confirm that extreme drought, heat waves and cold days have negative effects on maize yield. Specifically, one percentage increase in extreme-heat-degree-days and consecutive-dry-days may result in maize yield declined by 0.2% and 0.07%, respectively. Maize yield also may be reduced by 0.3% if cold days appear during the growing seasons. These results are robust if key socio-economic variables are considered in the analysis.

Future climate impacts on crop yields: Implications of the undergoing irrigation promotion policy in China

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An irrigation promotion policy has been undergoing in China with a particular focus on expanding irrigation areas by 2.67 billion ha (equivalent to 4.4%). Thus, quantifying adaptive potentials of expanding irrigation area under future climate is important for the effectiveness of the policy. In this paper, we assess effects of expanding irrigation areas on crop yields based on county-level data during 1980 – 2011 in Northern China, and estimate future climate impacts on yields across irrigation promotion policy scenarios in 2030s (in terms of different irrigation area expansion). Results indicate that effects of expanding irrigation areas on yields is limited and statistically insignificant (2% with variability between -3 and 6%), compared with those for climates. Consequently, yields were estimated to reduce by 5.9–8.7% under future climate when additional 4.4% irrigation areas were established, and there is no fundamental yield increase when additional 10 and 15% irrigation areas were expanded. This is possibly related to water shortages in our study region, which restrict expansion in irrigation area to convert into amplified availability in irrigation water. The results underscore the key for improving resilience of Chinese agriculture is to modernize irrigation technologies and infrastructures rather than to increase quantity of irrigation areas. The target to adoption of irrigation technology innovation is needed to further addressed in relevant irrigation promotion policies. An irrigation promotion policy has been undergoing in China with a particular focus on expanding irrigation areas by 2.67 billion ha (equivalent to 4.4%). Thus, quantifying adaptive potentials of expanding irrigation area under future climate is important for the effectiveness of the policy. In this paper, we assess effects of expanding irrigation areas on crop yields based on county-level data during 1980 – 2011 in Northern China, and estimate future climate impacts on yields across irrigation promotion policy scenarios in 2030s (in terms of different irrigation area expansion). Results indicate that effects of expanding irrigation areas on yields is limited and statistically insignificant (2% with variability between -3 and 6%), compared with those for climates. Consequently, yields were estimated to reduce by 5.9–8.7% under future climate when additional 4.4% irrigation areas were established, and there is no fundamental yield increase when additional 10 and 15% irrigation areas were expanded. This is possibly related to water shortages in our study region, which restrict expansion in irrigation area to convert into amplified availability in irrigation water. The results underscore the key for improving resilience of Chinese agriculture is to modernize irrigation technologies and infrastructures rather than to increase quantity of irrigation areas. The target to adoption of irrigation technology innovation is needed to further addressed in relevant irrigation promotion policies.

Response of Maize Yield Variability To Climate Variability In Northeast China

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Unlike the research of mean climate change impact on maize in China, understanding impacts of climate fluctuation will provide unique insights into how agricultural productivity are likely to be affected in the future. Baed on the trial data between 1981 and 2010 of the Heilongjiang province in northeast China (NEC), we here investigate how maize yield changes have historically responded to temperature and precipitation variability. We found the maize yield variability represented ~18% of the annual maize average yield at regional scale and was significantly sensitive to variability of growing degree days around the flowering season (FS), accumulated degree days during the reproductive season (RS) and the sum precipitation during RS. Our study suggests that 86.3% of maize yield variability was affected by climate fluctuation. However, the maize yield variability declined due to these significant factors decreased after 2000, especially for the effect of deficit growing degree days near FS delining by 5% since 2000 comparing with 1980s. Our finding suggests that maize yield varibility in NEC has been mailnly affected by climate fluctuation during reproductive period.

Impact of drought on agriculture in the Indo-Gangetic Plain, India using global SPEI datasets and CMIP5 model simulations

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In this study, we investigate the spatio-temporal characteristics of drought in India and its impact on agriculture during the summer season (April to September). For our analysis, we have used Standardized Precipitation Evapotranspiration Index (SPEI) datasets between 1982 and 2012 at 6 month timescale and 27 CMIP5 model simulations for future projections. Based on the criteria $SPEI < -1$ we obtain the vulnerability map and have found that the Humid subtropical Upper Middle Gangetic Plain (UMGP) region is highly drought prone with an occurrence frequency of 40-45%. This UMGP region contributes at least 18-20% of India's annual cereal production. Not only the probability, but the region becomes more and more drought prone with an increase in drought affected areas from 20-25% to 50-60%, before and after 2000, respectively. Higher correlation coefficient (-0.69) between the changes in cereal production and drought affected areas, confirms that at least 50% of the agricultural (cereal) losses is associated with drought. While analyzing individual impact of precipitation and surface temperature anomalies on SPEI (6), we have found that in the UMGP region increase in surface temperature plays the primary role by increased evaporation (drying) and lowering of SPEI. The linkage is further confirmed from the correlation analysis between the SPEI (6) and surface temperature rise, which exhibits strong negative values in the UMGP region. Furthermore, from the CMIP5 model simulations, we found that the wet region becomes more wetter and the dry region become drier in the future RCP scenarios (4.5 and 8.5).

Rice cropping areas adaptations to climate change in northeast China between 1980 and 2010

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Knowledge of the distribution of crop and their changes on regional scale is important for land management, and essential for understanding the response of rice cropping areas to climate change. We used a spatial production allocation model (SPAM) based on the cross-entropy to generate spatio distributions of rice which were applied to analyse the spatio-temporal dynamics of rice distribution in Northeast China during 1980-2010. The results show that (1) rice cropping area expanded northwards to 46°N before 2000. The increased sown area mainly occurred in the northern and eastern parts of Northeast China after 2000. Meanwhile rice also expanded eastwards to 131°E and higher elevation. (2) Rice cropping area has been greatly promoted in formerly inhospitable environments, especially in the annual accumulated temperature (AAT) between 2800 and 3400°C•d. Meanwhile the trend of precipitation increased before 2000 and decreased after that. The increased area of rice occurred mainly in the precipitation range of 300-600mm. (3) This study will analyze the response of rice cropping areas to such climate factors as AAT and precipitation by using linear regression model.

Modelling climate change impacts on food security in Africa

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The 2014 FAO estimates indicate that the prevalence of undernourishment has fallen from 18.7 to 11.3 percent of the world's population since 1992, representing a decline of 209 million people globally. Despite overall progress towards the UN Millennium Development Goal to "Eradicate extreme poverty and hunger", the African continent, and particularly the sub-Saharan countries, has seen an increase in the number of people who are food insecure, which has risen from 182 to 227 million over the same period. This increase has been attributed to limited progress on food availability, due to persistently high poverty rates and inadequate infrastructure. In addition, projections of a rapidly growing population coupled with global climate change, is expected to have significant negative impacts on food security in the future. To examine this state of affairs, we utilise the FEEDME (Food Estimation and Export for Diet and Malnutrition Evaluation) model using future scenarios of climate, land-use and population change for 40 African countries. FEEDME is based upon the FAO methodology for undernourishment calculation expressed in terms of dietary energy availability and minimum needs and uses climate change impacts on crop yields for 2050 under high and low emissions scenarios, coupled with FAO population estimates. The model projects a significantly increased proportion of undernourishment in Africa with more than 50% or more of the population at risk. We evaluate these results against crop 'yield gaps' estimates for the continent, which, if they can be closed, can significantly mitigate Africa's food security challenge.

Is crop production of Indian small farms more stable than large farms in response to climate variability?

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A recent study found that yields in low-income countries have been less affected by extreme weather events (e.g. droughts and extreme heat) than high-income countries. While there is not enough global data available to understand determinants, one hypothesis is that low-income countries typically have greater diversity in farm sizes and associated farm management practices than high-income countries. Smallholders have been posited to have more reliable yields due to on-farm crop diversity found to have greater net productivity than industrial farms. About a quarter of all 570 million farms counted by the World Census of Agriculture are found in India, which provides an ideal case to investigate the farm size to production resilience relationship. India's food production system is among the most heavily reliant on smallholder farmers globally, yet the country is a leading exporter of major agricultural commodities, including, rice, cotton, and sugar. This study empirically examines the yield stability of India's major crops in response to climate variability across farm size classes and their rates of recovery from weather shocks. Using a panel national dataset, we trace crop production trends from 1966-2010 at the district level. Using fixed effects and spatial models, we examined the relationship between farm size, production practices, crop productivity, and precipitation and temperature variability. Our research will bring evidence to the broader question of whether, and under what conditions and contexts, smaller farms are more resilient to climate change.

Assessing the potential of planting rapeseed in winter fallow fields in Yangtze River Basin of China

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The extent of winter fallow fields have significantly increased in China during the recent years. This research focuses on the Yangtze River Basin, one of the leading rapeseed production regions which has experienced the highest rate of expansion in terms of winter fallow fields. It quantifies the dynamics of the extent changes, identify the accurate starting and ending periods of winter fallowing at the grid cell level, and assesses the current and future potential of rapeseeds production in the region. In this research, we will use remote sensing Spot images and filtering techniques in time series analysis for quantifying the extent of fallowing. For identifying the accurate starting and ending dates of fallowing, we will work with a unique data base we have consolidated from 84 agro-meteorological observation stations from 1981 to 2011 in the Basin. For assessing the current and future potential of rapeseeds production in the region, we will enrich and update the cultivar parameters of AEZ model and employ the updated AEZ model to estimate the current and future potential of rapeseeds production. In the AEZ runs, we will take into account the benefits of adaptation in terms of plating dates and varieties. This assessment will help to address a very important issue in the food security of China – heavily dependent on imports of eatable oil and oilseeds.

Adaptive management of land and water for mitigating climate hazards in river deltas

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Many river deltas face higher sea levels and more extreme hydro-climate events due to both intensive human activities and global climate change. With the rapid socio-economic development in these regions, lots of lowland that can help soak up excess water during storms has changed into built-up area and more water is consumed in daily urban life and industries. The potential for floods as well as droughts to turn into costly and life-threatening disasters has increased. To cope with the threats of these potential disasters, several adaptive approaches have been proposed, including building up more dams upstream, developing water-saving societies, creating more wetlands near estuaries, and more. This presentation provides an assessment of the feasibility of these approaches in the deltas of the Pearl, Yellow and Mekong Rivers and consequently provide some suggestions for these regions within the context of adaptive water and land management.

Archetypes of vulnerability and food security: A spatially-explicit typology in African drylands

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Improved food production is key to achieving food security in African drylands. Agricultural productivity is however limited due to soil and water constraints and climate variability, land use change, inequitable trade conditions and social exclusion frequently exacerbate the already pronounced constraints on ecosystem functioning and food security. Vulnerability is employed as a concept to capture the relation between land-based socio-ecological systems and perturbations impacting upon them. To promote transitions towards food security and sustainable land use, we present a typology of farming systems' vulnerability to global change in African drylands. This typology explicitly incorporates malnutrition as cause and consequence of vulnerability. We quantitatively indicated the systems' most relevant environmental and socio-economic properties at a sub-national resolution including water availability, erosion sensitivity, agropotential, malnutrition, income, population density, urban population share, remoteness from markets and decision-making and governance. Cluster analysis revealed eight archetypical patterns of vulnerability showing distinct indicator combinations. For example, one pattern with high levels of malnutrition, a poor resource base and poor governance is indicated in the hyper-arid to semi-arid areas of East Africa. This typology presents a meaningful generalisation of heterogeneous socio-ecological situations enabling the evaluation of key inter-linkages between vulnerability and food security based on similarities among African dryland systems. Their evaluation supports the identification of entry points for improving food security and facilitates the transfer of successful strategies for resilience building. The manageable number of key indicators enable new insights into the prioritisation of intervention efforts and related monitoring efforts.

Impact of drought on terrestrial ecosystems in Mid-Latitude Region

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As the warming continues, droughts will become more frequent and more severe. The economic and environmental losses due to drought is pervasive, yet when it begins and ends is difficult to determine which makes it harder to assess the impact of drought. Drought is one of serious natural disasters that affect a number of livelihoods, since it is closely related to food system. More than 50% of agricultural activities are taking place in Mid-Latitude region where a large portion of major agricultural crops such as maize, rice and wheat are produced. Many parts of Mid-Latitude region are susceptible to drought condition, which will adversely affect terrestrial ecosystem that provide basic needs for a number of livelihoods.

This study used 16 day composite 250m resolution Terra MODIS data (MOD13Q1) from year 2010 to 2015 in the month of May to June in Mid-Latitude region for monitoring the changes of vegetation responses to drought condition. Agricultural lands were extracted in the region to examine the sensitivity of crops to drier condition by calculating NDVI anomalies. It is found that major crop producing countries in Mid-Latitude area; U.S., Black Sea region (Ukraine, Russia and Kazakhstan) has been negatively affected by drought condition which is reflected by the change in crop production level. This study will provide monitoring framework in examining the impact of drought at an extensive scale, and will further explain its relation to the crop production level and price of major crops.

What are the carbon and water costs of different land-based climate mitigation options?

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Future impacts of land-use and land-cover changes (LULCC) on biogeochemical cycles and biophysics are highly uncertain. Firstly, there are large uncertainties in possible future scenarios due to socio-economic pathways (e.g., food demand, trade liberalisation, technological development). Secondly, there are uncertainties in how cropland, pasture and natural vegetation respond to changes in climate. With a model comparison we address both these uncertainties. Future scenarios are run with the Integrated Assessment Model (IAMs) IMAGE and the land use model MAgPIE, representing idealized and policy relevant land-based climate mitigation scenarios. These compare a bio-energy with carbon capture and storage scenario (BECCS), an afforestation and avoidance of deforestation scenario (AD+AFF), and a scenario that combines both, to a reference scenario with no land-based mitigation (REF). The idealized simulations provide bounds on the global capacity for land-based climate mitigation, which are then compared with more realistic policy-relevant mitigation efforts. The socio-economic setting in all scenarios is based on the Shared Socioeconomic Pathways 2 (SSP2). All include climate change impacts for RCP2.6, which has direct effects on crop yields and terrestrial carbon stocks, and indirect effects on land-use dynamics. The land use change outputs are used to run 4 Dynamic Global Vegetation Models (DGVMs) JULES, LPJ-GUESS, LPJmL and ORCHIDEE. The DGVM outputs then show the range of impacts of each different future mitigation scenario on the carbon and water balance, and on the development of natural vegetation and crop yields over the 21st century.

A framework to reconcile ecosystem services and adaptive capacities in rapidly transforming dryland social-ecological systems

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Many natural resource-based societies face the challenge of adapting their livelihood strategies to cope with unprecedented rates of environmental change as well as broader social transformation. To analyze systems whose social and ecological dynamics are in rapid transition, nuance is needed in both domains. Generalizations or steady state assumptions on either the ecological “supply” or social “demand” side obscure critical dynamics and cross-domain feedbacks that may reveal the leverage points for promoting sustainable adaptation and resource use. To provide fuller analytical traction on a whole system, we present an empirically-based conceptual framework that couples “supply side” and “demand side” approaches to SES evaluation.

In both the ecological and social domains, there exists a *range of choice* in the pools of potential assets that can be mobilized to form a livelihood system. Ecological processes and human activities determine the portfolio of ecosystem services that are realized from the natural capital, while human adaptive capacities are mobilized through social processes and technology in order to actualize livelihood strategies. Abiotic limitations constrain the range of ecosystem services offered by natural capital, while social and political factors can limit the range of choice for livelihoods by curtailing adaptive capacities or by hindering processes through which they are mobilized. As capacities in both domains are mobilized within the externally-imposed limitations, the cross-domain interactions form dynamic feedbacks which can be assessed in terms of *social-ecological integration*. Our work contributes a model for policy-relevant research that supports sustainable land use and livelihoods in rapidly transforming social-ecological systems.

Land systems at the nexus of water, food and energy in the Lower Mekong Region of Southeast Asia

Economic, Environmental and Social Impacts of Hydropower Development in the Lower Mekong Basin

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The economic evaluation of the proposed Mekong hydropower projects in the Mekong Basin Development Plan concludes that the benefits outweigh the cost. This paper revisits the previous calculation and conducts the sensitivity analysis of the cost benefit analysis. The paper argues that by changing some key assumptions (discount rates for natural resources; fish value), the economic feasibility of the planned hydropower projects change from positive to negative in terms of Net Present Value (NPV). Furthermore, this paper challenges the previous assumption that hydropower profits would accrue to the country where the dams would be built resulting in Lao PDR being the main beneficiary. The new assumption of a profit split-- 30% for the host country and 70% for the country funding the project and importing the electricity over the concession period was applied. This new assumption results in project developers and electricity importers benefiting but poor, rural farming and fishing communities would suffer. It is recognized that there are uncertainties in the impact costs and some factors (social/cultural costs, lost capture fisheries, reduced sediment and nutrient flows) may be understated and the hydropower benefits considerably overstated. Further studies to reduce uncertainty and to firm up these NPV values are proposed. It is expected that the negative economic impact of the proposed hydropower projects will be even greater.

Evaluation of Soil, Macro Plant Nutrient and Carbon Loss in Mae Chan Sub-watershed Watershed of Mae Kong River, Chiang Rai Province

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GIS, USLE(Universal Soil Loss Equation) and soil sample analysis were applied to determined amount of soil and carbon loss, plant macro nutrient loss and soil delivery ratio(SDR) in Mae Chan sub-watershed of Mae Kong river. The results of this study stated that, amount of soil loss in Mae Chan watershed was about 5,193,119 tons/year. The average amount of soil loss was 80.31 tons/ha. The very slightly erosion class was approximately 102.47 km² (40.48 % of total area), slightly class was 49.89 km² (19.76 % of total area), moderately class was 18.42 km² (7.30 % of total area), severe class was 51.55 km² (20.41 % of total area) and very severe class was 30.19 km² (11.96 % of total area), respectively. The loss of Nitrogen, Phosphorus, Potassium, Organic matter and Organic carbon were 10,689.30, 50.73, 676.74, 128,031.4 and 74,136.9 tons, respectively. The loss of macro plant nutrients can classified as amount of fertilization loss as Urea, Super Phosphate and Potassium Chloride with amount of 13,917.02, 290.63 and 1,358.21 tons/year, respectively. Amount of organic carbon deposited in the stream was 7,604.47 tons/year. Finally, sediment yield 680,684.83 tons/year and sediment yield of organic carbon 8,828.37 tons/year.

Status and trends of aquaculture and fisheries in the Mekong Delta: an emphasis on food security

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The study was made to investigate the status and trend of land based aquaculture development as well as capture fisheries in the Mekong Delta as database for comprehensive management. The survey was implemented at 6 provinces in the MD to investigate the culture species, yield, production of different land based aquaculture systems. Each province has different natural condition such as full flooding effects (upstream) or saline intrusion effects in the dry season (downstream). In addition, capture fisheries activities were also studied in these areas including flooding and non-flooding areas where different fishing gears are used. The results of surveys showed that MD is diverse in culture systems and species such as intensive ponds, cages, pen, lining ponds, tanks, rice fields, garden-ponds or integrated systems. There are 29 fish species are being culture in the MD. Depending on the locations, aquaculture can be operated 1-3 runs per year. Diversity and intensification of aquaculture systems and species are oriented to increase. In the flooding areas, fishing is done in the flooding season on the rice fields where they are completely inundated. In other areas, fishing is conducted year around but mainly in the surrounding canals connected to the paddy and main rivers. The two main fishing gears are used the most are trammel net and draw net. At the downstream site as flooding is not available, rice field and even trends and canals are dry, fishing is very limited. Production of capture fisheries has been declining as reported by the fishermen. The fishermen/farmers have high awareness on the declining in aquatic resource reduction and also willing to collaborate to have better measures to protect the resources.

Understanding Agricultural Land System at the Nexus of Water, Energy and Food in the Greater Mekong River Basin Under Climate Change

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Increases in frequency, intensity, duration, and geographic scope of extreme climate events such as floods, droughts, storm surges, heat waves, and typhoons in Monsoon East Asia are imposing significant threats to the water, energy and food securities, in the Greater Mekong River Basin. These threats are further being escalated by human-induced disturbances to terrestrial ecosystems such as land use and land cover change, dam constructions and urbanization in the region. A key question is what is the role of land system in the nexus of water, energy and food in the region? Specifically, how has land use and land cover change over the past decades affected agricultural food production systems, water use and use efficiency, and energy demand, and what are the trade-offs among different water uses food, hydropower electricity, and other ecosystem system services. In this presentation, a framework is presented to include land as the nexus of water, energy and food systems that specifically examines these questions. Using case studies we demonstrate the complexity of the WEF nexus, potential solutions and recommendations to achieve an optimal balance among different uses of water through trade-off analysis. Attempts to quantitatively link the land processes to climate change, land management and food demands will be made to improve our understanding of the WEF nexus.

"Challenges in the land use and land systems at the nexus of water, food and energy in the transitioning Myanmar"

Zaw Naing

Mandalay Technology, Hlaing Township, Myanmar

"Myanmar is in its transition, from closed to open political and economic systems. There are many challenges in land related issues _ land grabbing, land expropriation, land disputes, etc. "Challenges in the land use and land systems at the nexus of water, food and energy in the transitioning Myanmar" will be presented.

Land use and global integrated assessments

Land use futures in the Shared Socio-Economic Pathways

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While food demand, especially for resource-intensive livestock based commodities, is expected to increase in the future, the terrestrial system has large potentials for climate change. However, uncertainties in future socio-economic land use drivers may result in very different land-use dynamics and consequences for land-based ecosystem services. This is the first study with a systematic interpretation of the Shared Socio-Economic Pathways (SSPs) in terms of possible land-use changes and their consequences for the agricultural system, food provision and prices as well as greenhouse gas (GHG) emissions. Therefore, five alternative Integrated Assessment Models with distinctive land-use modules have been used for the translation of the SSP narratives into quantitative projections. The model results reflect the general storylines of the SSPs and indicate a broad range of potential land-use futures with global agricultural land of 4900 mio ha in 2005 decreasing by 810 mio ha until 2100 at the lower and increasing by 970 mio ha at the upper end. GHG emissions from land use and land use change, as a direct outcome of these diverse land-use dynamics, and agricultural production systems differ strongly across SSPs. The inclusion of land-based mitigation efforts further broadens the range of potential land futures. It can be concluded that sustainable diets, rapid growth in agricultural productivity and globalized trade have the biggest potential for sustainable development. The SSP-based land use pathways presented in this paper aim at supporting future climate research and provide the basis for further regional integrated assessments, biodiversity research and climate impact analysis.

Sensitivity of parameter sensitivities to scenario choice: Towards robust global sensitivity analysis under deep uncertainty

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Complex social-ecological systems models assessing global challenges such as climate change, land and water resource use, biodiversity conservation, and food and energy security typically consider deep (i.e. incalculable, uncontrollable) uncertainty using internally consistent scenarios. These conditions of deep uncertainty challenge global sensitivity analyses as the independent variation of scenario parameters can cause inconsistency and implausible parameter combinations, and the selection of a starting point for scenario parameter values can influence the results of sensitivity analyses. The influence of this deep uncertainty on model parameter sensitivities needs to be understood and robustly quantified to reliably inform investment in data collection and model refinement.

We applied the extended Fourier Amplitude Sensitivity Test method to a complex social-ecological model (the Land Use Trade-Offs model of Australia) under four internally consistent global change scenarios (*global outlooks*). We assessed 50 model input parameters and 24 model outputs. The uncertainty of the model outputs, and the influence of model input parameters including both the first-order and total effects differed substantially under the four global outlooks. We then developed new sensitivity indicators that are robust to deep uncertainty using four criteria from decision theory. These robust sensitivity indicators are a valuable addition to global sensitivity analyses. They can provide comprehensive diagnostics of model performance, structure, reliability, and transparency and guide further investment in gathering and analysing additional data under conditions of deep uncertainty by incorporating the decision maker's risk preference.

The stability of global crop production to natural disasters

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Natural disasters can lead to devastating crop yield losses. These yield losses can in turn impact on global food production, influencing trade dynamics, prices and global food security. Despite a well voiced appreciation that we need a better understanding of how future global food production can absorb or resist shocks, the mechanics of exactly how this can be done is poorly understood. Here I will show how we can build a framework for improving the resilience of food systems by quantifying the spatial synchrony underpinning the temporal variation in global crop production. I will show what proportion of temporal variation in global food production is attributable to spatial synchrony in country level productivity, and how well synchrony in production is tied to the co-occurrence of disaster events. We will explore if the world currently has all its ‘eggs in one basket’, and what steps we might be able to take to mitigate the risks associated with global food production into the future.

Spatial Allocation of Statistics Data for Crop Yield Using Multi-source Data Based on Bayesian Network

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Since crop yield data are based on administrative units, there exist different calculation methods and statistical criteria, which result in the inconsistency in statistics data. A high spatial resolution gridded map of crop yield is of great value for the study and application of remote sensing of agriculture on a regional or national scale. Spatial allocation of crop yield statistics data is an important issue in the context of global climate change, which involving the crop yield accounting and food security. In this paper we introduce a new method for the spatial allocation of crop yield fusing multi-source data based on Bayesian network. In addition to common-used land-cover, population and GDP data, the phenological parameters extracted from time-series MODIS data were imported into our model. A high resolution of 1 km distribution of crop yield was generated and analyzed. The objective of this study is to downscale the crop yield using Bayesian network by fusing multi-source data. The specific objectives include: (1) Spatial allocation of crop yield, providing a basis for crop yield accounting and food security; (2) Building a model based on Bayesian network, introducing prior knowledge to improve the accuracy; (3) Fusing multi-source data, including land cover and time-series MODIS data. The novelty of the proposed model is that the crop phenological parameters were fused into the model as prior knowledge to improve the accuracy and efficiency of the model by utilizing the advantages of Bayesian Network.

Evaluating the accuracy of six global land cover dataset over China

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Land cover dataset is vital foundation to global change. So far, several global land cover datasets have arisen with efforts of many scientific communities. Aimed at providing guidelines for data usage over China, six widely used global land cover datasets, IGBP DISCover, UMD, GLC2000, MCD12Q1, GLCNMO2008, and CCI-LC were evaluated in this paper. We firstly compared their similarities and discrepancies in both area and spatial patterns, and discussed their inherent relations with data sources, classification schemes and methods. Next, six periods of validation samples were interpreted to calculate their classification accuracy. Further, we built a spatial analysis model and described spatial variation in classification accuracy based on validation samples. The results show that, for datasets produced by different institutes, GLC2000 and CCI-LC has the highest overall spatial agreement (53.8%). For datasets produced by same institutes, overall spatial agreement of CCI-LC 2000 and 2010, MCD12Q1 2001 and 2010 reach up to 99.8% and 73.2%, respectively; however, it's still inappropriate to use them as time series data for climate change model directly, since both CCI-LC and MCD12Q1 fail to represent the rapid changing trend of some classes in China, particular in urban, snow and ice. For all datasets, CCI-LC 2010 has the highest overall accuracy (67.2%), and the next is MCD12Q1 2010 (58.8%). Although all datasets exhibit high accuracy in homogeneous region, local accuracies in heterogeneous regions are quite different, e.g., Farming-Pastoral Zone of Northern China, mountains in Northeast China, and more attentions should be paid when using datasets in these regions.

Land use change and food security in an era of climate change

Huajun Tang

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Landscape Dynamics across the Drylands of Eurasia: People, Societies and Ecosystems

Poised between cold and dry: land surface phenologies in Central Asian highland pastures.

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To explore the vulnerability of high-elevation communities in the Kyrgyz Republic and Uzbekistan to changing climatic, sociodemographic, and socioeconomic conditions, we assembled image time series to characterize the condition of pastures near villages at high elevation (>2000 masl) and in remote pastures at higher elevation. Here we describe the application of the convex quadratic (CxQ) model of land surface phenology to highland pasturelands in selected oblasts in the Kyrgyz Republic and in Uzbekistan. We used 16 years (2000-2015) of Landsat normalized difference vegetation index (NDVI) imagery with MODIS land surface temperature imagery processed into accumulated growing degree-days. The peak height of the NDVI and the thermal time to peak are two key phenological metrics derived analytically from the fitted parameter coefficients of the CxQ model. Both exhibited sensitivity to elevation, which we describe in terms of phenometric lapse rates (PLRs). Interannual variation in PLRs was expressed differently for peak NDVI and the thermal time to peak. Peak NDVI increased with elevation up to a point but also exhibited more spatial variation in dry years than in wetter years. Thermal time to peak exhibited strong, highly significant negative linear relationships to elevation with steeper slopes in drier years. Both types of PLRs were modulated by aspect. These relationships and the associated CxQ models by elevation and aspect can provide expectations against which to detect changes in pasture status as a result of management or weather.

The interaction of land use/cover change-ecosystem-climate

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Climate change is widely recognized as the most serious environmental threat facing our planet today, and is becoming central to policy-making and land use decision-making. Climate change interacts with land use in two ways- firstly by direct influence on ecosystem processes and services (impacts), and secondly on the way that actors within the system respond to it, causing change in behavior, which in turn affects various ecosystem process (mitigation). Recent years saw the rapid changes of China's land use, the arable land has been increased in total amount, the balance of decrease in the south and increase in the north was resulted from the reclamations of grassland and forest land. In the same time, China's urban and industrial lands increased by 4.23×10^4 km² between 1990 and 2010. Because the total area is fixed, tradeoffs and synergies will inevitably occur, between human mitigation and adaptation responses on the one hand, and biodiversity and ecosystem services on the other. Thus, it is essential to consider the impact of responses to climate change on biodiversity and ecosystem services if we are to understand their impact on the sustainability of the overall system.

Asian Dryland Hierarchies in Rapidly Evolving Institutional Environments

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The largest dryland system on Earth—the Asian drylands—stretches from Eastern Mongolia to Israel and has experienced major international conflicts including: culture and religion (e.g., wars), institution shifts (e.g., collapse of the Soviet Union), resource extractions (e.g., oil), rapid land use change (e.g., urban and agricultural expansion), climatic change, and natural disturbances (e.g., dust storms). The objective of this study is to diagnose the independent and interactive driving forces of the biophysical and geopolitical influences on ecosystem ET, GPP, and water-use efficiency (WUE) across three hierarchies in the Asian drylands, which include 17 countries in three contrasting clusters (i.e., the East Asia, Central Asia, and the Middle East), over a 20-year study period (1992-2012). We hypothesize that ecosystem ET, GPP, and WUE in recent decades were primarily regulated by a range of institutional shifts (cultural, religious, governmental, territorial boundaries) that were also responsible for change in various land use practices. However, the underlying mechanisms for these changes at the cluster and landscape hierarchies vary significantly in their relative contributions to biophysical drivers. In turn, these changes affect resource disputes and use. Across the region, the major land cover changes have accrued, including: shrubland to grasslands or barren; grasslands to croplands, shrublands, or barrens; and croplands to grasslands or shrublands. However, these land use changes varied greatly among the three clustering systems—the Middle East and East Asia were dominated by desertification while Central Asia's agricultural lands were largely abandoned. We also witnessed great shifts from 1990 to 2000 among the clusters. A stronger shift from barren to grassland, for example, was observed in East Asia, while the Middle East faced greater changes from barren to shrublands or grasslands.

Rural land cover change in an era of urbanization: implications for grassland resilience on the Mongolian Plateau

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The Mongolian Plateau is one of the world's largest contiguous rangeland systems, which supports a vibrant nomadic pastoralist culture. Mongolia is undergoing dramatically high rates of climate change, as well as a rapidly modernizing and diversifying economy. Urbanization has created drastic changes to the Mongolian Plateau over the past 30 years, affecting land use and

land cover, livelihoods and environmental degradation. Research on urbanization patterns and processes have focused primarily on the urban areas themselves, detailing economic drivers and environmental impacts of urban expansion. Less attention has been paid to the impacts of increased urbanization on the rural portions of the country. This can be particularly acute in Mongolia where the majority of urban migration has been to the capital city, Ulaanbaatar. It is unclear what contemporary urbanization trends will mean for grassland resilience in the rest of Mongolia, which is still predominantly rural rangelands. We will evaluate the relationship between land use and land cover changes and rural-urban migrations in an arid rangeland system, within the context of changing climate and economic pressures.

Our specific objectives are to: 1) identify the environmental and socioeconomic drivers underlying contemporary rural-urban migrations in Mongolia; 2) innovate the way in which temporal satellite imagery can be deployed to characterize grassland dynamics, including degradation, restoration and conversion; and 3) assess the changes in spatial and temporal grazing pressures as a result of rural-urban migrations, and subsequent implications for rangeland health.

Global climate responses to anthropogenic groundwater exploitation

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In this study, a groundwater exploitation scheme was incorporated into the model CESM1.2.0 to create a new model called CESM1.2_GW, which was used to investigate climatic responses to anthropogenic groundwater exploitation on a global scale. An ensemble of 41-yr simulations with exploitation and an ensemble of control simulations without exploitation were conducted with water supplies and demands estimated. The results revealed that the groundwater exploitation and water consumption cause drying effects on soil moisture in deep soil layers and wetting effects in upper layers, along with a rapidly declining groundwater table in the central United States of America, in the Haihe River Basin of China and in northern India and Pakistan. Groundwater extraction was shown to be the most severe in the world in these areas. The atmosphere also responds to groundwater exploitation; cooling effects appeared in the lower troposphere over large areas of the north China Plain and of northern India and Pakistan. Increased precipitation occurs in the Haihe River Basin due to increased evapotranspiration from irrigation. Decreased precipitation occurs in northern India because water vapor is taken away by monsoon anomalies induced by anthropogenic alteration of groundwater. The local reducing effects of groundwater exploitation on terrestrial water storage show that both surface and subsurface water resources are unsustainable at the current high groundwater exploitation rate. Therefore, a balance between reduced groundwater withdrawal and rapid economic development must be achieved to maintain a sustainable water resource, especially in regions where groundwater is being over-exploited.

Sociodemographic resilience of high elevation communities: geopolitics, remittances, and climate change in Kyrgyzstan, 1991–2015

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The fall of the former Soviet Union in 1991, companioned with global economic and climate changes, has resulted in substantial impacts on its member countries. The impacts are particularly strong on high-elevation communities that had already experienced geophysical, climatic, and physiological stresses. This research investigates resilience of high-elevation communities. In specific, this research examines the impacts of geopolitical change (e.g., the Soviet Union breakdown), economic change (e.g., international migration and remittances), and climate change (e.g., increasing temperature) on high-elevation communities in Kyrgyzstan since 1991. We assess community resilience through demographic, social, and economic changes, including population change, age, gender, ethnic groups, migration, mortality, urban and rural differences, norms and values, marriage patterns, crime, impacts of remittances, income, employment, housing quality, and industry. For climate change data, we use remote sensing images to identify changes of land use and land cover and highland pasture conditions over time. We also look at four groups at risk of social disadvantage: children, the elderly, women, and different ethnic groups. Methods include geovisualization, econometric modeling, principal factor analysis, and remote sensing image analysis. This research provides significant insights into the impacts of remittances, climate change, and geopolitics on resilience of high-elevation communities.

What is the Main Cause of Grassland Degradation? A Case Study of Grassland Ecosystem Service in the Middle-South Inner Mongolia

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In this study, we analyze the changes of indicators of ecosystem services and functions, in order to understand the main cause of grassland degradation due to climatic variation or land use changes in the middle-south Inner Mongolia. The soil nutrient increased during 1988-2008. The water supply of supporting service also got recovery. The loss of net primary production declined, but the quality of the retained unconverted grassland degraded during 2000-2008. Our analysis results show that environmental degradation on the land-use-changed-area is lower than on the retained unconverted grassland during 2000-2008. It illustrates that the retained unconverted grassland is degrading fast, and it is highly likely that climatic variation has more negative impacts on grassland ecosystem service, and which is significantly higher than the so-called “overgrazing” induced grassland degradation. Moreover, it cannot be excluded that those species died out on the retained unconverted grassland due to natural selection or competitive evolution in an evolutionary process under the deteriorative weather condition rather than overgrazing. The positive impacts of human activities such as conservation programs and wildlife protections laws also benefit to regional grassland ecosystem obviously. In particular of the study area, some cultivated land and pasture land are converted to grassland or woodland after a series conservation programs implemented. Hence, human activities can delay the environmental degradation even if each planet has its life cycle, and human activities definitely have positively contributed to sustainability of some area on the earth. It indicates that grassland conservation has to be monitored by scientific methods, and to be comprehensively managed according to an integrated regional planning involving the considerations of climatic conditions, geographical characteristics, socioeconomic factors, and ecological functions and biodiversity.

Local-global interactions and land use change in the 21st century

Livestock in global scenarios: Implications for the future land use

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In order to cover the space of plausible futures, the GLOBIOM model, a global agricultural and forest sector model with detailed livestock representation, is applied to the matrix of alternative socio-economic (SSPs) and climate change scenarios (RCPs). The socio-economic scenarios cover the following livestock sector specific drivers: feed conversion efficiency growth, adoption rates of new technologies, grassland productivity growth, and human diet preferences. Based on these scenarios, decomposition analysis is carried out, in order to identify the most critical elements of sustainable livestock sector development in terms of prices, land use, water use, and GHG emissions. Depending on the climate change scenario, grasslands are relatively more productive than croplands, which favors livestock supply, but also grassland expansion into natural vegetation. The results show that the socio-economic pathways are the major driver of differences between the alternative scenarios, as compared to climate change impacts. Of particular importance is the ability to adopt new technologies which is key to satisfying the booming demand for livestock products in a sustainable manner. The results show that detailed representation of livestock and grassland management technologies is a prerequisite for sound forward-looking global sustainability assessments.

Fine crop classification, change detection and Long term trend analysis in Chinese broken regions based on deep learning

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Traditional machine learning methods as support vector machine (SVM), principal component analysis (PCA), have made successful applications for an automatic crop classification in counties as Australia and America with big farms, but have failed in China with broken crop regions and smallholders. Currently, many provinces in China still need intensive manual work for crop classification.

In this paper the deep learning method based on convolutional neural network (CNN) is introduced and extended to deal with this problem. First, to accommodate all kinds of different wave bands and field work data as soil and evapotranspiration, we design a new structure called elastic tensor for input data instead of the regular 2D pixel matrix. Then, multi-temporal multi-spectral images and field data with samples are trained to obtain the best neuron and layer number, the size of weight tensors and weight value. Third, upon the CNN output we introduce the unsupervised deep learning method to cluster the pixel samples to categories. With the combined supervised and unsupervised deep learning, we get the final fine training results.

The trained parameters are then used to classify the whole test data from multi-temporal and multi-sensors which has been geographically aligned. The changed areas are easy discriminated and then are used to analyse the long term trends of crop cultivation.

The authors confirm this submission has been approved by all authors and confirm that the first author is presenting author and will register for the meeting.

The role of diffusion in modern European land use change

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Diffusion of ideas, attitudes and practices is recognised as an important process in land use change, shaping spatial and temporal patterns of development in the land system. However, much of the existing empirical work on diffusion was carried out many years ago, before the advent of modern communication and information technologies. As a result, its continued relevance is not clear, and the extent to which diffusion will determine future land use change is uncertain. Nevertheless, social studies suggest that knowledge held within social networks remains critical to shaping responses to climate change and other drivers of land use change. We present work intended to uncover what, if any, role spatial diffusion plays in modern European land use change. We explore a number of examples of different forms of land use change, including the adoption of new crops and the uptake of subsidy schemes, to investigate whether diffusion is apparent in spatial and temporal patterns of change. Using a statistical modelling approach, we find strong evidence of diffusion in certain circumstances, even where it may not be expected to have a significant effect. We discuss implications for land system modelling and governance, as well as possible future developments under climate change.

A Global, Gridded Approach to Understanding the True Cost of Food

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As agricultural production expands and intensifies in response to growing food, fuel and fiber demands from a richer, more populous world, the environmental costs of this activity become increasingly evident. Greenhouse gas emissions from agriculture, deforestation and related land-based activities account for roughly one-quarter of the world's total, from all sectors combined. Much of the deforestation in the tropics has been driven by agricultural expansion and this has simultaneously contributed to the loss of biodiversity. Leaching of nitrogen fertilizer has been linked with degradation of groundwater supplies as well as the eutrophication of many of the world's coastal waters. And agriculture accounts for 70% of the world's freshwater withdrawals, thereby contributing to water scarcity in many of the world's arid regions. In short, there has been an inherent tension between the goals of providing affordable food to the world's population, on the one hand, and ensuring the environmental sustainability of the planet, on the other.

The fundamental challenge inherent in understanding the food-environment trade-off is that the drivers behind agricultural demand, namely population, income and biofuels, are global in nature with food prices determined in world markets, yet most of the environmental impacts are location-specific. Nonetheless, imposing local environmental restrictions can have global consequences. In this paper we propose a novel global-local-global approach nicknamed SIMPLE-on-a-GRID to analyze the impact on food prices of restrictions on agricultural production aimed at: (a) reducing terrestrial carbon emissions, (b) preserving biodiversity, (c) limiting nitrate leaching, and (d) ensuring ground water sustainability.

Potential Impacts of local water constraints and environmental flow protection on global agriculture, bioenergy production and land-use change

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Bioenergy is expected to play an important role in the future energy mix as it can substitute fossil fuels and contribute to climate change mitigation. However, large-scale bioenergy cultivation may put substantial pressure on land and water resources. While irrigated bioenergy production can reduce the pressure on land due to higher yields, associated irrigation water requirements may lead to degradation of freshwater ecosystems and to conflicts with other potential users. In this article, we investigate the trade-offs between land and water requirements of large-scale bioenergy production using the spatially explicit global land and water use allocation model MAgPIE. We find that producing 300 EJ of bioenergy per year – an amount consistent with a 2 degree global warming target by the end of the century – is likely to double agricultural water withdrawals if no explicit water protection policies are implemented. Since current human water withdrawals are dominated by agriculture and already lead to ecosystem degradation and biodiversity loss, such a doubling will pose a severe threat to freshwater ecosystems. If irrigated bioenergy production is prohibited to prevent negative impacts of bioenergy cultivation on water resources, bioenergy land requirements increase substantially (+ 41 %) – mainly at the expense of pasture areas and tropical forests. Thus, avoiding negative environmental impacts of large-scale bioenergy production will require policies that balance associated water and land requirements.

Disentangling the effects of local and global drivers of deforestation with the GLOBIOM model

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We explore the influence and interaction of different drivers of tropical deforestation at the local and global level with the GLOBIOM model. The bottom-up approach of the GLOBIOM model offers opportunities to reconcile several geographical scales in a consistent framework. The Amazon Basin and the Congo Basin are the two largest area of rainforest in the world but historical deforestation has been on very different scales and also driven by different factors in the two regions. We have built harmonized land cover-land use maps for Brazil, Cameroon, the Congo Republic and the Democratic Republic of Congo using the best data available and local expert knowledge in order to improve spatially explicit modelling of future land use change for these countries in GLOBIOM. We then investigate the relative impact of infrastructure development, local population growth, protected areas and forest code for the local drivers, and of trade liberalization and increased agricultural commodities demand for the global drivers, on past (2001-2010) and future deforestation (2011-2030). We also show the combined effect of local and global drivers of deforestation in the different selected countries. Finally, we explore the uncertainty of our results related to critical parameters of the model such as internal transportation costs, demand and trade elasticities.

The land biosphere as a net source of greenhouse gases to the atmosphere: Climatic costs of global food production

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The land biosphere can release or absorb the greenhouse gases, carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) and therefore plays an important role in regulating atmospheric composition and climate. Anthropogenic activities such as land use change, agricultural and waste management have altered terrestrial biogenic greenhouse gas fluxes and the resulting increases in methane and nitrous oxide emissions in particular can contribute to climate warming. Here we use bottom-up (BU) and top-down (TD) approaches to quantify the global net biogenic greenhouse gas balance between 1981-2010 as a result of anthropogenic activities and its effect on the climate system. We find that the cumulative warming capacity of concurrent biogenic CH₄ and N₂O emissions is about a factor of 2 larger than the cooling effect resulting from the global land CO₂ uptake in the 2000s. This results in a net positive cumulative impact of the three GHGs on the planetary energy budget, with a best estimate of 3.9 ± 3.8 Pg CO₂ eq/yr (TD) and 5.4 ± 4.8 Pg CO₂ eq/yr (BU) based on the GWP 100 metric. Our findings suggest that a reduction in agricultural CH₄ and N₂O emissions in particular in Southern Asia may help mitigate climate change. The results are a big wake-up call for the global climate community that shows the way we are managing our lands is not sustainable and not consistent with stabilizing the climate at low temperature scenarios. How we manage the global lands needs to become a central part in our strategy to mitigate global warming

A comparative analysis of existing spatially explicit global datasets on forest loss

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Forests are a critical ecological lynchpin, providing important environmental services. Yet despite forests' pivotal ecological and social roles, forested land is being steadily converted to other uses, including cropland, pasture, mining, and urban areas. This has resulted in major international efforts to mitigate deforestation. However, there is disagreement as to whether our efforts to address forest loss have worked. Globally, we don't know if the rate of deforestation is accelerating, decelerating, or has stabilized. This conflict is driven by several studies that have analyzed forest loss at a global scale, and offered contradicting conclusions on the rate of deforestation. To better understand the varying and sometimes contradicting conclusions of various spatially explicit studies on deforestation, it is necessary to understand the relationship between definition of forest loss used and outcome of forest loss patterns. A comparative analysis between global forest loss studies and their respective datasets will help disentangle these differences. This presentation will introduce a comparative analysis of existing spatially explicit global datasets on forest loss. The aim of the study will be to examine the technical differences in definitions of global forest loss for all existing datasets, in order to establish why the outcomes of these datasets vary and, sometimes, contradict one another. This study will attempt to understand the drivers of these differences in the datasets by examining how different assumptions and measures can drive these varying trend calculations.

Strengthening Sustainability Perspectives in Land Science

Peter Messerli

Centre for Development and Environment (CDE), University of Bern, Bern, Switzerland

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Global Land System Change: trade-offs between agriculture and natural ecosystems

Navin Ramankutty

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Long-term Earth observation: catalyst for novel land systems analyses at regional to global scales

Time Series Analysis of Big Earth Observation Data for Land Use and Land Cover Change

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The availability of open data archives of Earth observation images is posing a strong challenge to land use science researchers. Currently, most image classification algorithms ignore the time reference inherent to Earth observation data, producing land cover maps taking either a single or at most two time references. As a result, only a small part of the big data sets produced by remote sensing satellite are ever used for producing land cover information. This situation is leading many researchers to focus on methods for analysis of remote sensing image time series. However, the theoretical concepts behind the current generation of algorithms are still evolving. In this presentation, we will discuss the different approaches to remote sensing image time series, which include parametric methods, harmonic series analysis and its variations, and data mining approaches. We will also present examples of data mining techniques applied to the classification of big image data sets for the Brazilian Amazonia, using a time-weighted dynamic time warping method. We will discuss the benefits and drawbacks of data mining approaches to remote sensing time series analysis and point out possible extensions to global land cover mapping.

Crop area, yield and production forecasting using satellite-based integrated crop modeling system

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Reliable and timely information of agricultural production is essential for better decision making to ensure food security. Satellite remote sensing data can provide timely and accurate information on cultivated area by crop type and crop vegetative characteristics, facilitating accurate estimates of crop production. Here we present a satellite-based integrated crop modeling system which utilizes remote sensing data, weather forecasts and mechanistic crop growth model, Environmental Policy Integrated Climate (EPIC), to improve the accuracy and timeliness of crop area, yield and production forecasting with an illustration of soybean cultivation in Iowa, USA. Time-series satellite imagery are employed to create multiple soybean classification maps over the growing season starting from active vegetative growth stage to maturity at 16-day intervals and to estimate cultivation acreages at each time interval. In addition, at each time step, near real time satellite data are used to derive spatially distributed crop parameters (i.e. crop phenology and leaf area index) and NOAA weather forecast ensembles are used to produce required weather data. The EPIC simulations were implemented at each 16-day time step to estimate soybean yield and subsequently soybean production is determined. Further, we estimate uncertainties in crop area, yields and production over the state of Iowa using the USDA NASS crop inventory as reference. The time-series, spatially-explicit simulations are useful for identifying key time points of acceptable classification accuracy, for identifying key regions of yield anomaly and for evaluating the overall capacity of production forecasting using remote sensing, weather forecasts and crop growth model.

Remote Sensing Time Series Data Mining: New Tools for Agricultural Mapping

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Since remote sensing satellites revisit the same place repeatedly, we can calibrate their images so measures of the same place in different times are comparable. These observations can be organised in regular time intervals, creating large sets of remote sensing time series. Research on time series data mining shows that methods based on dynamic time warping (DTW) have achieved significant results. However, the DTW method works well for shape matching, but is not suited per se for remote sensing time series. It disregards the temporal range when finding the best alignment between two time series. In this work, we present a time-weighted version of DTW for land use and land cover classification which balances between shape matching and temporal alignment. This method is flexible to account for multiyear crops, single cropping and double cropping. It is also robust to account for other land cover types such as forest and pasture and works with a small amount of training samples. This conjecture has been validated in a case study in the Brazilian Amazon, where we have obtained results about agricultural expansion and forest degradation for large areas.

The potential of space-borne sun-induced chlorophyll fluorescence for agricultural monitoring

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Remote sensing of sun-induced chlorophyll fluorescence (SIF) is a novel optical tool for assessment of terrestrial photosynthesis or gross primary production (GPP). Space observations of SIF electromagnetic signal emitted by plants in the 650-850 nm spectral range hold the promise of providing a new view of crop photosynthesis on a global basis. Global retrievals of SIF from space have recently been achieved from a number of space-borne spectrometers originally intended for atmospheric research. Despite not having been designed for land applications, such instruments have turned out to provide the necessary spectral and radiometric sensitivity for SIF retrieval from space.

Accurately quantifying cropland GPP is of great importance to monitor cropland status and carbon budgets. However, model-based estimates of GPP are still highly uncertain over heavily managed agricultural areas. Exploitation of SIF in improving the representation of photosynthesis became a very relevant and active field. Recent space-borne measurements of SIF can offer an observational constraint on agricultural monitoring. In this presentation, we will demonstrate the potential of SIF data to improve our knowledge of crop photosynthesis at the synoptic scale. We will show examples of ongoing research exploiting SIF data for an improved monitoring of photosynthetic activity in large crop belts worldwide. Further discussion is made for benchmarking the regional modeling of regional GPP and crop yield.

Towards a consistent long-term global land cover and land cover change dataset based on several complete satellite time series reprocessing

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Towards a consistent long-term global land cover and land cover change dataset based on several complete satellite time series reprocessing

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In the context of the Essential Climate Variables (ECVs) the European Space Agency (ESA) launched its Climate Change Initiative in order to deliver global datasets matching the need for long-term satellite-based products for the climate modelling as well as for land surface characterization. Building on the ESA-GlobCover experiences, the research team has revisited the concept of land cover and improved the processing algorithms for five different satellites (AVHRR, MERIS, VEGETATION, PROBA-V, and ASAR) in order to generate a consistent global land cover time series. First, three maps at 300 m spatial resolution for three epochs centered on the years 2010 (2008-2012), 2005 (2003-2007) and 2000 (1998-2002) were released along with land surface seasonality products describing the seasonal variability of the land surface for three variables (vegetation greenness, snow cover and burned areas) on a weekly basis. More recently, annual global land cover products spanning from 1990s to 2015 aim to highlight the land cover change. The proposed method focuses on consistency between the successive global maps and documents the uncertainty associated to each map pixel while they are derived from different sensors of very different performances. A key challenge to turn land cover change into information for land system analysis concerns the validation of the land cover change detection. As this is a critical step in the acceptance of products by the users' communities, a specific effort is made to build independently a global validation database containing high spatial resolution interpretations over years.

Public good earth observation infrastructure for novel global land monitoring applications

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Open archives equate to big data and only the public infrastructure of systems such as Landsat and more recently Sentinel 2 offer the possibility of systematic exploitation of long-term image archives. Research-based and commercial missions may inform the use of long-term data records, but neither provide the systematically acquired, freely available, accessible and robustly pre-processed global data of operational earth observation systems. Equally important is the ability to share methods between researchers and agencies responsible for reporting to global policy initiatives such as REDD+. Advancing global land monitoring requires distributed monitoring capabilities, most efficiently enabled through public good earth observation infrastructure.

Monitoring and assessing land use and change: climate change related progress for land system science

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We should rethink our common Earth Observation paradigm that one cannot observe land use and land use change (as compared to monitoring land cover) from remote sensing given the new opportunities we have at hand. The climate change context has been one of the driving forces in global, regional and national monitoring of land cover and land changes and has resulted in rather clear requirements and support that gave help to demonstrate that. I will use the experiences and progress in this arena to highlight:

- 1) Observations are becoming available that lead to much more data-driven evidence/analysis of land changes and dynamics
- 2) The climate and Earth system modeling community still tends to be the key users for observation progress since they have better articulated and defined requirements
- 3) A dialog on opportunities and limitations of Earth Observations with the land change and system science community
- 4) The recently signed Paris Climate agreement will lead to more investments in assessing land use effects to climate and land use sector mitigation activities but it is essential to seek avenues to move beyond the rather climate changed focused progression in this arena

An important point could be to see how the Sustainable Development Goals and related indicators and monitoring needs can help in the related discussions.

An Improved Wallis Dodging and Mosaic Algorithm for Super-Resolution Reconstruction Remote Sensing Images

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High resolution remote sensing image plays a more and more important role in land use. however, high resolution remote sensing image are expensive. Super-resolution technique can obtains high resolution image form several low resolution images. Large-scale super-resolution reconstruction images using image division algorithm are difficult to achieve seamless image mosaic due to the phenomenon of uneven distribution of brightness and contrast. Aiming at the characteristic that super-resolution reconstruction images are gray images with the same size and overlapping degree, an effective improved weighted Wallis dodging algorithm is proposed, which can realize the consistency of image gray level information. Meanwhile, A weighted adjustment sequence is presented, in order to avoid the spatial propagation and accumulation of errors and the loss of image information caused by excessive computation in the calculation process. Subsequently, the improved method is employed to remove the uneven illumination for 900 super-resolution reconstruction ZY-3 images, and then the overlapping image mosaic method is adopted to accomplish seamless image mosaic based on the optimal seam line.

Remote Sensing Application on Land Resources Management in China

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Land survey and monitoring is the most basic work of national land resources management. The law requires the establishment of a national land management Information system that monitor the land usage changes. Remote sensing technique is a must have tool for land resources management This topic will introduce importance of land remote Sensing in China and major land remote sensing projects in China.

Managing urbanisation pressures in the coastal zone in the context of the blue economy and global environmental change

The Accumulation of Emerging Contaminants in Vegetables and Fruits in Coastal Zone

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Emerging contaminants have been attracting public attention because of their negative effects on human health and wide occurrence in various environments and foodstuffs. There is growing interest concerning the possible food safety posed by emerging contaminants in coastal zone. Isotope dilution method was developed for monitoring the potential bioaccumulation of typical emerging contaminants including nonylphenol, bisphenol A, estradiol, estrone, estriol, and ethinylestradiol in vegetables and fruits in coastal zone. Accumulation of emerging contaminants in vegetables and fruits from coastal zone with intensive reclaimed water irrigation was observed. The concentration of bisphenol A in vegetables and fruits ranged from 0.2 to 9.0 ug/kg while that of nonylphenol ranged from 5.3 to 18.9 ug/kg. The concentration of estradiol in vegetables and fruits ranged from 1.3 to 2.2 ug/kg. The accumulation of emerging contaminants in vegetables and fruits indicates a potential thread of these chemicals to human health through food chain in coastal zone with intensive reclaimed water irrigation. The rapid accumulation of emerging contaminants using edible marine macroalgae indicates another potential thread of emerging contaminants to human health through the food chain in coastal zone. Financial support from One Hundred-Talent Plan of Chinese Academy of Sciences (CAS).

The Water-Food-Energy Nexus in the MENA Region: Future Earth and the Global Land Project

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The triple challenge of water-, food- and energy security in the MENA region constitute a central theme to be addressed in the context of Future Earth and the Global Land Project. Being home to some 350 Million people living in a variety of different countries with a large diversity of cultural, societal and political settings, the MENA region faces severe pressures due to anticipated enhanced changes in climate conditions and associated impacts. One of the repercussions of climate change is an increase in extreme heat events in urban settings. Given an already high degree of urbanization and taking into account an expected increased growth of mega cities in the region implies severe consequences for human health and the need for appropriate adaptation strategies. At the same time, enhanced urbanization poses threats to the water-food-energy nexus because of increased demands for water and space cooling as well as for replacing arable land for food production within urban environments. The proposed Knowledge Action Network on the Water-Food-Energy Nexus aims to address the complex interplay between these three sectors and their underpinning sustainability challenges and requirements. Changes in land use resulting from growing urban structures and their resultant challenges to food production is a central focus of the Global Land Project. This paper will present ideas and approaches to address the Water-Food-Energy Nexus in the MENA Region in the context of our role as Future Earth MENA Regional Center and as the Regional Node of the Global Land Project at the Cyprus Institute.

Competition on land and water embodied in urbanization in China

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Competition over land and water between urban and agriculture system has become one of the major environmental issues that China is facing. This paper aims to predict the tradeoffs between food production/water consumption and economic development in the process of urban expansion for all 288 prefecture-level cities in China by 2030, so as to develop implications on urban planning for the sake of national food security and water security. Based on land-use data interpreted from remote sensing data, socio-economic data, spatial explicit urban expansion for each city was predicted by DinamicaEGO model. Then, agriculture census data were used to evaluate food production loss and water consumption change due to urban expansion, and tradeoffs between GDP and food production/water consumption and its spatial patterns were finally analyzed. The results showed that averagely 12.24 m² cropland / 1.87 million calories food was lost for every ten thousands RMB GDP gained as urban expanding. For three parts (eastern, western, and central) of China, cities in eastern China got the highest cropland and food lost. Total water consumption increased in all cities during urban expansion even though water for food decreased as cropland lost. Averagely 13.69 t more water was consumed for ten thousands RMB GDP gained. Cities in central China got the highest water consumption increment. Different composition and spatial patterns on tradeoffs between land/water and GDP suggest distinguished optimal modes on urban development in different regions, thus guidance for strategies on future urbanization could be drawn out.

Impactful mobilization of knowledge: confronting urbanisation pressures in the coastal zone

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There is a long history of human settlement in the coastal zone. Migration, urbanization, and development are expected to continue and increase into the future. Coastal urbanisation has costs and benefits to society, both directly based on the risks and utility derived from where people live and work and indirectly through distortions to cultural heritage, use patterns, and food chains. While accelerated urbanisation opens scope for new infrastructure, economy, and land-use planning to build risk management and adaptation into urban design it is also constrained by the reality of urban capacity.

Increased global sustainability focus, driven by the Sustainable Development Goals, provides a strong future facing, solution oriented approach for urbanisation research that demands partnership working at all scales. The urban sustainability space is dominated by research on coastal hazards to urbanised coasts and the production of economic and engineering options. However, urbanisation is also a source of inputs to environmental systems. A deeper understanding of the mediating pathways through health, water and food chains that feedback to human wellbeing, and the governance systems that shape these pathways, is needed

The demand exists to jointly identify a common agenda to bring together science, policy, and practice and deliver solutions through the ethos of co-design and co-production. This presentation provides a convening space for novel collaborations and knowledge transfer efforts focused on practical solutions for management on urbanizing coasts that can capture risk and enable reflection and organisation for management, even if this requires change in current urbanisation and development pathways.

Coastal environmental changes and the solutions in the context of urbanization and blue economy development in China

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The coastal zone is a social-ecological system (SES) that is both dynamic and complex. The high ecological, social and economic value of the coastal zone is influenced by global and climate changes, as well as pressures from anthropogenic activities. Rapid urbanization and the development of the blue economy in China has led to a concentration of the human population along the coast. This puts these coastal SES under increasing and multiple pressures, but also increases the risk to the population from dramatic accidents (e.g. oil spills, Tianjin explosion) and natural hazards (e.g. storm surges). Such accidents have resulted in the changes of the coastal environment, damage to natural resources, and loss of ecosystem functions and services.

A comprehensive understanding of the coastal natural status, changes and resilience is fundamental for seeking sound and effective solutions for the sustainable development of coastal zones. On one hand, theory and methodology of coastal sciences need to be established for better elucidation of coastal zone processes, including gradients and variability, sources and sink, biogeochemistry and cycling, and intensified production and associated consequences. On the other hand, effective techniques and adaptive integrated management of coastal sciences also need to be innovated for coastal environmental protection under the pressures of rapid urbanization and blue economy development in China.

Impacts of urbanization and economic development on mainland coastline and coastal wetland in China

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In china, urbanization and industrialization have always been two fundamental engines of social-economic development, and, the coastal area has always been the pole of social-economic development due to its more developed urbanization and industrialization. Various and enormous changes have been witnessed in coastal area in China since the reform and opening-up policy had been released in 1978. Among these changes, urban area expansion, coastline development, coastal wetland reclamation and sea reclamation have become most attractive issues and have drawn attentions by governmental officials, academic researchers and even publics. In light of this, based on remote sensing and GIS techniques, we extracted mainland shoreline data and coastal land-use and land-cover data in multiple periods in China, and official statistics are combined to analyse the impacts of urbanization and economic development on coastline and wetland change in China. It turned out that, urban area and the other kind of built-up area increased dramatically, while the farmland, wetland decreased sharply, furthermore, the length (and the ratio) of natural shoreline decreased remarkably. Urban expansion directly occupied lots of farmland and coastal wetland, and the rigid policy of arable land protection had boosted the coastal wetland and sea reclamation indirectly. Furthermore, economic development, coastal industrialization and urbanization have displaced lots of natural shoreline into various artificial shorelines. Accompanied with all of these changes were severely degraded and fragmented habitats of various coastal creatures, drastic reduction of coastal ecosystem services and the weakened sustainability of social-economic development in coastal area.

Progress in quantifying impacts of land use and land cover change in a changing climate using an Earth system modeling approach

Evaluating the need for integrated land use and land cover analysis for robust assessment of climate adaptation and mitigation strategies

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Several climate adaptation and mitigation strategies incorporate Land Use and Land Cover Change (LULCC), however, inconsistent LULCC across CMIP5 models demonstrates the high sensitivity of the earth system to, and current shortcomings of, LULCC. We use the integrated Earth System Model (iESM) to explore the contribution of land cover uncertainty to an 18 ppmv overestimate of 2004 atmospheric CO₂ concentration, in relation to the effects of CO₂ fertilization, climate change, and nitrogen deposition on terrestrial carbon. Using identical land use input, chronologically referenced LULCC that accounts for pasture, as opposed to year-2000 referenced LULCC, increases this bias to 25 ppmv due to additional deforestation. Maximizing forest during all land conversions reduces the new bias to ~19 ppmv, while minimizing forest increases the new bias to ~29 ppmv. Corresponding ecosystem carbon changes from the default in 2004 are approximately -28 PgC, -10 PgC, and -43 PgC, respectively. This 33 PgC uncertainty range due to maximizing versus minimizing forest area is 80% of the 41 PgC net gain in ecosystem carbon due to CO₂ fertilization and climate change from 1850-2004, 66% of the estimated 52 PgC gain due to CO₂ fertilization alone, and 138% of the estimated 24 PgC gain due to nitrogen deposition. This highlights the need for uncertainty characterization and improvement of LULCC scenarios through utilization of multiple sources and analytical integration of land use and land cover. Furthermore, LULCC scenarios need to be faithfully implemented in earth system models to assess potential climate adaptation and mitigation strategies.

Using sub-grid land model output to study impacts of land cover change within a changing climate

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Sub-grid information from land models has the potential to be a powerful tool for investigating the impacts of land use and land cover changes (LULCC) on local climate, but few studies have attempted to utilize this type of data. In this study, we modify the land surface configuration of the Community Land Model (CLM4.5), so that it may be used to isolate the effects of LULCC on local climate. We compare the default version (multiple PFTs on a shared soil column) to our modified version in which each PFT is assigned an individual soil column. We then use our modified version to examine the sub-grid difference in surface air temperature (ΔT_a , grass – tree PFTs), and quantify the contribution of different biophysical mechanisms to the sub-grid difference in surface temperature (ΔT_s , grass – tree PFTs). Our results show that column configuration has a large effect on PFT-level surface energy fluxes, suggesting care must be taken when assessing LULCC impacts with sub-grid information. The ΔT_a ranges from -1.5K in boreal regions to +0.6K in the tropics. The change in radiative forcing (albedo) is the dominant mechanism that produces negative ΔT_s in boreal regions, while changes in roughness and the Bowen ratio are the dominant factors that produce positive ΔT_s in the tropics. Our modified version of CLM4.5 provides promising evidence that sub-grid data are useful for isolating the effects of LULCC on local climate within a changing climate, and presents an opportunity to compare the biophysical effects of LULCC to other anthropogenic forcings, including rising greenhouse gas concentrations.

Numerical simulations of different high-resolution land cover datasets effects on the Beijing Climate Center Climate Model

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Abstract

As one of the most basic input elements of land surface, climate and earth system models, land cover (LC) and land cover change had direct and indirect effects on climate. In this study, three different high-resolution LC datasets were introduced in the Beijing Climate Center Climate System Model (BCC_CSM), to assess the influences of different LC datasets on climate simulations. These datasets are, respectively, 30 m Global Land Cover (GlobeLand30), Finer Resolution Observation and Monitoring–Global Land Cover (FROM-GLC), China and Global Long Term Data Recorder (CG-LTDR). These datasets were firstly merged with other remote sensing and climate datasets to regenerate plant functional type (PFT) data suitable for the BCC_CSM, and the area-weighted approach was used to aggregate the fine-resolution remote sensing datasets onto coarser model grid resolutions. These three LC datasets and the original LC data of BCC_CSM had generally consistent spatial distribution features, but with significant differences between them, especially in the vegetation PFTs. The simulated climate features with three LC datasets were mostly consistent with those of original LC dataset in the model. Compared with observation and simulations with original LC dataset, the simulation results with three new LC datasets showed different roles in reducing the model biases of temperature and precipitation.

Combining models and observations to quantify the historical impacts of Land Use/Land Cover Changes

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Human activities have profoundly transformed the land surface through land use/land cover change (LULCC). The direct impact of LULCC on climate through changes in the land surface properties has been investigated in numerous climate modeling studies. Most of these studies and notably the LUCID multi-model intercomparison have pointed to an overall cooling effect of historical deforestation despite the large uncertainties (1). This is because LULCC-induced albedo increase is thought to have a dominant influence at latitudes where most of the historical deforestation took place. This finding is however challenged by the more recent results from the CMIP5 intercomparison (2). While both the LUCID and CMIP5 models agree on an albedo-induced cooling in winter, a majority of CMIP5 models suggest an evapotranspiration-induced warming effect of LULCC in summer contrasting with LUCID results. Moreover, those models exhibiting a daytime summer warming also tend to be more in line with in-situ measurements of the local effect of deforestation (3). Observations, however, suggest an opposite response between daytime and nighttime temperatures that most models do not capture. After discussing the causes for the discrepancies between models and observations we will propose a general framework to combine satellite data (4) and model results to derive spatially-explicit maps of albedo, evapotranspiration and temperature changes that best reflect our current understanding of the role of LULCC.

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Increased Influence of Nitrogen Limitation on CO₂ Emissions from Future Land Use and Land-Use Change

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We estimate the impacts of nitrogen limitation on the CO₂ emissions from land use and land-use change (LULUC), including wood harvest, for the period 1900-2100. We use a land-surface model that includes a fully coupled carbon and nitrogen cycle, and accounts for forest regrowth processes following agricultural abandonment and wood harvest. Future projections are based on the four RCPs used in the IPCC Fifth Assessment Report, and we account for uncertainty in future climate for each scenario based on ensembles of climate model outputs. Results show that excluding nitrogen limitation will underestimate global LULUC emissions by 20-30% during the 20th century and by 90-150% during the 21st century. The underestimation increases with time because: (1) Projected annual wood harvest rates from forests summed over the 21st century are 380-1080% higher compared to those of the 20th century, resulting in more regrowing secondary forests, (2) Nitrogen limitation reduces the CO₂ fertilization effect on NPP of regrowing secondary forests following wood harvest and agricultural abandonment, and (3) Nitrogen limitation effect is aggravated by the gradual loss of soil nitrogen from LULUC disturbance. Our study implies that: (1) Nitrogen limitation of CO₂ uptake is substantial and sensitive to nitrogen inputs, (2) If LULUC emissions are larger than previously estimated in studies without nitrogen limitation, then meeting the same climate mitigation target would require an equivalent additional reduction of fossil fuel emissions, (3) The effectiveness of land-based mitigation strategies will critically depend on the interactions between nutrient limitations and secondary forests resulting from LULUC.

Impact of Accelerated Dryland Expansion on Desertification

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Drylands are home to more than 38% of the total global population and are one of the most sensitive areas to climate change and human activities. Projecting the areal change in drylands is essential for taking early action to prevent the aggravation of global desertification. Here, we found that the expansion rate relative to the observed climatology (1961-1990) would accelerate to 23% (11%), and the drylands would cover approximately 56% (50%) of the global land surface by the end of the 21st century under representative concentration pathways (RCPs) RCP8.5 and RCP4.5. Such an expansion of drylands would lead to reduced carbon sequestration and enhanced regional warming; the warming trends over the present drylands would be twice as great as those over humid regions. The increasing aridity, enhanced warming and rapidly growing population will exacerbate the risk of land degradation and desertification in the near future in developing countries, where 78% of dryland expansion and 50% of the population growth will occur under RCP8.5.

Simulating long-term effects of rainforest to oil palm conversion on carbon, water and energy fluxes and carbon stocks

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In Southeast Asia, the rapid expansion of oil palm monocultures and the concurrent destruction of rainforests and peatlands have been in the spotlight for their prominent roles in greenhouse gas emission. A thorough quantification of the carbon (C) balance of oil palm plantations and the long-term and large-scale forest – oil palm replacement effects is necessary for understanding the climatic impacts of tropical land use change.

This study presents a comprehensive analysis of the C dynamics and water and energy exchanges of oil palm plantations throughout all developmental stages (from planting to rotation) with a new modeling scheme designed for palm species within the Community Land Model framework (named CLM-Palm). Validated with available field data, the simulation shows clear distinctions between young and mature oil palm plantations and old-growth rainforest in C fluxes (e.g. GPP, NEE) and biophysical properties (e.g. evapotranspiration, surface albedo and temperature). A transient simulation spanning two rotation periods (each 25 years) showed that long-term oil palm cultivation is only able to restore about a half of the original total C storage capacity of the forested site before clear-cut. More than 50% of the net primary production by the oil palm plantation is not retained on the site but instead exported as oil products which are soon reverted to CO₂. Soil C stocks decline slowly and gradually due to the limited litter return in the managed plantation. Conversion of rainforest to oil palm plantation also has potential warming effects on the land surface at the site scale.

Annual changes in plant functional types and their responses to climate change

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Changes in plant functional types (PFTs) on the Northern Tibetan Plateau (NTP), largely unknown, have important implications for both local and regional climate. In this study, we used the soil water and heat improved Lund-Potsdam-Jena Dynamic Global Vegetation Model to investigate PFT changes through examining the changes in foliar projective coverages (FPCs) and try to understand the mechanisms of the changes through examining the responses of FPCs to changes in root zone soil temperature, soil moisture, air temperature, precipitation and CO₂ during 1957-2009. Vegetation changes were not uniform across the region during 1957-2009. About 34% of the NTP displayed increasing trends in vegetation coverage during 1957-2009 compared to 13% with decreasing trends. Precipitation was the major factor that affects FPC changes. Increases of total FPC in the southwest were related to the increases in alpine meadow and steppe due to the positive effects of increasing air temperature. Over the northeast, increases in total FPC were the results of the balance between increases in alpine meadow, temperate needleleaf evergreen trees, temperate grass/shrub and decreases in alpine steppe because of the positive precipitation and soil moisture impacts and negative air and soil temperature, and CO₂ impacts. Decreases of total FPC in the northwest were due to the negative effects of increasing air and soil temperature and CO₂ on alpine meadow and steppe. For the southeast, changes in total FPC were generally small. Different responses of individual FPCs to climate change result in spatially varying patterns of vegetation changes on the NTP. Changes in plant functional types (PFTs) on the Northern Tibetan Plateau (NTP), largely unknown, have important implications for both local and regional climate. In this study, we used the soil water and heat improved Lund-Potsdam-Jena Dynamic Global Vegetation Model to investigate PFT changes through examining the changes in foliar projective coverages (FPCs) and try to understand the mechanisms of the changes through examining the responses of FPCs to changes in root zone soil temperature, soil moisture, air temperature, precipitation and CO₂ during 1957-2009. Vegetation changes were not uniform across the region during 1957-2009. About 34% of the NTP displayed increasing trends in vegetation coverage during 1957-2009 compared to 13% with decreasing trends. Precipitation was the major factor that affects FPC changes. Increases of total FPC in the southwest were related to the increases in alpine meadow and steppe due to the positive effects of increasing air temperature. Over the northeast, increases in total FPC were the results of the balance between increases in alpine meadow, temperate needleleaf evergreen trees, temperate grass/shrub and decreases in alpine steppe because of the positive precipitation and soil moisture impacts and negative air and soil temperature, and CO₂ impacts. Decreases of total FPC in the northwest were due to the negative effects of increasing air and soil temperature and CO₂ on alpine meadow and steppe. For the southeast, changes in total FPC were generally small. Different responses of individual FPCs to climate change result in spatially varying patterns of vegetation changes on the NTP.

Modeling the impacts of irrigated area expansion on the water system in northern China

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The irrigated area increased rapidly during the past half century in the northern China. However, the impacts of irrigation are not well simulated in the Earth system models. In this study, a cropland module is incorporated into a land surface hydrological model with special focus on the use of green and blue water for irrigation. The blue water use refers to the consumption of water in cropland which is originated from rivers, reservoirs and lakes, and groundwater. The green water use refers to precipitation used in rainfed and irrigated croplands. The model is used to estimate the source of crop water use. The total water consumption of each crop, namely barley, corn, rice, soy, and wheat, is divided into water originating from blue and green water resources. Blue water consumption is found to be a large portion of the total cropland water consumption in the northern China. In the past half century, both green and blue water consumption increased along with expansion of cropland and irrigated area. Increase of blue water consumption is especially large. The share of blue water consumption in model estimated runoff became more than half in many river basins, suggesting that water demand for food has imposed a great pressure on water resources in the arid and semi-arid area of China.

Study on the spatial trend of the influence of the temperate forest land reclamation on the regional temperature

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The effect of temperate forest land reclamation on regional temperature is the result of the interaction change of albedo and evapotranspiration. The change of evapotranspiration has a direct effect on the heat distribution of latent heat and sensible heat, which leads to a certain spatial gradient of climate effect with the degree of moisture. This study takes the temperate forest in Northeast China as an example, and concerns about land cover change of forest land reclamation. Firstly, the surface energy budget and near surface air temperature changes would be simulated based on WRF model, in which local land cover data and time series of MODIS albedo and leaf area index data is input to improve the accuracy of the model. Then, according to the observation data of the weather station, the dryness index is calculated to quantitatively describe the spatial variation of the degree of moisture. Based on the quantitative moisture data, the quantitative relationship between the land surface net energy flux, latent heat flux, the air temperature near the land and dryness index would be analyzed. By comparing the variation of the three parameters with the change of dryness index, the quantitative relationship of the spatial pattern of the influence of the change of evapotranspiration in the land cover change on the regional temperature would be described. The results showed that, from the semi humid area to humid area, there was a significant warming gradient of near surface air temperature change with the influence of forest land reclamation.

Progress in land system science

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A preliminary study of improving global leaf area index (LAI) estimation based on data assimilation research testbed and the community land model version 4

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The leaf area index (LAI) is a key variable in regulating the global carbon, energy, and water cycles, while both in-situ observation and simulation show biases in amplitude and phase. Land data assimilation, combining observation and simulation together, can provide the most accurate variable estimation. Meanwhile, satellite-derived dataset could provide the data basis for land data assimilation.

The Community Land Model with the prognostic carbon–nitrogen option (CLM4CN) is linked with the Data Assimilation Research Testbed (DART) developed by the National Centre for Atmospheric Research (NCAR). Random 40-member atmospheric forcing is used to drive the CLM4CN with or without LAI data assimilation. The Global Land Surface Satellite LAI data (GLASS LAI) LAI is assimilated into the CLM4CN at a frequency of 8 days, and LAI (and leaf carbon / nitrogen) are adjusted at each time step.

The results show that the Ensemble Adjust Kalman Filter as well as including carbon-nitrogen control is the best method for LAI assimilation. In detail, the CLM4-CN simulated LAI systematically overestimates global LAI, especially in low latitude. While if updating both LAI and leaf carbon and leaf nitrogen, the analysed LAI can be corrected, especially in low latitude regions.

Based on assimilated LAI and potential LAI, the influence of simulation ability for land surface variables, and land-atmosphere exchange variables are analysed. The results show the most obviously improved regions locate in the Amazon regions, the centre of Africa, the east and northeast of Asia, the southeast of North America, and the west of Eurasia.

Wilderness: a land governance concept built on science, applied by a diverse international community

The contribution of wilderness protection to adaptive capacity: A case study from Wyoming and Montana, USA

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Lands protected for wilderness character provide a range of water-based benefits that support regional economies and contribute to quality of life. Outdoor educators value wild rivers for teaching search and rescue and backcountry medicine, mountain snowpack holds water for late summer when farmers value it most, residents depend on ground water replenishment, and healthy rivers provide refuge for fish species and recreation. Understanding distribution of these benefits can guide improving land governance systems focused on sustainable and resilient human-nature relationships. Recent research improves knowledge of how public lands policies influence community resilience through water benefits.

Using Q-methodology, we investigated the importance of water-based benefits and the various factors threatening those benefits flowing from the Shoshone National Forest (over half is protected as Wilderness) to areas of Montana and Wyoming. The diverse opinions of 96 stakeholders yielded four major orientations of residents toward water: environmental, agricultural, recreation, and Native American. Wilderness protection contributes uniquely to the adaptive capacity of each perspective. For example, those aligning with the environmental perspective place high value on wilderness for protecting watersheds from extractive industries, which supports adaptation for a regionally important trout species. Despite the mostly positive impact of wilderness designation on community adaptation concerns, in some cases wilderness was perceived as an impediment to reaping some water benefits. This presentation will focus on the nuance and detail of the four perspectives by highlighting both the costs and benefits of wilderness protection, and how those costs and benefits affect community vulnerability and adaptive capacity.

Where is Wild Asia? Concepts of wilderness mapping and protection applied to China and beyond.

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Whilst wilderness is a concept that may be thought of as European in its origins, it can be applied at all spatial scales from global to local and across a range of social and cultural settings. Knowing where wilderness is and being able to map its boundaries with some element of certainty is essential for effective policy-making and implementation in regard to nature protection and ecosystem service delivery. This paper looks briefly at the history of map-making and the idea of wilderness, from the blank spots on early maps to modern Geographical Information Systems. Lessons learnt from wilderness mapping projects across multiple spatial scales and areas in Europe and North America are summarised before looking in detail at contemporary Asia and the inherent differences to western society including history and culture. Modern mapping tools and datasets are applied to China and her neighbours to explore remnant patterns of wilderness and compare these to protected area networks to assess the efficacy of wilderness protection. Distinctions are made between “de jure” wilderness (i.e. that which is legally protected as IUCN Cat1a/b or 2 protected areas) and that which is “de facto” (i.e. those landscapes that bear all the hallmarks of wilderness and yet remain unprotected by formal or limited designations). The paper concludes with suggestions for collaborative work on mapping projects and strategic thinking on wilderness protection across Asia.

First global management guidelines for wilderness protected areas

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Published in September 2016 the International Union for the Conservation of Nature (IUCN) Management Guidelines of Protected Areas 1b are the first international management guidelines for wilderness. This presentation would highlight this publication and its international use. These guidelines were produced and reviewed by an independent, international team of experts (Indigenous Peoples and non-Indigenous Peoples) who are field managers, academic researchers, policymakers from governments and non-governmental organizations. The product created and reviewed by this team is the first-ever international guidelines produced for wilderness managers. These guidelines will provide instructions for managing wilderness around the world, examples of those who successfully manage wilderness, and the tools and principles necessary to manage wilderness.

The IUCN protected area category of wilderness allows us to understand nature *on its own terms* and maintain those terms while allowing (and even encouraging) humans to experience wilderness. No other category of protected area management allows for such a relationship between humans and nature. Wilderness is important to culture, science and the environment. Wilderness protected areas provide ecosystem services, monitoring baselines, wildlife corridors for movement, traditional cultural practices in nature and wilderness-dependent recreation. Threats posed by inappropriate human development, climate change and other environmental degradations require good scientific practices to guide management practices. Good management necessitates understanding the ecology and the people in relationship with the wilderness area, and considering human needs, histories, and expectations as well as the requirements of wild nature itself. The IUCN Management Guidelines outlines the challenges, techniques, and tools of wilderness protection.

The role of a land ethic in wilderness designation and research

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The role of a land ethic in wilderness designation and research

The concept of “Wilderness Area” was defined in the US Wilderness Act of 1964 as a place where a human is a visitor who does not remain; a place where humans leave only footprints and take only memories. The Act describes it as a place primarily in pristine condition where natural processes are allowed to exist unfettered (wild) by human controls. A more broad definition of wilderness was adopted as part of the IUCN protected area management categories which classify protected areas according to their management objectives. Category 1b ‘Wilderness areas,’ retain and are managed to preserve their natural character without permanent or significant human habitation. Increasing adoption of a land ethic by societies around the world has led to unique applications of the wilderness concept as a legislative, policy or zoning concept to keep areas intact, avoid development that is not sustainable and contribute to adaptive planning in the face of climate change uncertainty. This flash talk will first define the concept of a land ethic and discuss its influence on development of the National Wilderness Preservation System in the US and around the world and its influence on defining a wilderness science agenda.

The possibility of wilderness protection in China and in the Chinese mind

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Wilderness has been widely recognized as an important component of the world conservation movement and a specific category (Category 1b) of the International Union for the Conservation of Nature (IUCN) Protected Area Category System. It is sometimes advocated as a land classification providing opportunities for humans to experience natural and unfettered environments; it also makes important contributions to conservation by providing core areas for biodiversity, refuges for endangered species, baseline understanding of environmental change influences, protection of quality and quantity of drinking water, as well as safeguarding spiritual and intrinsic values of nature. Wilderness legislation and policies exist in many parts of the world. The European Parliament adopted a resolution in 2009 supporting the protection of wilderness in the existing Natura 2000 network. In Asia, Japan's Nature Conservation Law set aside five IUCN Category 1b Wilderness Areas; Sri Lanka has a National Heritage Wilderness Areas Act and 9000 km² protected as wilderness. As the world responds to China's increasingly important roles in the world economy, ecological conditions and politics, there is a growing interest in understanding Chinese perceptions of issues of international significance. Conservationists are interested in the potential benefits of and barriers to application of wilderness to Asian cultures.

Land systems in an urbanizing and telecoupled world - POSTER SESSION

Spatial context of suburbanisation: case of Bratislava's hinterland

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Housing development is one of the most widespread driving force of land use change in the European landscape. Houses are mostly developed in a form of clusters in the suburban zones of vital economic regions. Although substantial differences within the European regions exists, the regional maps suggest that in the last decade suburbanization trends are more unrestrained in the former „Eastern-block“ countries. Our paper analyses the hinterland of Slovakia's capital city Bratislava from the perspective of the spatial arrangement of housing construction. Moreover, by analysing migrant structure of 111 municipalities constituting the hinterland of Bratislava using multivariate statistics we identify several types of suburban development with different character of population structure and spatial arrangement of housing construction. While migrants from the city of Bratislava prefer densely built-up and compact large-scale housing projects, movers from other parts of Slovakia form fragmented and dispersed spatial pattern of housing construction. This can be explained not only by property price variation but also by different cultural background and housing aspirations. The analysis reveals a hidden mosaic of spatial and social structure which is important to understand the current trends that decisively form the socio-spatial organisation of hinterland of postsocialist cities.

Identifying conservation priorities in a rapidly urbanizing landscape: a habitat network perspective

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Abstract: Biodiversity conservation is challenging in urbanizing landscapes where there is recurring habitat degradation and limited space for subsequent restoration. Conservation efforts based on natural reserves can not necessarily maintain certain ecological processes that take place across whole habitat network. There is a need to conserve or restore critical habitats outside protected areas for maintaining the functional connectivity of networks. In this study, we developed a connectivity modelling approach associated with varying conservation scenarios to identifying habitat conservation priorities in a rapidly urbanizing area of Shenzhen, China. We incorporated unprotected habitat patches into the reserve network via four scenarios and prioritized the contributions of those patches to the overall network connectivity. We also investigated the responses of species with different dispersal abilities to habitat changes under each conservation scenario, respectively. The results showed that habitat patches around protected areas could create large connectivity gains and should be prioritized for conservation. Connectivity benefits from different scenarios were closely linked with species' dispersal abilities. Key patches that could enhance connectivity substantially were also identified as conservation priorities. The species-specific and site-specific conservation schemes we provided are useful to making informed decisions in urban planning and management.

Impacts of urban expansion on net primary productivity in the drylands in northern China

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Assessing the impacts of urban expansion on the Net Primary Productivity (NPP) is essential to understand the ecological issues caused by urbanization in the drylands in northern China. In this study, we assessed the impacts of urban expansion on NPP in the Hohhot-Baotou-Ordos (HBO) region – a rapidly urbanizing area in the drylands in northern China. Based on the land use/cover map with resolution of 30 meters, we examined the spatiotemporal patterns of NPP of urban land in HBO in the period of 2009-2013, and compared them with those derived from other land cover types. The results showed that the mean NPP of urban land was 572.50 NDVI*PAR, which was 3.81% higher than the regional average. The largest NPP value of urban land, occurring in July, was equal to 123.94 NDVI*PAR, which was 7.33% higher than the regional average. The higher NPP in urban land is mainly attributed to urban green space in HBO.

The Evolution of the Urban Sprawl in the Sao Paulo – Rio de Janeiro Corridor and its effects on wetland ecosystem

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The Paraíba do Sul river basin is located in Southeastern Brazil linking the two main metropolitan regions in Brazil (Sao Paulo and Rio de Janeiro). This region comprises a Cenozoic rift valley bordered by two large mountain chains. Important cities are located in this region along the Paraíba do Sul river. This region has played an important role in the Brazilian development history, characterized by cycles of different agricultural activities in the past, and an intensive process of industrialization from the 60s. Currently, the landscape is a diversified mosaic where pastures dominate, followed by patches of forests, silviculture, agriculture, and urban areas. The Paraíba do Sul river has a large alluvial plain that can reach 6 km wide and exposed to periodic flooding. Since the beginning of the 20th rice irrigation is planted in the alluvial plain whose physical environment is suitable for this crop (melanic soils, extremely low slopes, and high level phreatic). Remote sensing multi-temporal data (Landsat TM) has showed a significant decrease in irrigation area varying from 32.4 to 6.4% in the alluvial plain for the period 1988 to 2003. In the Sao Paulo – Rio de Janeiro corridor the advance of the urbanization is one of main cause of the reduction of wet rice cultivation and elimination of wetlands ecosystems. The next steps of this research are to evaluate, quantitatively, the landscape dynamic in the last 30 years and the consequences of urbanization on the loss and degradation of wetland ecosystem.

Measurement of negative externalities stem from different kinds of rural-urban land conversion in urbanization: Based on method of Choice Experiments

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Abstract : The rapid urbanization in China results in large scale of rural-urban land conversion which brings out increasing negative externalities. This paper classifies the urban land uses which converted from rural land to three kinds, including residential and commercial land, industrial and transportation land, public management and service land. The Choice Experiment method is employed to the case study of Wuhan City in China. 339 residents were sampled at random to evaluate their willingness to pay regarding different negative externalities' attributes, and finally the external externalities from three kinds of rural-urban land conversion are measured. The result shows that rural-urban land conversion can bring out seven kinds of external externalities, including traffic congestion, noise, inadequate public facilities, poor security situation, natural landscape vanish, air pollution and personal safety decline; the intensity of external externalities originate from different kinds of rural-urban land conversion are different; and the external costs of rural land transferring to residential and commercial land, industrial and transportation land, public management and service land are 63770 yuan / ha, 57978 yuan / ha and 69632 yuan / ha respectively.

The regulation of land use scale in new urbanization perspective

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New urbanization is a hot topic in our country, but also the focus of scholar research and public policy difficulties. However, when the research perspective focus on land management, we discovery that accompanied by the accelerating process of urbanization, China's land use facing more challenges. the unprecedented pace and huge of urbanization, and the extensive land use lead the urban expansion coefficient to "scientific boundaries," the stock of arable land resources approaching "survival red line" and the urban living environment beyond the "ecological bottom line". In view of this, this paper first defines the new content and features of urbanization on the basis of in-depth analysis of China's urbanization development status; then, focus the research perspective on land management, found that China's urbanization development path presents Logistic Curve (S) law, and the growth rate of urbanization differences in distinct regional, such as the Beijing of the eastern part while the urbanization growth rate by the accelerated growth occurs changes to decelerate growth inflection point in 1975, earlier than the nation point in 2011, inflection point in the central region of Hubei province consistent with the national, while the western region of Gansu Province in 2030 will be a turning point, much later than the country and the central and eastern regions. To predict the scale of 23 provinces in 2015 Residential towns chemical mine land use regulation, in order to give some rational advice for our government.

Integrating market and regulation mechanisms to predict urban growth

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Urban growth patterns are influenced by regulations (e.g. zoning) and market mechanisms. Although zoning has been included in spatially explicit land-use models as a constraint (binary variable – planned for built-up or not), we are not aware of any studies trying to spatially explicitly model the outcome of current zoning practices. Economic land-use models assume that market mechanisms are the main driver of land-use change. However, they do not explicitly model regulations like zoning and often implicitly assume that zoning follows the market. We use data on past zoning plans in the canton of Bern in Switzerland to predict the location of future zones. The prediction involves a logistic regression calibrated to changes in zoning plans (from past to present), using a variety of socio-economic and biophysical factors as independent variables and a mechanism for allocating clustered zones instead of single disaggregated zones. Within zones we use an economic model to allocate built-up areas including land-prices as the main driver. Our results show that zoning may not simply follow the market, but seems to be mainly influenced by the location of existing built-up areas and roads. Using a combination of the two models we are able to show that uncertainty about future drivers of urban growth (e.g. population growth) may result in sprawl-like growth patterns.

Prediction of land use change for southeastern China based on CA-Markov model——Case study of Quanzhou Bay

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With the rapid development of coastal cities, there appears new characteristic which influences the land use dramatically in city development in China. This study simulated the spatiotemporal changes of land use in Quanzhou Bay Area in Fujian Province, China using CA-Markov model in IDRISI software. our results showed that farmland is converted to built (urban) most of which is located in the riverside and seashore and close to the transportation lines during the time period of 1994 and 2024. In 1996-2001 and 2001-2010, the built land has increased 4868 ha and 13168 ha respectively. The central urban area of Quanzhou City , such as Jinjiang, Shishi City and Hui'an areas all become centralized from dispersed situation, the urban size in Quanzhou Bay area has reached great-leap-forward development, and formed many urban groups. Urban development tends to be more compact and the development of built area appears the intensive utilization trend in this region. The study provides reasonable support for future development planning of region and conservation and construction of ecological environment.

Influence of Vegetation on Land Surface Temperature

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Vegetation is an important part of the earth underlying surface, and land surface temperature (LST) is a key parameter of land surface physical process in regional scale or in global scale, an important index of monitoring the earth resource and studying the ecological environment system of land surface. This paper investigated the applicability of vegetation fraction derived from a normalized linearity spectral mixture analysis model as an indicator of vegetation abundance to estimate the vegetation-LST relationship, regarded Zhengzhou region as study area, LandsatTM/ETM+ image as main data sources. The transformed TM/ETM+ images were unmixed into four fraction images (green vegetation, impervious surface, water and soil) with a constrained least-square solution. It managed mono-window algorithm to retrieve land surface temperature based on the LandsatTM/ETM+ hot infrared image and the meteorological data, thus gained the land surface temperature image. Finally it received the conclusion by analyzing the connection between green vegetation fraction image and LST image: the vegetation-LST relationship was middle negative correlation.

Action mechanism of land finance on economic growth in China under the industrial structure perspective

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In recent years, land finance has become the hot spot of research in China. Many papers have studied the relationship between land finance and economic growth. Yet, the internal structure of land finance is neglected and the empirical research of cities' data is lacking. In China, land finance usually is the action of municipal governments. So this paper examines the action mechanism of land finance and its impacts on economic growth by constructing a panel data model of land finance, economic growth and industrial structure with the annual data of 33 cities in China from 2009 to 2013. The major findings are follows: First, the promotion of land finance on economic growth is mainly based on industrial structure upgrading caused by land tax. Second, in land finance, compared with land tax, land grant income has no significant effect on promoting economic growth directly. Third, both of land tax revenue and land grant income have significant effects on the industrial structure upgrading. As a result, preferential land tax and land grant policies should be used to promote the industry structure upgrading and economic growth.

The growing land footprint of Chinese pork production

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As developing economies urbanise and grow, their populations tend to undergo a dietary transition. The consumption of traditional staple foods declines, and meat and dairy consumption rises. Livestock products, however, have a disproportionate impact on the environment, and so there is concern about the sustainability of these emerging diets. Using government data on the grain use in different pork production systems and FAO trade data, we quantified the changing land use of Chinese pork production – which increased 50% from 2000-2013. We find that while the total land use of Chinese pork rose 17%, the international land use rose 2.5-fold. These figures reflect two competing trends: the increasing efficiency and expansion of modern, industrial pig and arable farming, and the decline of, and increasing use of grain- and soybean-based feeds in, smallholder production systems. We find that global land use would have been 29% larger if yields had not increased over the time period and 9% lower if smallholder production had not declined in importance. Our results highlight both the importance of efforts to increase agricultural yields, and promote the use of low impact animal feeds – such as the food and green wastes used in traditional pork production systems.

Modelling the impact of rural migration on tropical deforestation in South-West Ethiopia

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A major driver of tropical deforestation is rural frontier migration. In this paper an attempt is made to formally describe the human-environment interactions that are manifested in a forested system experiencing a large influx of rural migrants. The Guraferda district in South-West Ethiopia was selected as an exemplary case-study. On the basis of an extensive field surveys in several villages, the relation different social groups in the area were identified: the native population, recent immigrants and investors. For each of these groups their livelihood and their relation with the forest resources was analyzed on the basis of interviews and mapped via remote sensing.

To formalize the identified human-environment interactions, an agent-based model was developed. The model simulates the decision-making process concerning deforestation of the identified agent types. The native population consists of shifting cultivators, while the new immigrants are technologically more advanced and are sedentary farmers. For each grid cell of the landscape, utilities for the agent types are calculated. High potential yields increase utility, while proneness to diseases, high population density and the presence of forest decrease utility. Learning behavior is implemented, allowing native agents to learn from migrants and vice versa, thus increasing productivity. Agricultural investors are added to the model as a passive agent type that can acquire land. Results show that in-migration started with the forced resettlements in 1985, after which voluntary migrants followed in great number thereby pushing the native population to new frontiers. Ongoing land acquisitions by external investors are accelerating this process.

A comparison with observations shows that the model is able to reproduce spatial patterns of deforestation in land systems under pressure of different groups of land users at is therefore a valuable tool for exploratory research in land change science.

Analyzing Optimization of Settlement System in Reclamation Region Heilongjiang Province ——A case study of Jiansanjiang Authority

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The purpose of this paper is to analyze the optimization experience of settlement system in Reclamation region Heilongjiang province, summarize the available reference and promoting values. This paper takes Qixing, Daxing and Chuangye farm as study area. The method includes field research, spatial analysis and literature research. The results show that, First, the number and area of settlements decreased attribute to the optimization of spatial structure and scale structure of settlement system in 4 years. The conservation and intensive use of residential land is promoted, and for local residents, the production and living is more convenient. Second, the optimize measures of settlement system includes spatial optimization of settlement system, orderly organization in the process of optimization and various financing. The conclusions is the optimize process of settlement system should be done in a short time with the protection of clear rights of land and property, diverse financing channels, consummate system of social security, agricultural modernization and the rapid development of secondary and ternary industries, the construction of various agricultural ancillary facilities and a reasonable road network. While normal countryside should reasonability guide and orderly advance the natural historical process of the optimization of urban and rural system with the change of agricultural population structure, and the steady development of non-agricultural rural population, urbanization, industrialization and agricultural modernization.

Spatial-temporal Differentiation of Conversion Efficiencies of Agricultural Land to Non-agricultural Land in China

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Based on DEA-malmquist TFP index and ESDA model, this paper analyzed the characteristics of spatial-temporal differentiation of conversion efficiencies of agricultural to non-agricultural land in China from 2000 to 2008. Several results were presented: 1) the efficiencies of agricultural land conversion were relatively low, which implied that the input factors were not sufficiently used; 2) with the improvement of land administration system and the innovation of land use technology, technical efficiency has increased and technology development has significantly improved total factor productivity; 3) there were positive spatial autocorrelations in technical efficiency among provincial regions. The "hot spot" areas were mainly located in the Yangtze River Delta, Pearl River Delta and Beijing-Tianjin-Hebei regions in Eastern China, whereas the "cold spot" areas were mainly in Xinjiang, Qinghai and Sichuan provinces in Western China; 4) Agricultural land conversion efficiencies declined from eastern region to central and western regions, with the distribution closely related to the economic spatial pattern. Because of significant advantage of late-development, agricultural land conversion efficiencies of western region were improved most among the three regions, which led to gradual decrease in regional efficiency differences. The paper also pointed out that at present the primary goal of policy regulation of agricultural land conversion in China should not be increasing the size of regional agricultural land conversion. More attention should be paid to increasing the supporting inputs of capital and technology, so as to improve the resources efficiencies of agricultural land conversion and promote the change in the pattern of resources utilization.

Integrated economic-land use change modeling in the Amazon

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Since mid-2000s, several measures have been taken to curb Amazon deforestation in Brazil, which dropped 79% up to 2015. However, this process raise concerns owed of the unintended effects of such interventions, like land use displacements. Here we explore an innovative modeling approach for the Amazon in order to simulate how the global demand for agricultural commodities and different regional land use policies could affect future deforestation trends inside and outside the Amazon, paying special attention to leakage effects over the Cerrado. A global economic model was taken to integrate supply and demand factors at both global and regional scales, coupled with a spatially explicitly land use model. Leakage effects are simulated in two different ways, regarding land demand and land allocation, based on the relative land rents of different land use types and spatial regression. Six contrasting multi-scale scenarios are explored focusing on deforestation rates and spatial pattern analysis. Our results unveil that Amazon conservation might not be the end of deforestation in Brazil once it can lead 43% increase over the Cerrado cleared area up to 2050. Biofuels targets compliance can further press land cover changes over these regions revealing that productivity gains will be decisive for both Amazon and Cerrado conservation. In summary, closing the agricultural frontier in the Amazon cannot ensure biodiversity conservation or carbon savings in absence of complementary measures committed with land use efficiency, controlled land use expansion and new economic alternatives.

Identification of fractional urban signals for regional climate models

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Rapid urbanization has changed land use and urban structure in China and therefore greatly modified land surface properties and land-atmosphere interactions, causing further local and regional climate change. Climate model simulation and urbanization process analysis are usually limited by poor accuracy of coarse-resolution land use/cover products employed in regional climate models. This study sought to identify better urban representations from Landsat images and monitor urban expansion by changing patterns of urban density and inner connections. We used the improved normalized indices based method to classify urban and built-up areas from Landsat images, and evaluated at both the pixel scale and the model grid scale, with overall accuracy of 88% and k coefficient of 0.76. Moreover, urbanization process was examined from 2000 to 2009 in the Pearl River Delta. We aggregated the original results of urban classification data from Landsat images as fractional cover information in 1 km grids. The total fractional urban change in 2000-2005 (9.03%) was much greater than in 2005-2009 (3.38%), whereas urban fractions in the interval of 0.8-1 increased more in the latter five years. We also compared the fractional cover of urban expansion with the corresponding period of existing land-cover products. It showed that coarse-resolution land-cover products had deviations and could not capture well the underlying conditions and urbanization process. Different fractional cover of urban scenarios were expected to provide better inputs for accurate modeling of climate feedbacks over expanding urban clusters in China.

Linking transboundary production and local change: Laos in the context of an integrating Greater Mekong Sub-region

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This proposed research aims to connect changes in livelihoods and land-use practices in upland villages of Laos to the transboundary agricultural commodity networks that increasingly embody economic integration in the Greater Mekong Sub-region. Agrarian scholars have long sought to identify ways of linking localized rural change with wider political-economic processes and structures that govern them. Frameworks aiming to capture these linkages analytically have more recently emerged from economic geography and land change science literatures. In the former case, chain and network concepts (global commodity/value chains and global production networks, or GPN) have sought to depict the functions and governance of spatially dispersed modes of production, but are yet to effectively respond to environmental and social outcomes at local scales. Land change science has meanwhile advanced frameworks for understanding how economic activity drives changes in productive landscapes across space (teleconnection, telecoupling), in terms of material flows and land conversion – recently beginning to integrate GPN perspectives, though remaining challenged by addressing the socially embedded nature of such networks. The proposed research aims to harness complementarities between GPN theory and telecoupling in a study of maize production in northern Laos to examine a) how transboundary commodity networks form and b) their effects on livelihoods, labour allocation and land-change at sites of production. The research will advance critical perspectives on the functions of such networks and their effects on access to and conversion of resources, common focuses of agrarian studies that are presently absent in much global chain/network and land change science research.

Urban vulnerability/resilience to climate extremes

The relationship between urbanization, land use system and water intensity

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The change of consumption in resources by urban expansion has significant effects not only on cities but also on their hinterlands. Resources required for urban expansion would be imported much more from the hinterlands and may cause resource shortage problems. For example, food, energy production systems and manufactories would have to compete for water in a limited water supply situation, and thus intensify the nexus of water intensity for energy and food consumption because of higher demand of resources in commercial and industrialized regions. These issues come down to the land system that supports all the production activities of water, energy and food production. Therefore it is crucial to couple management of land use with management of resources such as water in order to pursue urban sustainability.

Such a coupled management requires knowledge on the interaction between resource demand during urban development and land use activities driven by socio-economic patterns. This study aims to develop the methodologies of the nexus management by performing the integrated water resource management for a small island that faces water shortage and a scattered watershed. Using teleconnection method with the geographic information system, we map the risk of the supply chain nexus and identify the areas that lead to higher risks of water resource security and efficiency. The strategies of land system management as well as the adaptation measures like water recycling or lifestyle modification can then be developed to decrease tradeoffs of resources efficiencies and risks.

Resilience and vulnerability to extreme heat in New York City

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Although resilience and vulnerability may be two sides of the same coin, the concepts often have different implications in empirical research. Vulnerability refers to conditions of exposure, sensitivity and coping capacities that exacerbate or attenuate risk. These three dimensions are shaped through historic processes; yet vulnerability research generally treats them as temporally static conditions. Resilience research, on the other hand, explicitly addresses the temporal dimension, but often focuses narrowly on biophysical exposure while neglecting important social risk factors.

Through a case study of New York City, I illustrate an approach to integrating resilience and vulnerability to health impacts of extreme heat events. By the 2080's, the frequency of heat waves in New York City are anticipated to triple and heat-related premature mortality is expected to increase by 70% by the year 2050. With high rates of poverty and high proportions of racial and ethnic minorities, the northern Manhattan neighborhood of Harlem is particularly vulnerable to extreme heat. By examining spatial relationships between landscape-based extreme heat exposure indicators and demographic sensitivity indicators at a fine scale, I identify areas in Northern Manhattan that are especially vulnerable to extreme heat. I use this analysis in an engaged climate action planning process, aimed at building community capacity to withstand extreme heat events. This scientifically-informed visioning process illustrates ways in which spatially-explicit vulnerability analysis can be used to inform capacity-building processes and to understand ways in which these processes enable communities to become more resilient.

The Truly Disadvantaged? Assessing Spatiotemporal Variability in Social Vulnerability to Climate Change in Urban India

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The rapid pace of urbanization in India has significantly increased the vulnerability of urban areas to the dangers of climate change as well as and other natural hazards. Characterizing social vulnerability of urban areas should provide a reference for urban risk management. We have developed a Composite Urban Vulnerability Index (CUVI) for India's urban areas by integrating 13 indicators from three aspects (exposure, sensitivity, and adaptive capacity) that shape the vulnerability of a society. The spatial-temporal patterns of social vulnerability of urban areas and its changes over three periods (2004-05, 2009-10, and 2011-12) are identified and mapped. The analysis reveals that social vulnerability has declined considerably over the study periods at national level. There is clearly a heavy concentration of social vulnerability in central and eastern states, such as Madhya Pradesh, Chhattisgarh, Orissa, Jharkhand, and West Bengal, attributable largely to the high levels of poverty, inequality, and problems relating to unemployment, housing, and access to basic civic amenities like safe drinking water and sanitation. Only the urban populations in relatively prosperous Northern and Southern states are relatively less vulnerable to climate change. The results signify that while social communities in urban areas across India are, in general, developing resilience to climate change, large contrasts exist, attributing to the socioeconomic and geographical differentiation among States.

Resilient Spatial Planning: Reinventing urban and regional planning for sustainable spatial transformation

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It is more and more realized that interwoven comprehensiveness is the nature of global challenges today. There perhaps can never be any single-handed solution, which exhibits our usual segmented and single-directional understanding of our world and its problems and mechanisms. Any public policy tool has to be not just comprehensive but also coordinative and integrative. The key challenge is how to find a truly holistic rather than amalgam solution, as the latter will inevitably lead to the invalid laboring towards something like “if planning is everything, maybe it’s nothing”.

As a comprehensive tool, planning has been repeatedly criticized and experienced many “turns”. However, the criticisms and “turns” are essentially re-emphasis of some under-integrated aspects (such as the human aspect, the rural aspect or the democratic aspect) and turning from some biased aspects to some biased others. The difficulty for a successful innovation of planning is how to reconcile and integrate the mega-complex (often seemingly conflicting) aspects confronting planning. Since the birth of modern planning, our knowledge of these aspects has been greatly developed (1960s-70s is probably the first big jump and since 1980s we see another great jump). But without discovering a structure that can support such a mega-complex reconciliation and integration intellectual endeavor, the reinvention of planning cannot be successful. The paper will propose that Resilient Spatial Planning, with the Resilient Spatial Structure, Resilient Toolkit and Holistic Planning Methodology as three pillars, could be a new integrative planning genre meeting these demands.

Extreme climate events, globalization, and capital relocation: telecoupling and urbanization in Yangon, Myanmar

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Yangon, Myanmar has rapidly urbanized since the country started its economic liberalization in the late 1980s. Privatization, relocation of the capital from Yangon to Nay Pyi Taw, and extreme climate events, such as cyclone Nargis in 2008, along with globalization reflected by massive inflows of foreign direct investment (FDI), overseas aid, and tourism, have all exerted significant influences on the urban transformation of Yangon. The socioeconomic and environmental interactions between multiple human and environmental systems over a distance, known as telecoupling, have molded the urbanization process. In this study, we first assessed the spatiotemporal changes of urban land expansion, the restructuring of urban land, and the environmental changes (e.g., air quality, green space, flooding vulnerability) from 1988 to 2015 based on satellite imageries, historic land use maps, and expert validation. We then used the telecoupling framework to understand the influences of human systems (e.g., institutional change of privatization and capital relocation, globalization by FDI and tourism) and natural systems (e.g., landscape change, extreme climate event of cyclone Nargis) on Yangon's urbanization and sustainability, encompassing economic development, environmental change, and social equity. We employed both qualitative (e.g., expert panels and interviews) and quantitative methods (e.g., regression and correlation analysis) to explore the complex relationships. Our analysis indicated that a distinct different set of main driving forces had affected the urbanization process for 1988–1992, 1992–2005, and 2005–2015. Our study provided an example on how the telecoupling framework can be applied to reveal the complex interactions during an urbanization process.

White roofs are an effective strategy for adaptation to urban climate change on a large scale

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Urban areas are shown to have more heat stress than rural areas in a warming future. Urban climate mitigation and adaptation strategies have profound impacts on the lives of urban residents. However, the assessments of commonly proposed urban temperature adaptation strategies are either incomprehensive or poorly constrained. Here we use a “shot-gun” approach, that combines climate modeling and an UHI (urban heat island) attribution method, to show that white roofs are the most effective strategy in terms of UHI reduction. Under climate change, it is able to offset the climate warming induced by greenhouse gas. Across all the selected cities in this study, white roofs reduce the daytime UHI on average by 4.9 K, 5.9 K, and 5.6 K under current climate, RCP 4.5 and RCP 8.5 scenario, respectively. Cities are turned into “cold islands” (negative UHI) by white roofs in current and future climate. Green roofs are not as effective as white roofs, but are generally more effective than street vegetation. Significant reduction of vertical temperature gradient induced by white roofs in a warming future seems problematic because it would lessen the dispersion of air pollutants in the city. Comparisons between white roofs and rooftop solar PVs are also discussed in this paper. This study underscores the importance of considering geographically when devising urban adaptation strategies rather than one-size-fits-all solutions.

Populations’ Demand for Ecosystem Services and Landscape Sustainability

Measuring unequal impacts of afforestation on the provision of ecosystem services to rural households in India.

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Afforestation is emerging as a major tool to achieve global carbon sequestration goals, yet there is relatively little research documenting the impacts of afforestation on the provision of ecosystem services to rural populations. Changing land cover shifts the mix of goods and services provided by land to local people, and these shifts may have positive or negative impacts depending on prior land cover, the type of afforestation, and the livelihood strategies people follow. We collected comprehensive data on afforestation projects conducted in Kangra District, in the foothills of the western Himalaya in India, and then visited a subset of villages to collect information about how different land covers were used by rural populations, and how these uses shift as a result of local afforestation projects. We find that afforestation often replaces degraded forests or pasture lands with single species plantations. While these plantations have the potential to generate timber and revenue, as well as provide global public goods such as carbon sequestration, they decrease the availability of fodder, firewood, and some non-timber forest products. These changes appear to have unequal impacts at the village level, as poorer households are more likely to be dependent on these products.

Sustainable management of ecosystem services based on their relationships between supply and demand

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Societal demand for food, water and other life-sustaining resources is growing at unprecedented levels. Both ecosystem service and human development policies aimed to improve human well-being through the conservation of ecosystems that provide valuable services. Yet, how ecosystem services deliver at multiple scales, influence multiple stakeholders, and change through time is rarely carefully analyzed. Here we examine two different policies in China, both of which ostensibly aim to protect and provide ecosystem services. The programs are (1) the Paddy Land-to-Dry Land (PLDL) program in Beijing, China that aims to improve ecosystem water provision and water purification service; (2) the Relocation and Settlement Program (RSP) of Southern Shaanxi Province that pays households who opt voluntarily to resettle from mountainous areas and aims to reduce disaster risk, restore important ecosystem services, and improve human well-being. We compare the different approaches of these programs using household surveys and biophysical data in an integrated economic cost-benefit analysis for multiple stakeholders. The ecosystem service delivery influences multiple stakeholders at multiple scales during the program implementations. However, we found household livelihood behavior dynamics during policy implementation and the differentiation of different stakeholders to policies played a key role in successful program implementation and acquiring expected policy effects. Our results from these two cases indicate accounting household livelihood behavior dynamics and various scales of time and space is required to understand the ways that local changes can influence ecosystem service and human wellbeing outcomes. These have important applications for achieving multi-win goals in ecosystem service conservation programs.

Measurement and pattern of rural livelihood diversity in the Three Gorges Reservoir Area

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Livelihood diversity is an important strategy for farmers to deal with environmental changes and maintain their livelihood. Livelihoods diversity can affect the ecosystem services trade off in multiple spatial and temporal processes, and then are closely related to the ecological security and human well-being, which is the key to the sustainable development of mountain areas. We choose the Three Gorges Reservoir area where there rural livelihood vulnerability was more prominent as our study area, carried out the participation rural survey. And based on International Standard Industrial Classification of All Economic Activities, We built four diversity indexes, from capital diversity, crop diversity, behavioural diversity and income diversity to assess the rural livelihood in this region, analyzed the livelihood diversity spatial pattern and the affecting factors. The results showed that the diversity index of industry classification measure was better than the traditional method, but the level livelihood diversity in Three Gorge Reservoir area was generally low. Livelihood diversity displayed obvious spatial pattern which was closely related to the geographical location, elevation, land use etc. The livelihood of biodiversity had more obvious scale characteristics and there were significant differences in the household, village and township scales. Livelihood diversity is an important strategy for farmers to deal with environmental changes and maintain their livelihood. Livelihoods diversity can affect the ecosystem services trade off in multiple spatial and temporal processes, and then are closely related to the ecological security and human well-being, which is the key to the sustainable development of mountain areas. We choose the Three Gorges Reservoir area where there rural livelihood vulnerability was more prominent as our study area, carried out the participation rural survey. And based on International Standard Industrial Classification of All Economic Activities, We built four diversity indexes, from capital diversity, crop diversity, behavioural diversity and income diversity to assess the rural livelihood in this region, analyzed the livelihood diversity spatial pattern and the affecting factors. The results showed that the diversity index of industry classification measure was better than the traditional method, but the level livelihood diversity in Three Gorge Reservoir area was generally low. Livelihood diversity displayed obvious spatial pattern which was closely related to the geographical location, elevation, land use etc. The livelihood of biodiversity had more obvious scale characteristics and there were significant differences in the household, village and township scales.

Drivers of secondary vegetation dynamics in the Brazilian Amazon

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Recently, the political dimension of secondary forests gained importance in the context of climate change mitigation due to their role as potential carbon sinks. In this context, Brazil's submitted INDC (Intended National Determined Contribution) declared the country's commitment to zero illegal deforestation by 2030 and compensate GHG emissions from legal deforestation by restoring 12 million hectares of forest. However, despite the fact that secondary vegetation covers around 20% of the Brazilian Amazon deforested area, it consists mostly of a temporary land cover, with limited potential for sequestering carbon on the long term. Therefore, to assess the feasibility of the Brazilian target and better inform decision makers about the possible outcomes of public policies, it is necessary to expand the current understanding about secondary vegetation dynamics. In this study we aim to expand the knowledge about the drivers of secondary vegetation for the whole Brazilian Legal Amazon. We draw on remote sensing based bi-annual land use and cover maps, covering the period between 2004-2014. We developed a statistical model to investigate the relationship between socio-economic, biophysical and policy related variables and the increase and decrease of secondary vegetation on a municipality level. Specifically, we aim to understand how land availability constraints (e.g. forest debt according to the Brazilian Forest Code) have influenced change in secondary vegetation areas in the last decade. Additionally, we evaluate the expansion and retraction of secondary vegetation to understand if regrowth occurs in areas of high or low potential of carbon sequestration to provide policy relevant recommendations.

Forestland Subdivision as Rural Gentrification? Urban ecology in exurban forests.

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An estimated 35% of US forestland, and nearly 41% of EU forestland is owned by family forest owners. A major ecosystem management goal therefore is to ensure those households contribute to long-term forest sustainability. Much research to date has focused on how increased subdivision of private forestland, or parcelization, is associated with forest fragmentation. This parcelization often occurs through a decrease in the commodity value of forest products, coupled with increasing demand for forests for recreational or residential use. We argue that this forest subdivision process can be the local expression of a landscape-level amenity transition or "consumption countryside." Therefore, spatial analysis that focuses too narrowly on correlating metrics of parcelization and forest fragmentation is missing a larger process of rural or exurban "redevelopment." Moreover, traditional policies, e.g., tax relief to forest landowners with larger parcels, may be undermined by a land market that heats up through the process of exurban land conversion. Applying insights from the urban gentrification literature to the issue of forestland parcelization yields important insights about necessary landscape-level forest management.

Sustainability in an urbanizing world: the role of people

Harini Nagendra

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The pattern, trend and environmental impacts of the large-scale urban/industrial expansion

Impacts of urban impervious surface areas and greenness on surface heat regulation in urban ecosystem

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The metropolitan area of Beijing is a focus of concern with regard to China's urbanization and environmental challenge. Severe environmental issues such as extreme heat and air pollution, which are related to impervious surface expansion. Beijing has experienced fast urban expansion in the past three decades. Through urban surface radiation and flux observations stations on comparison with impervious surface vs. green space using two eddy covariance platforms since 2011 in Beijing, we found that (1) LST was about 3–6 °C higher in urban than in rural area, with about 6–12 °C higher at impervious surface than green space, resulted from the differences in solar radiation and land surface characteristics; (2) Different LSTs in urban were primarily caused by the differences in land surface radiation and energy fluxes; (3) Mean Bowen ratio increased significantly from 0.73 in the outskirts to 0.90 in suburbs to 1.22 in urban area, mainly due to the significant differences in LE, which declined from 282.45 W/m² in the outskirts to 244.02 W/m² in suburbs to 196.95 W/m² in the urban area. For the purpose of heat stress regulation, it is recommendable to upgrade the traditional low-rise residential areas to modern high-rise residential areas that have lower sensible heat and preserve water surfaces in city center. We found that the thermal regulating strength of vegetation (LE/VFC) decreased exponentially with increased green space coverage and recommend the municipal administrator to focus on expanding the green spaces in intensively built-up areas like the city center and the southern part of built-up area.

Impacts of urbanization and farmland expansion on ecological land system in terrestrial China, 1990-2010

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With the accelerating urbanization and farmland expansion, ecological land system mainly consists of forest, grassland, wetland and presented as the primarily providers of ecosystem services, was encroached in recent 20 years. Based on long-term land use and land cover change datasets detected from satellite images in China, the spatial patterns and temporal trends of ecological land system were analyzed, and the driving forces were discussed. The area of ecological land system was 5.6 million km² and covered nearly 60% of the terrestrial China. From 1990 to 2000, the ecological land was encroached by 68201.5 km², in which 83.56% were occupied by urbans and farmland. During 2000-2010, the ecological land was encroached by 43490.2 km², and 77.55% were occupied by urbans and farmland. The encroachment was mainly driven by farmland expansion in northern China, and urbanization in Eastern and Southern China. Compared the before 10 years, the area and proportion of ecological encroachment were decreased obviously, especially the farmland expansion, which could be contributed by the ecological conservation and restoration programs like Grain for Green Program. However, the ecological encroachment by urbanization increased by 2.81 times in the after 10 years, which reminded that faster urbanization would be the potential change forces for ecological conservation in future. Therefore, under the climate change and economic development, the balance among ecological conservation, urbanization and farmland expansion should be considered, and the red line of ecological protection should be constructed through nature reserves, key ecological function areas, and priority areas for biodiversity conservation.

Mapping fractional impervious surface area distribution in China using integration of DMSP-OLS and MODIS data

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Mapping impervious surface area (ISA) has obtained greatly attention due to its importance in many applications such as socioeconomic research, energy consumption, population estimation, air pollution, and urban climate change. However, ISA mapping at regional or global scale using remotely sensed imagery is a challenge due to the confusion of spectral signatures between ISA and other land covers such as bare soil, water or wetland, and the mixed pixel problems due to coarse spatial resolution and the complex urban land cover composition. The city light (e.g., DMSP-OLS) data are often used to map global ISA distribution, but its coarse spatial resolution and data saturation problem produced inaccurate estimates. This research proposed a new approach to integrate DMSP-OLS and MODIS NDVI to reduce above-mentioned problems. A support vector machine (SVM) approach was then used to develop the ISA estimation model based on the relationship between ISA from Landsat images and the newly developed index from the DMSP-OLS and MODIS NDVI integration. The ISA estimates from this proposed approach was further compared with the results based on individual DMSP-OLS and MODIS NDVI respectively using traditional linear regression analysis. This research indicates that the newly proposed approach provided better estimation performances than single DMSP-OLS or MODIS NDVI variable. Compared to the traditional approach, the SVM approach improved the spatial patterns of ISA distribution and the estimation accuracy. This paper provided a rapid and accurate approach to map fractional ISA distribution in China based on the integration of DMSP-OLS and MODIS imagery.

The rapid expansion of China's industrial land in the rural areas and the environmental costs

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China's industrial growth accompanied huge environmental costs. In response to the environmental awareness among city residents, the government relocated factories from urban areas to rural areas. Our study indicates that the area of rural industrial lands (RIL) was 30.0×10^3 km² in 2010 in China. The expansion rate of RIL in the 2000s (0.2×10^3 km²/yr) was about 7 times that in the 1990s (1.6×10^3 km²/yr), about 70% of the expansion in the 2000s took place after 2005. The rural mining (RM) area has increased from 4.9×10^3 km² in 2000 to 7.2×10^3 km² in 2010. As the results, the RIL area under high risk of landslide has increased 172% from 1990 to 2010. About 80% of the increase took place after 2005. The RM area under high risk of landslide has increased 45% in the 2000s. The number of settlements within 1 km distance from the RIL and RM and the nature conservation areas within 4 km distance from the RIL and RM increased dramatically from 2000 to 2010. The crop production and the net primary productivity of the China's ecosystems lost due to the expansion of RIL and RM. We also found significant correlations between soil and water pollutions and the closeness from the RM in China

The problem of China's land use and suggestions for policy improvement

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With the rapid urbanization and industrialization, China is facing series of prominent problems in land use and land management. Those problems include that the farmland preservation is challenging, the rural and urban construction land use is still extensive, the carrying capacity of resources and environment is hard to support the ongoing urbanization, the "land finance" has accumulated risk to economy development, the rural land intuitions does not meet the demand of rural-urban integration development. The article put forward some suggestions for policy improvement with aim to ensure land supply for economic development and urban-rural integration development, which include improving the system of land use regulation, land use rights market, land taking, the policy of extant construction land and the policy of rural collectively-owned construction land.

ASSURE: a model for the simulation of urban expansion and intra-urban social segregation

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Numerous cities in developing regions worldwide are expanding at a tremendous rate. This requires adequate strategies to address the needs of these growing cities with diverse populations. Nonetheless, the development of urban policies is often hampered by the lack of reliable data or insight in the socio-spatial dynamics of this urban expansion. This paper therefore presents ASSURE, a spatially and temporally explicit model that can simulate urban growth and intra-urban social segregation, taking into account alternative policy strategies and expected social dynamics. The model has a flexible structure that allows incorporating specific city-conditions that influence residential decision making and adapting the simulation to the data available. This, in combination with the transparent model structure, makes ASSURE a potentially valuable decision support tool for urban planning. The potential is demonstrated with an example where the urban growth of and social segregation in Kampala (Uganda) is simulated based on (semi-)quantitative and qualitative data for ca 800 households collected through interviews. The results of the simulations show that depending on the scenario, the spatial segregation and accessibility problems will evolve differently.

A combined ABM-CA approach for analyzing effects of peer-influence and landowner decision-making processes on patterns of urban development

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In many parts of the U.S., population growth combined with continued demand for low-density housing is transforming the structure of peri-urban landscapes. Despite the substantial amount of privately owned land, the important decision-making roles that individual landowners play in shaping patterns of urbanization and landscape change is understudied. We introduce a data-informed simulation model developed to analyze the decision-making processes that determine spatial characteristics of fragmentation in peri-urban areas by combining the utility of a cellular automata urban growth algorithm (CA module), based on the FUTURES model, with an agent-based model (ABM module). The CA module is conceptualized as a ‘developer’ in the urbanization process and responds to demand for development by selecting candidate development locations based on site suitability factors. The ABM module is composed of landowner agents categorized by typologies of willingness to sell (WTS). Their WTS allows the CA module to convert a location to a new development. We consider landowner typologies that differ in preferences, values and socio-economic characteristics, leading to variation in WTS and subsequently different urban growth patterns. We also include peer influence as an integral component of the landowners’ decision-making processes. To test the spatio-temporal behavior of the simulations, we applied the model for Cabarrus County in North Carolina. The simulation results show specific landscape characteristics that are the result of landowner decisions as prescribed by our model, and others that do not align with our hypotheses. These simulations contribute to further description of processes underlying emergent urban growth patterns in heterogeneous landscapes and mixed ownership characteristics.

A analysis on the urban sprawl and urban landscape pattern between 1985 and 2000 in the Pearl River Delta, China

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Urbanization is an irreversible trend worldwide, especially in rapidly developing China. Accelerated urbanization has resulted in rapid urban sprawl and urban landscape pattern changes. Quantifying the spatiotemporal dynamic of urban land use and landscape pattern changes can not only reveal the characteristic of social transfer and economic development but can also provide insights into driving forces of land use changes. In this study, we coupled remote sensing (RS), a geographic information system (GIS), gradient analysis and landscape metrics to quantitatively compare the spatiotemporal dynamics on land use, urban sprawl and landscape pattern for nine cities in the Pearl River Delta from 1985 to 2000. The results show an increase in buildup land and shrinking cropland in the Pearl River Delta. For the whole region, the phenomenon of urbanization was obvious, and for the nine selected cities, there existed a great difference between the sprawling process and the magnitude, both at spatial and temporal dimensions. Guangzhou and Shenzhen are shown as the two most intense examples of urban sprawl. The urban landscape changes could help understand the different stages of urban development and reflect specialty urbanization. The results also provide important implications for future urban planning and land management strategies in China.

The emergence of metropolitan institutions in the Barcelona and Milan regions and their influence on urban land change

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The creation of the metropolitan bodies of Barcelona (1953) and Milan (1961) goes back to the early 1960s. Despite their different national and regional socio-political contexts, both institutions emerged in an effort to regulate the uncontrolled urban expansion of the central cities beyond their administrative boundaries. This paper adopts a territorial, multi-scalar governance perspective to comparatively examine a) the establishment of the two metropolitan bodies; and b) the similar yet specific development of land use regulatory systems for urbanization and sprawl containment. Interviews in both Barcelona and Milan with planners, politicians and stakeholders at different institutional levels, and document analysis on the most relevant plans and regulations for land use management at the national, regional, provincial and local level, have been combined with an examination of land use data (1950s-2000s) for both metropolitan regions. The paper evaluates the regulatory effectiveness of the two metropolitan bodies in terms of land containment strategies and sustainability, the Barcelona case being relatively more successful than the Milan one. In the paper, it is suggested that such difference can be explained by the divergent trajectories of the two metropolitan bodies as political institutions. While the Barcelona metropolitan body has been consolidating, recently establishing itself as a proper administrative governance scale (*administración pública*) in 2011, the role of the Milan metropolitan body has been confined to perform a relevant, but politically marginal, role as a research centre on urbanization and infrastructure issues. The paper will describe and discuss these two similar, yet differentiated trajectories in terms of territorial, multi-scalar governance, and which consequences they have had for land use and urban development.

Research on the Path of Land Consolidation in Shanghai

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Basing on the current situation, characteristics and problems of land use in Shanghai, the paper proposed how to select land consolidation routes in Shanghai using data analysis, field survey and other methods. As a metropolis, Shanghai should adhere to the leadership of "land consolidation plus" strategy on global land consolidation. The strategic objectives are the increasement of cultivated land, the promotion of intensive land use level, the improvement of ecological condition, the stimulation of rural inner vitality, and the optimization of spatial form. Meanwhile, Shanghai should use "City - District - Country units" three levels land consolidation planning system to guide the implementation of urban and rural development strategy. Also, Shanghai should build intellectual support platform, resource integration platform and idea communication platform by practicing "land consolidation plus", so that the value of rural would be explored, remodeled and spread. At last, Shanghai should build global working mechanisms and policy system, including the balancing mechanism of spatial development rights, the division and cooperation mechanism, the benefit-sharing mechanism, the reward and punishment mechanism, etc. These paths can effectively promote the development and transformation of Shanghai's economy and society. It can also provide a reference of land consolidation for other large cities.

Spatial-Temporal Variations of Ecological Land in China During 2010-2015

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Ecological civilization construction strategy has played a more and more important role in China. In order to recognize the ecological situation, we choosed ecological land as an indicator. At first, we picked out the scope of the ecological land based on *the Land Use Condition Classification for National Standard (GB/T21010-2007)* by the contingent valuation method. The results showed that the primary category of ecological land include woodland, grassland, waters and other land. The secondary categories comprise forestland, shrubland, other woodland, natural grassland, artificial grassland, other grassland, park and green land, river, lake, reservoir, pit pond, tidal flat, inland beaches, glaciers and perennial snowfield, wetland.

Secondly, we analyzed the spatial structure and regional disparity of ecological land in 2015. The total area is 580 million ha, and include 286.40 million ha woodland, 252.99 million ha grassland, 37.30 million ha water and 3.70 other land. From the perspective of regional disparity, the south, northeast, and southwest area of China are mainly woodland, the Tibet and Qinghai are mainly grassland. Water is mainly distributed in Shanghai, Jiangsu and Zhejiang.

Thirdly, we proposed the spatial-temporal variations of ecological land during 2010-2015. The results showed that the total ecological land kept on declining from 582.26 million ha to 580.40 million. The area of all ecological land types was decreasing except for reservoir, especially the other grassland and forestland, decreased 0.52 and 0.50 million ha respectively. The developed provinces such as Beijing, Tianjin, Shanghai, Zhejiang, Jiangsu showed more significantly reduced rate.

At last, we analyzed the sources and flows of main ecological land types. From 2010 to 2015, the increased wood land mainly came from cropland, grassland and construction land, while the decreased woodland are mainly transfered into construction land and cropland. The grassland were mainly transfered from forest land, cropland and park and green land, while transfered into cropland and construction land. Water area was mainly from cropland and forest land, and transfered into mud flat and pond. Wetland was mainly from water and cropland, while mainly transfers to cropland, park and green land, forest land, grassland and construction land.

Review and Prospect of land reclamation in China Coal Mining Areas

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China is the number one coal production and consumption country, coal consumption accounts for approximately 75% of the annual energy consumption in China. The coal mining activities severely impact the eco-system and environment, and due to large scale of land occupation and degradation, around 4 million ha has been damaged, and the land loss speed achieved 70,000 ha/a. Since the rapid increase of coal production in China, mining subsidence is now and will continue to be a serious mine environmental issue in the foreseeable future and the conflicts in land resource between coal industry and agriculture. To solve these conflicts, China has made great efforts in the mine land reclamation since 1980s. This paper introduces the importance of land reclamation in China, reviews the landmarks of the policy, regulations on land reclamation coal mining areas over the past 30 years, outlines the key technologies in the coal mine area with high ground water table and the ecological fragile and arid area, including the concurrent mining and reclamation, Yellow river sediments backfilling, soil reconstruction and the ecological restoration techniques. At last, the research prospect of the land reclamation in farmland restoration, ecological system restoration, contaminated site remediation, reclamation products and commercialization has been introduced.

World Café / Open discussion - Agriculture as a driver of land-use and land-cover change Connecting the debates: Smallholder decision-making and large-scale land acquisitions

Monitoring LSLA and their contribution to land use change: results and challenges for the Land Matrix

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The Land Matrix is a global, independent monitoring initiative (www.landmatrix.org). It reports on international large-scale land acquisitions (LSLA) larger than 200ha, excluding smaller or purely domestic deals, as well as land transactions between private and commercial land owners. Currently it lists 1156 concluded deals amounting to about 39 Mio ha of land, making it the world's most extensive inventory of large-scale land acquisitions.

Based on the Land Matrix data and selected case studies of the upcoming Analytical Report of the Land Matrix, this presentation analyses the targeted social-ecological contexts of land deals to identify main trade-offs and synergies associated with LSLA-triggered land-use change. Analysis of the data showed that large-scale land deals in the global South do not target "idle" or "marginal" land. Land deals target croplands, forests and grasslands, in each a case creating distinct socio-ecological impacts. Data from 2012 and 2016 datasets will be presented, based on most recent analytical report of the Land Matrix.

Keeping up-to-date and accurate data in a global inventory remains challenge. Furthermore, depending on the context, other forms of land acquisitions are also impacting on land use change. For instance, domestic investors are important actors in many countries. Smaller land deals heavily influence land use changes. Accumulation of land, previously owned by private owners in the hand of large companies is another process, presently not systematically captured in the Land Matrix. Currently, the Land Matrix aims at decentralizing its efforts, by creating national land observatories or forging links to other observatories.

Applying the ecosystem services concept to urban and urbanising land systems

Latin American cities as regional landscape controls of change and stability

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Urban centers are a distinctive cultural landscape feature with huge and growing influence on the functioning of ecological and land systems. Most studies on the ecological effects of urban growth have focused on the impacts on increased consumption of nearby or distant resources that drive land use and ecological change. However, urban centers constitute long term persistent landscape units and (in addition to change) they promote landscape stability and resilience by different mechanisms (e.g. peri-urban forest transition, stable agricultural systems relying on urban-based knowledge and products' demand, protected areas derived from urban culture and aesthetics). We use community ecology (e.g. disturbance ecology, rank-abundance curves, density dependency and foraging theory) to describe the trends and processes of land use change associated with the history of urban growth and spatial dynamics of Latin American cities since the European invasion in the early 16th century to the present. Much of the urban matrix of Latin America was established during the 16th century and persisted to the present in association to distinctive features of the Latin American landscape (low rural population and overall population density, strong historical influence of teleconnections, and a central global role as provider of agricultural products and reservoir of biodiversity). Different examples show that urban centers contribute to landscape and land use stability and resilience, which have received much less attention than the drivers and forcing factors of change.

Are Smart Cities Ecologically Foolish? Crowding Out Biodiversity and Ecosystem Services in India's Growing Cities

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‘Smart cities’ have been much in the news lately, across the world as well as in India. ‘Smart’ is an attractive prefix. In one stroke it appears to do away with the current image of grime, congestion and chaos that plague Indian cities, replacing it with an alternate image of clean, efficient and safe spaces. Among the factors recognised as vital for an improved quality of life in smart cities is the need for a smart environment, and the concept note and subsequent public discussions around it are sprinkled with mention of environmental sustainability. However, these mentions of sustainability shed poor light on what the term actually means in the context of urban planning in India. This presentation interrogates the ecological intelligence of smart cities, drawing on a long term programme of research in Bengaluru, one of India’s largest and fastest growing cities. Describing changes in land use, land cover and ecosystem services in urban natural spaces such as lakes, parks and wooded groves, we highlight the dangers of the failure to view these resources as multi-use spaces that support a range of ecosystem services. The smart cities model is proposed for 100 cities across India. However, its limited view of the importance of biodiversity and ecosystem services in urban environments is a major cause for concern. Urban planning needs to be developed on a foundation of urban nature to enable cities that are ecologically resilient, and socially just.

Valuing land assets through ecosystem services to inform development planning at urban fringes

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VALUING LAND ASSETS THROUGH ECOSYSTEM SERVICES TO INFORM DEVELOPMENT PLANNING AT URBAN FRINGES

The identification and valuation of ecosystem services by stakeholder surveys in a land assets framework is described for Onkaparinga, a local government area spanning the urban-rural gradient in the Adelaide metropolitan area (South Australia). 128 ecosystem services-defined land assets were identified on hybrid land use-cover maps sent to 171 stakeholders. The land assets identified were grouped into production spaces, and soil and water assets (both of which provide high levels of provisioning services), built environment assets (relatively in high supporting services.) and conservation spaces (balanced provisioning, regulating, and supporting services). Production spaces are also key economic assets for nationally and for South Australia, while conservation areas are vital for regional environmental sustainability. Experts valued the stakeholder-identified assets in a scoring exercise. Five scenarios ranging from high production through to high sustainability were developed by weighting the values of the ten most important provisioning, supporting and regulating services and then were evaluated by the key stakeholders using multi-criteria analysis. Key findings are that the public-at-large, and even many stakeholders, have little understanding of the ecosystems services concept, let alone how it can be used to inform the planning and development processes by council planners to target the best options for preserving assets as well as enhancing their ability to improve the wellbeing of residents by providing a range of ecosystem services. Education and training is required before this concept can be operationalized.

Tradeoffs and synergies between intensive land use and ecological service in urban land system: An empirical study of Xuzhou City development

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Intensification is an apodictic pathway for the rapid urbanization in China considering the huge population and limited arable land, meanwhile, ecologicalization should also be very important due to the urban diseases such as traffic jam, urban heat island effect, urban haze, so the judicious pathway for land use decision in the process of urbanization is a difficult problem, therefore, it is urgent to study the tradeoffs and synergies between intensive land use and urban ecosystem service in urban land system. In this paper, Xuzhou, which became the first National Ecological Garden City in February 2016, was taken as a case study to examine tradeoffs and synergies between both sides. Data employed was from social statistics and remote sensing images in 1985, 1995, 2005 and 2015. Based on the multi index evaluation and models to measure intensive level and ecosystem service ability, the degree of tradeoffs and synergies as well as their change during the past 30 years were assessed. The results indicated that: (1) There existed a significant phenomenon of synergies between the intensive land use and urban ecosystem service within the built-up area of Xuzhou City. The level of land intensive use was improved steadily as well as the ecosystem services value. This implies that it is possible to realize a win-win status between intensive and ecological land uses. The improvement of intensive land use can spare more urban space for ecological construction, in turn, the ecological spillover effect can significantly increase the value of urban land so as to promote intensive development of urban space. (2) The tradeoffs also existed between the intensive land use and ecosystem service. On one hand, the tradeoffs presented among the multi ecosystem services such as supporting, regulating, culture and supply. On the other hand, there was a nonlinear relationship between the level of intensive land use and ecosystem service. The tradeoffs were mainly influenced by urban economic development, land scarcity and urban infrastructure investment. Within a specific urban space, there is an ideal combination of intensive land use and ecosystem service, which however remains difficult to gain quantitatively. (3) The spatial distributions of intensive land use and ecosystem services were heterogenous. Compared to the old downtown, the newly expanded and economic development districts had a higher land eco-utilization with higher floor area ratios. This might be the positive outcomes from urban planning and land governance. However, these new tall buildings in urban periphery inhibited the air flow as to create a negative effect of “concave of urban center”, which was harmful for the diffusion of atmospheric pollutants like haze. So this effect makes clear that it is essential to weigh and balance the intensive use and eco-utilization of urban land system.

A comparative study on the temporal and spatial patterns of ecosystem service value based on land use change in Liaoning

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Research on ecosystem service value based on land use change was one of the hot topics in the study of Global Land Projection. Based on the data of land use area from 2005 to 2010 in every prefecture-level City of Liaoning province, we studied land use change with the use of dynamic degree of land use change and its ecological services value with the help of ecosystem service value coefficient of Xie Gaudi in China, and we analyzed the influencing factors of ecosystem services values in terms of correlation analysis. Results indicated that the area of garden land, forest land, grassland and construction land throughout the whole province increased relatively, while the area of cultivated land, water and unused land decreased. Spatially, ecological service value in Chaoyang, Dandong was the most and it was the least in Panjin, Yingkou and Liaoyang. Temporally, ecological service value has increased from 2005 to 2010 in Liaoning. Driving factors effecting the change of ecosystem service value in Liaoning Province can be summarized as economic, population and urbanization level. We proposed some measures and suggestion for the sustainable utilization of land resources and ecological environment protection in every prefecture-level City of Liaoning province.

Conceptualizing and modelling spatial planning as a driver of land system change in urban regions

Evaluation of urban planning implementation: An analytical framework for Chinese cities and case study of Beijing

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Most existing studies on urban planning implementation (UPI) evaluation examine the conformity between planned and observed spatial urban development. The results are, however, typically too general to provide adequate policy recommendations for planners and researchers. The stages between creating a plan and its outcome are seldom discussed in detail, primarily because of the absence of an applicable analytic framework and data. In the present paper, we propose a framework for UPI evaluation which provides an in-depth and accurate application to show how the conceptual framework for assessing conformance and performance (sequential conformance) of plans proposed by Hopkins (2012) could be applied in practice. We examined the degrees of conformance and performance between an urban master plan, detailed plans, development permits and observed development outcomes, using Beijing as an example. The results reveal discrepancies between all basic stages of plan implementation, and the poor planning implementation was primarily due to the existence of large areas of development without development permits. Moreover, there was clear cross-referencing in the planning implementation process, which undermined the formal planning implementation procedures. These results suggest that the poor match between a plan and its outcomes may result from poor plan using, not poor planning. Therefore, attention needs to be paid not only to creating plans but also to monitoring the performance of various levels of plans and development permits in the UPI.

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Measuring spatial information contained in strategic spatial plans - a prerequisite for conceptualizing planning as a driver of urban land change

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Theoretical and empirical understanding of the contributions of strategic spatial plans (SSPs) to land use and land cover changes in urban regions are still missing. One of the challenges that hamper scientific progress is the lack of methods to analyse the information contained in strategic plans and to assess their role in shaping future land changes. Therefore, the objectives of the paper are to: a) determine the type of spatial information contained in SSPs of West-European urban regions; and, b) develop a methodology for measuring the spatial information with landscape metrics. Theoretical sampling is applied for the selection of case studies since it allows for discovery and facilitates covering the existing variation in design and content of SSPs. First, we conduct a systematic categorization of the spatial information in the selected plans. Text of the plans and cartographic representations (icons, diagrams, maps) are analysed in respect to the information they provide on spatial concepts, neighbourhood configurations and land use. Particularly, the level of abstraction and complexity of cartographic representations are analysed in terms of logic differentiation of topographic elements and boundaries, graphical differentiation of point, area and line symbols, representation of time and flows. Secondly, a theoretical link is established between the spatial information and landscape metrics. Previous studies showed that in simulated land use scenarios, landscape metrics are useful to characterize changes in landscape configurations of metropolitan areas. Based on these findings we develop a methodology for measuring spatial information on urban development patterns in strategic plans. Of priority to the study are metrics that measure information explicitly taking into account the complexity of urban landscape mosaic. Future research will focus on testing the metrics in real-world case studies.

A proposal for a theoretical model linking strategic spatial planning and land-use change in European urban regions

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Planning and political factors are known to have a considerable influence on land-use change. However, they remain under-researched. One of the reasons for this may be that spatial planning is context-sensitive, while land-change modelling aims at generality. Specifically, planning and policy often originate and act on local and regional scales in contrast to economic, natural and cultural drivers, which tend to work on national to global scales. A key challenge for land change science is thus to conceptualize and model spatial planning and policy practice as drivers of land-use change. Within the five-year CONCUR-project we address this task as follows: By focusing on strategic spatial plans, and based on state of the art literature in a broad range of fields, such as territorial governance, complexity theory, plan evaluation and strategic spatial planning, we propose a theoretical model of how planning contributes to land change with the following core concepts: (1) spatial information and concepts as contained in strategic spatial plans, (2) key elements of territorial governance, and (3) supra-regional development trajectories. Empirical data from selected European urban regions is used to describe and illustrate these core concepts. Future research will assess the applicability of the proposed theoretical framework by operationalizing and testing the model in selected regions. Ideally this will lead to tools that can be systematically applied in land-change modelling.

Land use competition and regulatory pathways in the context of New-type Urbanization Plan in the Northern China Plain

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Cultivated land was primarily encroached by urban land in China. Identifying and mitigating the competition between cultivated protection and urban construction is the urgent issue to be addressed towards sustainable land resource utilization in the context of China's new-type urbanization plan. Revealing the competitive relations and trade-offs between cultivated protection and urban construction, and selecting regulatory pathways will provide scientific support to alleviate the contradiction of competitive land uses. The Northern China Plain has little potential to increase grain production capability, but rapidly increasing of urban land demand. To break the current dilemma in this region, with the support of multi-source data and interdisciplinary methods, including spatial analysis, multilevel modeling and directional distance function, this paper aims to summarize the characteristics of grain production and urbanization in different stages in Northern China Plain, examine the spatio-temporal pattern and explain the driving factors of competitive relations between cultivated protection and urban land expansion, evaluate the trade-offs between grain production and urban development under various scenarios, screening the potential pathways for optimal land allocation, and finally put forward integrated land resource regulatory options.

Spatial pattern and mechanism difference analysis of impervious surface expansion in typical coastal economic zones

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China has experienced rapid urbanization since the Reform and Opening. In particular, the coastal areas of artificial construction land area increased dramatically. Beijing-Tianjin-Hebei region, Yangtze River Delta region and Pearl River Delta region are typical urbanization areas in China. And the coastal zone in these areas is undergoing rapid economic development and over exploitation of resources. Because of the occupation of important ecological land, there are a series of ecological environment problems, such as the disappearance of coastal native wetlands, the reduction of natural conservation and biodiversity conservation area. In this article, based on the impervious surface data of the typical coastal economic zones in 2000 and 2008, the occupancy and supplementary relationship between impervious surface expansion and ecological land of the coastal zone buffers in the three typical coastal economic zones were analysed. The results showed that: (1) During 2000-2008, Beijing-Tianjin-Hebei region had the largest impervious surface area with 1695.45km². The smallest area was in Pearl River Delta region with 1152.19km². However, from the point of view of the impervious ratio, the area ratio larger than 80% was maximum in Pearl River Delta region with 36.14%. (2) Analysis of impervious surface expansion source indicated that the main types were ecological land and cultivated land in the three typical economic zones. Among them, the proportion of ecological land occupation was largest in Pearl River Delta region with 61.9%. The impervious surface expansion was mainly caused by the occupation of cultivated land. (3) The spatial variation of impervious surface expansion in buffers showed that, with the increase of buffer width, ecological land and cultivated land occupation due to impervious surface expansion was a linear increase feature in Beijing-Tianjin-Hebei region and Yangtze River Delta region. However, in Pearl River Delta region, this feature was logarithmic function increase and had threshold value in about 80km.

Legal evaluation method and result on illegal land use

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Legal rules on illegal land use is seen as a approach in keeping the harmony of a society, and its effectiveness evaluation play a vital role in obstructing illegal land use. Aiming to realize the weakness of relevant policy, a evaluation system will be established through choosing indexes from current data of 31 provinces ,including its quantity, types,frequency, etc. and weighing with PCA. Then, comprehensive evaluation method will be used to assess legal effect province by province. It is indicated that legal effect on illegal land use of east part of China demonstrated worse than that of rest parts. On the basis of different results, finding out policy discrepancy among provinces and giving some advise on implement, duty, etc. to modify the rules for the sake of reducing illegal land use behavior.

Estimating Urban Carbon Dioxide Emissions in Yangtze River Delta Urban Agglomerations

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Cities are responsible for more than 70% of global CO₂ emissions, while occupying just 2% of the earth land. To tackle the climate change issues at city scale is becoming increasingly needed and urgent especially in rapidly urbanizing regions. However, the lack of comprehensive, consistent and comparable statistical data on energy consumption and human activities at city scale hinders our understanding of the changing patterns and driving forces of carbon emissions. To address the challenges, we develop an efficient and effective method and use nighttime light as a proxy to estimate urban CO₂ emissions in the 25 cities of Yangzi River Delta urban agglomerations in China between 1992-2013. It is found that urban CO₂ emissions in YRD region had increased by approximately 10 times from 243 million tons in 1992 to 2070 million tons in 2013. The faster growth in CO₂ emissions than that of urban sprawl indicates that more carbon intensive activities have been aggregating in urban areas during the last 22 years. This method could be used as a complement to the existing CO₂ accounting approaches, and would provide policy makers important information for designing policies and taking actions to reduce the carbon footprint at city scale.

Spatio-temporal dynamics of cropping pattern in Northeast China using CROPS Model

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Research on cropping pattern change is one of the most important areas in agricultural land change science. Difficulties in acquisition of cropping pattern data in long time series remain challenging issues. Therefore, mechanisms driving cropping pattern change of rice, wheat, maize and soybean in Northeast China are analyzed for the past three decades (1980-2010) in this research, based on a cropping pattern simulation model (CROPS). The research attempts to take a natural- and social-science combined approach by defining input parameters using remote sensing images and statistical data. Result from this research are explain the spatio-temporal dynamics of cropping pattern and to clarify the change process and reason. At the same time, the study research conversion process of crop type in the period, and make clear the conversion area and spatial location of the crops. The research is of great importance in optimizing agricultural crop structures, ensuring national food security and promoting sustainable development.

Exploring mismatches and power asymmetries in telecoupled land systems

Telecoupled land use and ecosystem services between nature reserves and cities

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Global urbanization is increasing demand for ecosystem services in distant areas, including remote nature reserves, to support a growing urban human population and households. To understand the spatial separation between provision of and demand for ecosystem services, we apply the integrated framework of telecoupling (socioeconomic and environmental interactions over distances) to analyze the causes, effects, and agents of ecosystem services flows between cities and nature reserves. We focus on Chengdu, a large city with 14.3 million people in Southwestern China, as the receiving system of ecosystem services, and 41 nature reserves for giant pandas as the sending systems. Results show that the nature reserves provide diverse ecosystem services (e.g., provisioning services, such as food and clean water; cultural services, such as recreational benefits) to Chengdu. The causes behind the ecosystem services flows include different land cover and land use between the urban system and nature reserves. The ecosystem service flows have resulted in both socioeconomic and ecological effects, including community development, land use conversion and forest changes. We have also found that there are a diverse set of agents that made the flows possible, including farmers in and around nature reserves, traders, city consumers, government agencies, and reserve staff. This study helped to better understand the complex relationships between urbanization and nature conservation, and has important implications for achieving sustainability and resilience in both cities and nature reserves.

Power Dynamics in Telecoupled Human and Natural Systems

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International trade is an important telecoupling process that connects people and the environment in distant places around the globe. Power dynamics are crucial in shaping telecoupled human and natural systems, but no systematic research has been conducted on the typology of power dynamics. Here we provide a typology to classify and describe the power dynamics affecting trade relationships of telecoupled human and natural systems. We focus on primary sector trade, using examples and theories from the literature to classify trade relations into four kinds of power dynamics under the telecoupling framework (sending-system driven, receiving-system driven, spillover-system driven, and co-driven). Power symmetries (co-driven) are less common than power asymmetries. They generate different effects on sending, receiving, and spillover systems. The typology provides a good foundation for understanding, comparing, and managing different telecoupled systems.

Living with transition in a telecoupled landscape: land-use decisions and farmers' agency in Northern Laos

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In Northern Laos, remarkable land use and livelihood changes are unfolding as a result of widespread commercialization of the agricultural production. These changes are increasingly influenced and intensified by telecouplings, i.e. distal socioeconomic and environmental linkages operating across and between spatial, institutional and temporal scales.

While analysing the drivers of land use changes has always been a key component of land system science, the influence of telecouplings on local land use decisions is not well understood. An outstanding question is, for example, whether the distal interactions in telecoupled land systems determine land use changes at local level to the extent that local land users are largely deprived of agency. This presentation therefore raise the following question: Is there any scope for local agency and local land use decision-making in telecoupled land systems?

We explore this question through a case study of farmers' land use decisions and livelihood strategies in a rural village in Northern Laos, where a wide range of commercial crops have been introduced in the past ten years. Based on seven months of ethnographic fieldwork in 2014 and 2015, the analysis illustrates how households' land use decisions are heavily influenced by new market trends, relations with external actors and investors, and by a strong desire to "follow the society's development". A central point of the presentation will be to illustrate that telecouplings to a large extend gets mediated through existing networks of actors and power structures in the interacting systems.

Globalization and land use changes on tropical forest frontiers: the concept of ‘telecoupling’ and its operationalisation in land system science

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Landscapes on forest frontiers in the tropics provide powerful examples of the challenge to reconcile human development with planetary boundaries. These social-ecological systems not only have to meet the livelihood needs of local populations but also ensure ecosystem services worldwide. Global forces have come to outweigh local determinants of land use change in these landscapes, intensifying interactions between distant socio-ecological systems. Land change scientists have recently conceptualized this phenomenon under the term "telecoupling".

Current research endeavours seek to operationalize this new concept with a view to overcome major methodological and empirical research gaps. This paper reports on a research project, which analyses the effects of intensifying telecouplings in forested landscapes in Southeast Asia and Africa in view of sustainable development transformations. We reveal major challenges and potential pitfalls of the telecoupling concept relating to questions such as (i) what are meaningful boundaries of social-ecological systems allowing to define what is considered in- and outside? (ii) how can we avoid the holistic trap where everything is connected to everything? (iii) what diagnostic procedure do we choose for our analysis?

We will illustrate that these pitfalls can be avoided, if the telecoupling challenge is closely related to the normative framing of sustainable development. By focusing on key sustainability challenges of land changes and by systematically exploring winners and losers of such dynamics we can make the necessary analytical choices needed to avoid arbitrariness of focus and the holistic trap. We will present concrete examples to demonstrate how these conceptual insights are operationalised.

From urban-rural divide to connected spaces – basics for spatial governance

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As urbanization is one of the major drivers of land use change, functional spatial interrelations and interdependencies between urban agglomerations and their rural surroundings are of main interest for land use science as well as governance practice. The influence these linkages have on the development of land-use patterns is made evident in general through the concept of urban-rural teleconnections (Seto et al., 2012). Up to know the interrelations are reflected in various forms. The provided paper will discuss existing models, describing functional interrelations, in relation to their adoptability to governance settings in Europe as well as potential improvements.

Based on one example, a model of Stead (2002), new functional interrelations, accounting for modified directions of interrelations, as well as an extended systematic understanding of functional interrelations are explained. An extended model based on Stead shows the importance of reflecting new immaterial linkages like energy, knowledge and innovation, lifestyles and values. Additionally reciprocal processes like migration and commuting patterns are reflected. This provides the basis for the discussion of existing land-use-related governance setting. In conclusion, existing and potential strategies of sustainable spatial development and land management are discussed, which consider these interlinked spaces as an important field.

The presented results are worked out within the German research programme “Sustainable Land Management”, with its focus on a more profound understanding of interacting ecological and socioeconomic factors of land use and corresponding governance approaches.

Environmental justice in telecoupled resource systems: a meta-analysis of case studies of conservation and protection of natural resources

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The concept of telecoupled social-ecological systems has been proposed to understand how social-ecological changes are driven by processes operating at multiple scales and across distance. The local implementation of global initiatives for the conservation and protection of natural resources is a prime example for telecouplings which are frequently fraught with conflicts and multi-dimensional disparities. This contribution has the objective to operationalize and assess the potential of the telecoupling concept to better understand and assess environmental justice in the implementation of global conservation and protection initiatives, and its consequences on local resource governance. While most telecoupling literature has dealt with material flows, this study focuses on financial, normative and information flows linked with these global initiatives. We perform a meta-analysis of case studies of reported local implementations of global conservation initiatives and their influence on local resource governance regimes and institutions. Environmental justice is addressed looking at the transformation of power dichotomies and asymmetries, and conflicts, to the resolution of sustainability trade-offs and to social learning processes. On this basis, we identify recurrent patterns of institutional transformations linked with the implementation of global conservation and protection initiatives, and assess the opportunities and challenges posed by their telecoupled nature for more environmentally just resource governance.

Global High Resolution Population Denominators and Urban Spatial Dynamics

Spatiotemporal Methodological Advances for Mapping Population

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Contemporary, fine spatial scale, gridded population data is a crucial component for research across disciplines. We use such data for understanding the ‘now’ of hazard risk and mitigation management, health and disease modelling, and economic-, environmental-, and sustainability-related research. But to understand how human population changes through time, and incorporate this in modelling population change at fine spatial scales, novel ways of treating data and statistically describing associations of measured population counts with associated covariates are needed. The WorldPop project, now in its twelfth year, is an effort to improve the “denominator,” or the population background against which persistence, transmission and eradication models for various diseases are developed. The research presented here illustrates current modelling methods and approaches for providing modeled population data at multiple temporal and spatial scales as developed by the WorldPop team. The ensemble modelling approaches described incorporate multiple years of census data, and multiscalar approaches that merge temporally-explicit and invariant data to produce comparable gridded population data across time. As a case study we present WorldPop data from China 1990-2010 and describe how patterns of development and urbanization are decoupled from population change as a result of growth and migration in a rapidly changing environment.

Modelling and forecasting urban expansion in Africa

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The rapid rate of urban growth in sub-Saharan Africa will mean that the majority of the population on the continent will be classified as urban by 2030. Urbanization has profound social, environmental and epidemiological implications and makes spatial and quantitative estimations of urban change, population density and socio-economic characteristics especially valuable information for vulnerability and health assessments. The production of human population distribution datasets for the future remains limited by the lack of spatial urban expansion forecasts that will drive major population distribution changes. The performance of urban expansion models largely depends on the quality and type of data available, which have so far been limited, and reduced the confidence and the applications of models for Africa. Satellite remote sensing offers an effective solution for mapping settlements and monitoring urbanization at different spatial and temporal scales. In Africa, urban landscape is covered by slums and small houses, where the heterogeneity is high and where the man-made materials are natural. Innovative methods that combine optical and SAR data are therefore necessary for the delineation of urban extents. This presentation will synthesize the latest developments in the production of multi-temporal urban extents and urban expansion models for Africa, and will highlight the challenges that need to be tackled, particularly when working in low income settings.

Global High Resolution Population Modeling and the Built Environment

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Based on UN estimates, approximately 1 billion people have been added to the world's population over the past twelve years, with the largest percentage of the global population residing in Asia and Africa, respectively. Another billion people is projected by 2030 and demographic changes, especially in urbanized areas, will have significant socioeconomic, development and health impacts, radically alter land use and affect the climate change risk landscape. The WorldPop project (www.worldpop.org.uk) was built to meet the increasing demand for gridded population data sets that explore the interactions and dynamics of these rapidly changing demographics over space and over time. Based on an ensemble, regression-based modeling framework, population distribution data sets are produced at 100m spatial resolution and provide the open spatial demographic datasets of choice for researchers in 100+ government agencies. This research outlines how “urban” is operationalized within the WorldPop modeling process, the spatial and temporal considerations for how built area environments are represented and the relative importance of these different inputs for informing the distribution of population. The current approach supports population density and urban definition change analyses in the most robust and accurate manner available at this time. The datasets can be used in support of identifying and modelling populations at risk in epidemiological, climate, and disaster management applications, among others.

Satellite-based modeling of urban sprawl in post-industrial regions – A comparative study of ‘bottom-up’ and ‘top-down’ approaches

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In Germany land is used intensively. Especially the ongoing growth of settlement and transport areas and the resulting ecological problems concerning landscape fragmentation and soil sealing are still challenges in terms of a sustainable development in Germany. Even in shrinking regions like the old industrialized agglomeration of the Ruhr one can observe an increase of settlement areas and transport infrastructure. This study compares two land-use modelling approaches for the spatially explicit simulation of urban growth. The first model is a classic bottom-up approach: the cellular automata (CA) SLEUTH is based on four simple but effective growth rules. In order to improve its performance, SLEUTH has been modified by combining it with a robust suitability map by using support vector machines (SVM). The second spatially explicit simulation approach can be characterized as a top-down one. The Land Use Scanner establishes suitability maps for different land-use classes. The demand to be allocated is calculated by the socio-ecological model PANTA RHEI REGIO. The paper presents the modelling results for the Ruhr Area in the year 2025 – assuming that current land-use trends will continue. We analyse the outcomes in terms of the spatio-temporal urban land-use pattern and quantity in a polycentric region. It turns out that, despite different modelling techniques and underlying data, both the magnitude of settlement development, as well as its simulated general pattern in 2025 is similar in the results. The differences of both model approaches can be used as stimulating decision support for regional spatial planning.

European land monitoring – recent trends and 25-year data analysis

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European land monitoring – recent trends and 25-year data analysis.

The Copernicus - The European Earth Observation Programme - comprises satellite-borne earth observation, in-situ data and a services component. Copernicus land monitoring service contains Global, pan-European, Local and In-situ components.

The pan-European component produces 5 high resolution (20 m pixel) data sets describing the main land cover characteristics and updates for the Corine land cover and change dataset (100 m raster, 44 land cover/land use classes, areal coverage ca 6 million km² of 39 countries in Europe).

Land cover change in Europe, based on earth observation data has been already reported for the period 1990-2000 and 2000-2006 (EEA, 2005, 2010). A new reporting for 2006-2012 (set of 39 countries) has become available in 2016. This shows the slowing of annual general land turnover and reducing urban sprawl. However, share of arable land and permanent crops is still the predominant source for urban land uptake and its relative contribution has been steadily increasing (48% of land uptake in 2012).

Integrated assessment of land resources puts the land take process in a number of contexts. One is soil protection, seeking to reduce detrimental impacts of soil sealing and loss of productive land. Another is degradation of terrestrial ecosystems and their ability to supply ecosystem services where land monitoring allows for better understanding of habitat change – one of the main drivers of biodiversity loss.

Next reference year for a pan-European component update is scheduled for 2018.

New perspectives on longwave remote sensing of urban systems

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Urban heat islands (UHIs) will grow and intensify as urban areas expand and densify. Characterization of UHI using remote sensing has focused on the use of thermal infrared (TIR) sensors at spatial resolutions of ≥ 1 km to reveal the surface UHI using land surface temperature, in contrast to in situ measurements of air temperature at points in networks or along routes. The city, its suburbs, and the rural matrix all emit longwave electromagnetic radiation at wavelengths both shorter and longer than TIR. Here is explore new concepts for the characterization of the surface UHI: diurnal and nocturnal degree-days and their accumulations. Growing degree-days are constructed from daily Tmax and Tmin. Usually, Tmax happens during daytime and Tmin occurs overnight. The MODIS instruments on Terra and Aqua have daytime and nighttime overpasses that straddle noon and midnight. Although these times rarely coincide with Tmax and Tmin of air temperature, the relatively consistent observation times of land surface temperature enable different tempos of thermal dynamics across the landscape to be revealed. Examples will be drawn from the western hemisphere.

Polycentric city-regions in the state-scalar politics of land development: The case of China

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China's recent rapid urban growth has embraced city peripheries, with such great expansion occurring that polycentric city-regions have been created. Recognizing that multiple levels of government are entangled in this process our paper attends to multi-scalar state interactions in the process of city-region formation. Using two cases from Jiangsu province in China's east, we demonstrate that as a consequence of urban expansion the scale of urban politics is shifting from the intra-urban to the metropolitan, involving processes such as annexation and the selective mapping of governance under a city-administering-county system. Additionally, the scalar relations between the different levels of government, which centre on land interests and the corresponding redistribution of fiscal revenue and social provisions, play an important part in the formation of city-regions. We argue that the state-scalar politics involved in peri-urban development demand more attention and theorization in future studies of Chinese urbanization.

Land Systems Science Contributions to Mitigation and Adaptation to Global Environmental Changes: from global approaches to local realities

The role of future land-use change in Southern Amazonia to reach the aims of Brazil's National Climate Plan

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During the past decades Southern Amazonia (Brazil) was a deforestation hotspot. Between 1996 and 2005 the CO₂ emissions related to land-use change made up ~60% of Brazil's total GHG emissions. Important driver was the expansion of cropland and rangeland in response to a growing demand for agricultural commodities. Only recently progress has been made in decoupling further increases of agricultural production from deforestation rates. Nevertheless the land-use sector will play an important role for achieving the national targets for the reduction of GHG emissions.

Assuming further increasing global demands for food, bioenergy and biomaterials it is uncertain whether existing policies and potentials to improve crop productivity are sufficient to prevent the expansion of agricultural land and to ultimately end deforestation. In order to explore future pathways of land-use change in Southern Amazonia we have developed scenarios until 2030. The generated maps reflect changing agricultural production due to demands from domestic and global markets as well as different assumptions regarding agricultural intensification and effectiveness of policies targeted at the protection of natural ecosystems. Based on these maps land-use related greenhouse gas emissions were calculated. The results indicate that sustainable intensification of agriculture together with strict protection policies are essential requirements to slow down the loss of natural ecosystems and to reduce the respective greenhouse gas emissions as an important element to reach the national climate targets. Alternatively a fundamental change towards a less meat-oriented diet could be identified as a suitable way to mitigate climate change impacts of land-use change.

Downscaling public perceptions of climate change and hazards: a new method to generate high-resolution social data for mitigation and adaptation

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How people perceive risk is a critical component of decision-making in the context of climate change vulnerability, yet high quality data on public perceptions and attitudes are often lacking at scales necessary for policymakers or researchers. In addition, most indices of vulnerability lack these data despite evidence that perceptual and cognitive factors are key determinants of sensitivity and adaptive capacity. Although climate scientists have developed a variety of methods for downscaling data from global climate models to finer regional and local scales relevant for decision makers, similar methods for downscaling social data are lacking. This research presents multilevel regression and poststratification (MRP) as a methodology for providing locally relevant data on human perceptions, beliefs, attitudes, and behaviors regarding climate change and climate-related hazards. This method leverages individual-level survey data along with existing demographic and environmental data sources to generate estimates of public perceptions at various spatial scales ranging from the state or province level to the neighborhood level. This presentation discusses recent examples of MRP used to project public perceptions of climate change in the U.S. and Canada, and highlights a new high-resolution model to estimate risk perceptions of extreme heat events using climate, remote sensing, and demographic data. Such comprehensive fine-scale projections of geographic variations in perceptions can help to improve targeting of communication, education, and preparedness efforts to enhance adaptive capacity and facilitate mitigation.

Evaluating green infrastructure planning strategies for increasing urban's resilience ability

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Taiwan is a mountainous island and average 3.1 typhoons hit it every year. Moreover, climate change increases scale of typhoon and heavy rain, and increases impact in urban environment. Therefore, sustainable urban planning becomes an important issue in Taiwan. Green infrastructure planning is one of the useful strategies to reduce climate change, such as typhoon, impact on urban environment. Objective of this work is evaluated strategies of green infrastructure planning for reducing typhoon's impact on urban environment and increasing restoration ability in urban area. Historical data, 1904, 1921, 1976, 1994 and 2007, was applied to analyze environment change in the past hundred year in Tainan City. Landscape Change Model in Idrisi Taiga was used to simulate land use change during 2008-2030 under various green infrastructure strategies. Adaption and resilience indicators were used to evaluate urban restoration ability with various strategies. Results show that highways and roads construction induces green space transfer to build-up land in the past hundred years. It reduces urban's resilience ability while happen typhoon. However, increase area of green space is useful to increase urban's resilience ability. This research proposed approach is an effective tool contributes to green infrastructure planning in urban area.

Land-based adaptation to global change: Learning from socio-ecological drivers of soil and water conservation

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Linking land system science and global change research, the conservation of land resources is a promising strategy for sustainable agricultural intensification in order to adapt farming systems to climate, market and other stresses. At a local level, factors that drive the adoption of conservation measures operate and interact in specific ways. Integrating our knowledge of the local specifications of these drivers with regional and global patterns of vulnerability can significantly enhance our understanding of land-based adaptation to global change. However, the factors that influence the adoption of conservation practices remain actively debated. Therefore, this study presents a meta-analysis of case studies that investigate the adoption of soil and water conservation measures, as an important approach to resource conservation. Synthesising 63 adoption cases in the drylands of western Africa, this meta-analysis reveals a multitude of factors that drive the adoption of soil and water conservation practices. The drivers differ strongly between particular practices and methods of analysis used in the case studies. Our findings highlight the adoption of soil and water conservation as an emergent property of farming systems. They demonstrate the need to better understand the socio-ecological foundation of adoption and the pathways along which adoption evolves in space and time. This study concludes with methodological principles to advance future research on land system science as a prerequisite of improving land-based adaptation efforts. This synthesis is an essential step towards enhancing our capacity to understand and model critical adaptation processes focusing on an intermediate level of complexity.

Land use and urbanization

Urban Expansion and Contest over Agricultural Land: Experiences from India

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This study examines land use conflicts and contestations that have originated in India due to expansion of urban areas. Urban growth in India has received a tremendous boost, with the level of urbanization increasing from 17 percent in 1951 to 31 percent in 2011. It is projected that the urban population will reach 915 million by the year 2050, constituting more than one-half of India's population. The number of urban agglomerations, having a population of more than one million has increased from 5 in 1951 to 53 in 2011. The urban land is about 7.74 million hectares, which is only 2.35 percent of the country's total land area. The mega cities are mostly spilling over to adjoining agricultural belt in peri-urban areas leading to tremendous increase in the price of land in such areas and creating conflicts between real estate developers and farmers. The study finds that huge agricultural land is converted into built environment in the form of townships, malls, super-speciality hospitals, residential complexes, market complex, residential schools etc. The farming land around the big and medium sized cities are bought from the small or marginal farmers by alluring them through relatively higher value of land but in the process they are being dispossessed from the ownership of land. It also indicates that some of the farmers are unwilling to sell their land but yield to persuasion and/or coercion. Finally, we propose a land utilisation and management strategy and land use planning to cater to the growing urbanisation needs.

How to make good use of land during the integrated development of Beijing, Tianjin municipalities and Hebei province

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Abstract: This paper calculate the ecological deficit of Beijing, Tianjin municipalities and Hebei province according to their data of land use and product consumption, and find that in 2012, Beijing's per capita ecological deficit was -1.5592 hectare, Tianjin's percapita ecological deficit was -1.8304 hectare and Heibei's percapita ecological deficit was -0.6570. The total per capita ecological deficit of these three areas was -0.9843 hectare. After using the multi objective linear programming, and according to the population growth forecasted by the grey system, if the three areas still would like to sustain the 7% economic growth, the per capita ecological deficit will be -1.92 hectare in Beijing, -3.04 hectare in Tianjin and -0.65 hectare in Heibei province.

Mountains a context with distinct patterns and consequences of land systems change: Towards a synthesis of land system dynamics

Increasing socio-ecological resilience in mountain regions

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Land system science has made fundamental advances in understanding the mutual interplay between social and ecological systems that shape land use and land cover. Many studies have investigated the consequences of changes in land systems for the local environment and human well-being and have demonstrated that these local changes are at the same time central factors of global environmental change. But, while our understanding of these trends increases, there are rising concerns among scholars and policy makers about our declining capacity to cope with unexpected shocks accompanying them. Anticipating the response of socio-ecological systems upon upcoming pressures and pulses is highly challenging due to their inherent complexity, such as non-linearity, feedback loops, and multiple spatial and temporal scales.

We use a multi-method approach to backcast socio-economic pathways developed in an eight-year inter- and transdisciplinary project. The project was conducted in mountain ecosystems, whose compressed topography, vertical gradients, and isolation make them particularly vulnerable to global change. This vulnerability impacts the delivery of critical ecosystem services to people living inside and outside these areas.

Results suggest that, both, policy adaptations and early interventions into the system at the landscape scale can sustainably steer land use changes and help cope with challenges of global change. Moreover, we show that the resilience of the system to climate extremes and socio-economic pulses requires high landscape- actor-diversity. We conclude that global pressures can only be absorbed, if diversity in the ecological and the social system is fostered across scales from now on.

Migration and related land system changes, the case of Nepal

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In Nepal, changing demographic patterns are leading to changes in land use. A high level of male outmigration in the mid-hills is affecting household structures, and, consequently, the way land is managed.

In this paper I show that within two small watersheds these population dynamics have very different consequences on land. In some cases when the workload of the women left behind becomes too high, land is often abandoned – often, that furthest from the house. Other families change their cropland into grazing land due to increasing livestock which lessen work burden. Eventually some families also leave their land to move towards valleys or urban centres for easier access to infrastructure and services.

In the first case, while land abandonment was widely expected to increase soil erosion, I demonstrate in this paper that it can in fact lead to an increase in vegetation cover in the long term, due to favourable ecosystem recovery conditions. However, negative impacts are several, including the increase of invasive species and a decline in soil fertility. Whereas in the second case, the recent increase in goat farming investment made easier by the remittances inflow and promoted by government and NGOs, is likely to increase gullying and loss of vegetation cover.

Land management measures such as terraces and forest management do exist. However, in both cases, these measures fail to take into account the changing population dynamics and thus their management decisions. It is therefore worth revisiting the question about migration and land degradation.

Land use and land cover change in the Caucasus Mountains after the collapse of the Soviet Union

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Mountainous regions have distinct environmental settings and land use patterns are unique. The uniqueness of the mountains also poses challenges for understanding land system change. The mountainous regions are prone to be affected by social and political changes, such as armed conflicts. The Caucasus Mountains, a global biodiversity hotspot, went through drastic socio-economic changes shortly after the collapse of the Soviet Union. Here, we aim to investigate how land use has been changed in the Caucasus region to increase understanding about how national policies and conflicts influence land use pattern in the mountainous environment. First, we used open-access Landsat archives to produce wall-to-wall land change maps for the whole Caucasus, including Russia, Georgia, Armenia, and Azerbaijan at five year intervals between 1990 and 2015. Cross-boundary comparison was conducted to capture the effects of national policies. Second, we selected one Landsat footprint covering Chechnya, Ingushetia and North Ossetia of Russia to investigate the influence of wars on the land system. We analyzed a dense Landsat time series from 1984 to 2015 to identify land use and land cover change at annual intervals, using LandTrendr (Landsat-based Detection of Trends in Disturbance and Recovery). The results showed that the Caucasus has been going through substantial land use change in the post-Soviet Union era, characterized by agricultural land abandonment and forest regrowth. Land use, however, showed different change patterns across different regions and periods. This study highlights the social and political drivers of land change and contributes to land system science in the mountain regions.

Implications of future land use change for landscape and biodiversity

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The future change of land use has important implications for future landscape, biodiversity, carbon sequestration, or tourism development. For example over the past five decades a shift from decreasing to expanding forest area in Europe has been noticed. This shift is most pronounced in marginal areas, such as mountains where landscape has been change significantly. Therefore, the aim of this study is to assess future land use change and it's implication for landscape and biodiversity in one of the European mountain region; the Polish Carpathians (about 20 000 km²). We modelled the magnitude and location of future land use change between 2015 and 2060 using the Dyna-CLUE allocation framework. We defined three scenarios of future land use change trajectories: (1) biodiversity and landscape conservation oriented, (2) liberalisation with limited role of different polices like EU polices e.g. CAP or spatial planning, and (3) extrapolation of current land use change. Based on modelling outcomes we assessed changes in landscape fragmentation and connectivity. We found significant diffrences in landscape fragmentation and connectivity between three modelled future land use patterns. Landscape fragmentation was the highest in the second scenarios and the lowest in the first. In consequence connectivity of e.g. forest area varied between different scenarios and was the highest in the biodiversity and landscaped oriented scenario. Our results are among others clear example for strong influence of future land use change and land-management decision on shape of landscape spatial pattern and in consequence on e.g. biodiversity change in given region.

Soy and beef supply chains: from local land use dynamics to trade, governance and consumption patterns

Rising meat imports of the Former Soviet Union from South America have increased greenhouse gas emissions

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The countries of the Former Soviet Union (FSU) emerged as major meat importers on global markets because livestock production collapsed following the dissolution of the Soviet Union in 1991. Most meat has been sourced from South America, where livestock production is associated with high carbon dioxide (CO₂) emissions due to land-use change, and higher relative methane (CH₄) and nitrous oxide (N₂O) emissions than in the FSU. At the same time the collapse of the livestock sector in the FSU contributed to substantial carbon sequestration on abandoned pastures and on croplands formerly used for fodder production. We here assessed the net effect of the emerging meat telecouplings between the FSU and South America on greenhouse gas (GHG) emissions by contrasting emissions reductions in the FSU with the emissions embodied in traded livestock products to the FSU from 1991 to 2015. We first calculated product- and country-specific non-CO₂ emissions from animal husbandry as well as the CO₂ footprint associated with land-use change. Then, we estimated the emissions embodied in the bilateral trade of livestock products to the FSU. Our results demonstrate the high emissions embodied in meat imports to the FSU, mainly because expansion of meat production is a major driver of deforestation in South America. Moreover, emission intensity per unit of meat produced has been substantially higher in South America than in the FSU. Lower non-CO₂ emissions from animal husbandry as well as carbon sequestration on abandoned croplands in the FSU only partially compensate for the high emissions embodied in imported meat. Land use policies and interventions targeted at GHG emission reduction must account for the net balance of emissions embodied in trade.

Transformative transparency: enabling greater supply chain accountability to help deliver on zero-deforestation commitments

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Recent commitments to zero deforestation supply chains offer a unique opportunity for increasing the sustainability of the production, trade and consumption of major agricultural commodities. However, these commitments still only account for a fraction of global trade of forest-risk commodities, and few have moved from pledges to on-the-ground action. Key barriers to progress are the lack of transparency around how supply chains operate and a poor understanding of how transparency information can lead to improved accountability. We illustrate the potential to drive transformative change in supply chain sustainability through a new approach to understanding supply-chain transparency (<https://tp.sei-international.org/>). This approach is based on harnessing customs and other data to assess the risks and opportunities associated with sourcing from specific production landscapes (e.g. municipalities) and linking them to specific traders, consumer countries and other downstream actors. Using the case of South American soy we discuss the key transparency criteria and actionable information to help different actors engage and deliver on zero-deforestation commitments. These include the ability to offer a cost-efficient and standardised mapping of impacts and risks associated to supply chains, the ability to produce comparative impact analyses and benchmarking for entire regions and commodities at a scale congruent with regional decision making, and the capacity for communicating this information using user-friendly visualizations. We illustrate this by looking at how spatio-temporal patterns of soy sourcing and the involvement of supply-chain actors allows an assessment of the direct performance and leakage of major supply chain and territorial governance interventions (e.g. Brazilian Soy Moratorium and new Forest Code).

Alternative economic policies and future land-use in Northern Argentina

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Understanding how land-use change patterns may evolve in the future in response to policy interventions is important to identify strategies towards sustainable land management. This is particularly so in South America, where cropland and cattle ranching continue to expand rapidly into natural ecosystems. There is also an increasing recognition that soybean cultivation and cattle ranching, are linked, and that policy interventions in one region may affect others via displacement. Exploring how different economic policies may influence land-use trajectories in South America's soybean and cattle productive regions is therefore important. Here, we developed a net returns model to understand past land-use change (cropland and cattle ranching) for the period 2000-2010, and used this model to assess the land-use change outcome of different economic policies for the Argentine Pampas, Espinal, and Chaco regions till 2030. We explored the effect of (1) policies to increase agricultural productivity, (2) market instruments related to market liberalization, and (3) policies to improve infrastructure. Our results suggest that land-use conversions in Argentina resemble an agricultural business model with increasing returns to scale, leading to clustered expansion of land-use conversions. Most of the new cattle ranching would be established in the Chaco at the expense of forest areas, whereas the Pampas will likely experience continued cropland expansion. Cropland profits may drive both cropland and cattle ranching expansion under different scenarios of economic policies. Our results highlight the variety of future land-use trajectories that different economic policy interventions may determine and the importance of well-informed land-use planning for steering future development pathways.

The growth in soy exports and soy-pasture dynamics in Uruguay since the 1990s.

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We provide the first analysis of soy and land-use change in Uruguay (the 10th largest producer globally) based on agricultural, economic and land-use statistics, field surveys, stakeholders interviews and farmer questionnaires.

The large increase in soy in Uruguay in the late 1990s was a response to high global soy prices; Argentine investment tied to soy production flowed into Uruguay and soy replaced sunflower, and natural and artificial pastures in the eastern *littoral* (Colonia, Paysandú, Rio Negro and Soriano departments) and central Uruguay. This affected ranching (the internal beef market and beef exports were affected) and dairying (where affects were restricted to national food supply). The loss of natural pastures reduced biodiversity overall, though mandatory conservation tillage and woodland protection policies in cultivated areas have offset this. Decreasing soy prices during the last three years have seen a shift back from soy to artificial pasture in central Uruguay, but not in the *littoral*.

Multinational and internal investment have replaced Argentine investment in the last 15 years through GM-seed, agrochemical and machinery imports; silo construction; and the development of Nueva Palmira port on the Río Uruguay, which serves Uruguay, Argentina and Paraguay. New infrastructure and investment have maintained the land area under soy in the *littoral* (40.1-44.9% soy, 29.1-34.6% artificial pasture, 2.6-5.2% natural pasture, field transects February 2016) during the period of lower prices. Land prices have remained high creating spillover effects in the ranching areas of central and northern Uruguay, and the Paraguayan Chaco.

Telecoupled land use and land cover change in distant countries

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International agricultural trade has become an important driving force of land use and land cover change (LULCC). Such LULCC was usually studied separately within importing or exporting countries, although it occurred at the same time. To better understand and compare the LULCC in relation to international agricultural trade among trade partners, we adopt the integrated framework of telecoupling (socioeconomic and environmental interactions over distances). Three countries – Brazil, China, and the United States – constitute an excellent example of telecoupled systems through processes such as soybean trade. As the world's top two soybean producers and exporters, most exported soybeans from Brazil and the United States were consumed by the largest soybean importer China. We focus on spatial dynamics of soybean lands in three major soybean production regions from 2005 to 2010, including Heilongjiang in China, Mato Grosso (MT) in Brazil, and the U.S. Western Corn Belt (WCB). Soybean areas experienced a significant decrease in Heilongjiang and kept relatively constant in MT and WCB. Our results indicate that the spatial continuity of soybean lands had substantially declined in Heilongjiang, signaling the looming reduction of soybean production. Although the Sino-US soybean trade was negatively affected by the fast-growing soybean trade between Brazil and China, our results show that largely continuous soybean lands still increased significantly in WCB but had no significant change in MT. Through simultaneously analyzing the LULCC in the three distant soybean production regions enhances the understanding of LULCC among trader partners and has important implications for agronomic and environmental management.

Sustainable Land Use Through Supply Chains: Connecting Consumers to Producers

Applying Complex Biophysical Models in Supply Chain Programs: Challenges and Opportunities

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To meet the growing demand from consumers and companies for greater transparency about the environmental and social impacts of food, fiber and fuel resources requires analysis of the full supply chain of production. One key element that can be difficult to characterize is the on-farm environmental impacts of crop production, which are not directly controlled by the companies being asked to account for the footprints of their final products. In the United States, commodity crops are produced by independent land owner-operators who sell their crops to aggregators, who in turn supply the raw or processed commodities (e.g. soy beans or soybean oil) to consumer facing companies.

One approach to using this consumer interest to drive meaningful change at the farm level is the co-design of a metrics program that simultaneously can be used to report on corporate sustainability goals and serve as valuable information to farmers on opportunities for improved efficiency or reduced environmental impact of their operations. This presentation will discuss the initial development and evaluation of the environmental sustainability metrics developed through the multi-stakeholder (farmers, conservation groups, food and retail companies, agribusiness and universities) alliance Field to Market in the United States.

An early consensus decision by the alliance to focus the metrics program on environmental outcomes has driven a program that makes use of simulation models to assess not just practices (e.g. fertilizer rate, tillage type) but the environmental outcome of concern (e.g. water quality, soil erosion). To transform readily available data entered by producers into environmental outcomes requires use of simulation modeling, ranging from relatively simple algorithms to the use of more complex biophysical process based models. As the program continues to evolve and work toward more robust simulation modeling, both close collaboration with science and research communities and appropriate communication to users regarding model output have become essential. Meeting these challenges, however, enables strong voluntary participation in the program and allows for meaningful assessment of the impacts of supply chain engagement on addressing environmental concerns associated with crop production.

Water sustainability in sugarcane production: creating an adoptable standard

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Demand for sustainability standards is growing, with a particular emphasis on water sustainability. Two major challenges face the creation of new metrics. First, there is a growing literature addressing the process of standard setting as well as assessments of the impact of standards. However, little concrete guidance exists to define sustainability, and thus there is little guidance on the content of standards, particularly for water. Second, the water environment varies dramatically around the world, so the definition of sustainable water use varies as well, and a standard must be responsive to this. Using the development of a water standard for the sustainable sugarcane certifier Bonsucro, I will discuss our approach to these issues. By separating the problem of water productivity from water availability, we were able to design a standard that can be achieved by all producers. We then went through a process of designing a scientifically sound measure, which was transformed into a metric through the stakeholder-driven process of threshold setting. The new standard was accepted as part of Bonsucro's Production Standard in 2014. They project it will affect 20% of sugarcane production by 2020.

Applying urban ‘foodshed’ models to land system science

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The term ‘foodshed’ is commonly used to describe the geographic area from which food consumption is sourced. This concept was popularized by rural sociologists writing roughly two decades ago and has been applied frequently to describe local food systems since then. However, for larger urban areas, data availability constrains the ability for systematic, spatially explicit foodshed analysis. We outline a generalizable framework for foodshed analysis at the city and national scale by drawing from techniques in economic supply chain analysis (e.g., multi-regional input-output, MRIO). We apply this framework by using simple hypothetical case studies to illustrate how foodshed analysis could be used to understand telecoupling and urban vulnerability. Foodshed analysis is relevant to urban vulnerability assessment by explicitly linking agricultural production with food consumption as well as by highlighting the nature and degree of food import-dependence. Robust spatially explicit models of real-world foodsheds will ultimately require integration of complex cross-scale data on, for example, agricultural production, consumer demand, international food trade, and freight transportation networks. Realizing the potential of foodshed analysis for applications in land change science and food system resilience could help to support these data needs for seamless assessment of urban and regional foodsheds.

Telecoupling Framework for the Global Land System Science Community

Land systems as telecoupled systems: trade-offs in a globalized system

Darla Munroe

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Understanding Urban-Rural and Rural-Rural Interactions in a Globalizing World: Implications for Production Landscapes

Landscape dependencies and rural-urban migration

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How landscapes are used to produce human goods is changing. More of the world is urbanized than ever before, and the movement of people from rural to urban areas changes our collective demand and dependency on the landscape. Movement out of rural areas puts less pressure on local provisioning ecosystem services. However, increased population in urban areas increases reliance on different, and often distant, environmental inputs necessary to sustain well-being and urban functioning. Using our own field-collected data from around 900 households in the Miyun watershed near Beijing, China, we focus on movement out of rural areas and aim to make three main points. First, we conceptualize the changes in population demands on the landscape within the context of urbanization. Second, we use the household data from the Miyun watershed to characterize the nature of migration in the region. Third, we assess the changes in demand for local ecosystem services implied by these patterns of migration. Out of the 3,052 individuals identified as being within a household in our dataset, 14% migrate for work. Of these, 71% are permanent migrants (living outside the home all 12 months), and 54% send money back to the household (median value of 8000 RMB). Recent graduates (n=154) and males that were previously farming or engaged in wage labor were most likely to migrate (n=142). In aggregate, our regression results indicate that an additional migrant in the household reduces rural landscape dependency by 40-50%, all else equal. Further work is needed to quantify the changes implied by moving to and living in urban settings.

Rural connections between almond production and irrigated pasture in California, USA

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Rural-rural teleconnections are a way to describe land systems dynamics over disjoint rural space. Here we empirically evaluate the existence and dynamics of such connections in rural California. Traditionally, cattle ranchers have relied on irrigated pastures to maintain forage for their herds over the dry summer months. Over that last decade, however, many irrigated pastures have converted to high value almond production. This has not only led to the loss of pasture, it has changed the whole dynamics of cattle ranching across large spatial scales. The loss of summer pasture has left many producers with two choices 1) leasing land at high elevations with strong summer forage or 2) reducing herd size. Increased stocking rates at high elevations may lead to ecosystem degradation and over grazing in these areas. At the same time, reducing herd size may lead to excessive vegetation and increased fire risk on existing rangelands. To explore these dynamics we modeled the dynamics of almond expansion onto irrigated pastures. We then used this model to predict changes in cattle density in different environments. Future research will link these rates to changes in ecosystem services.

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Malagasy clove production systems in a telecoupling world

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Cloves are a cash crop widely cultivated in the north-eastern Madagascar since colonial times. In the last decades, cultivation within monocultures disappeared and small scale cultivation either in combined agroforest systems or as solitarian trees on pastures are dominant today. In the last years, cultivators experience a pronounced increase in clove prices induced by global price levels determined by distant socio-ecological systems. These price signals lead to a shift towards clove production, which is at first sight a diversification of incomes for a household, but increases dependency on non-influenceable factors.

Using a Bayesian network-based land-use modeling approach in a participatory manner, we developed land-use change scenarios for the coming 15 years. The land-use decision model was set-up for our case study area in north-eastern Madagascar through local actor interviews, workshops, questionnaire data, and a game approach.

The resulting scenarios contrast land-use change trends induced by rising clove prices from developments with a sudden decrease in prices showing land-use changes and changes in the share of income provided by clove production systems. We discuss the effects of such exogenously induced drivers on local cultivation systems. As next steps, validation and discussions with local actors about potentials and threads of adaptations in cultivation strategies are needed.

Untangling the Complexity of Telecouplings and Global Land System Change: Challenges and Opportunities for Bridging Geographic and Disciplinary Boundaries

Lessons from above: remote sensing and spatial analysis for telecoupling research

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Geotechnologies, particularly remote sensing, provide updated information about the state of land surface and have been fundamental tools to help societies understanding how land changes are connected to human systems (e.g., urban sprawl, agricultural expansion and intensification, forest transition). Spatial analysis integrating socioeconomic data (e.g., census geodatabase) in geographic information systems are key to comprehend how humans interactions across the Globe (e.g., international trading, food demand and security) can be connected with land change dynamics in regions affected by these interactions. The telecoupling framework builds on previous studies about coupled natural-human systems envisioning local land change processes intrinsically related to other processes taking place over long distances. Thus, telecoupling research must quantify and qualify land change dynamics in different temporal and spatial resolutions. We started organizing spatial datasets, in standard data formats, to be used as model inputs. The geodatabase itself as well as our model's results will be available through a web interface for data and model visualization. This *Telecoupling Information Platform* will connect stakeholders, farmers and policy makers with interest in land change dynamics resulting from food commodity markets. In particular, food flows between Brazil and China will be assessed as a telecoupled system. A previous Brazilian experience with an online geospatial database platform (i.e., SOMABRASIL), which uses open source technology, has demonstrated the increasing demand from society to assess land change geoinformation to aid in decision making.

Economic insights into telecouplings

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International trade in goods and services is one of the most important mechanisms underpinning global scale telecoupling. Nowhere is this more evident than in the agricultural system, where growing demand in one region (e.g., meat consumption in China; biofuels in the United States) reverberates in land use changes around the world. And it is not just demand growth which drives such telecouplings. Innovations on the supply-side (e.g., new technologies for growing soybeans in Brazil; introduction of containerized shipping), can strengthen existing trade linkages or create entirely new telecouplings. In other cases, such as the introduction of GMO technologies, this can eliminate trade linkages between regions with different regulatory regimes. A central question in the economic analysis of global trade linkages is the extent to which historical ties will persist into the future – particularly in light of changing relative prices. The more persistent are these ties, the more predictable are the trade-based telecouplings. In these remarks, I will discuss the geography of international trade and how it, in turn, drives land-based telecouplings at global scale.

Telecouplings and Human-Environment Interactions

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Human-environment interactions are inherently complex, and in the past research with this focus showed a preference for local studies where the complexity of these interactions could be measured and understood with any degree of rigor. The next leap took place during the course of the Land Use and Land Cover Change Program when Focus 1 of LUCC focused on comparative case studies. Progress was made during this decade of research but the studies did not link to each other per se. They largely examined similar processes in different places. This work was parallel to that undertaken under the CHANS rubric of coupled human and natural systems. In those studies, too, the focus was on understanding complex systems in one place and to talk about the pervasiveness of CHANS systems, without connecting them. The ambition of telecoupling as a framework is that it purports to carry out analyses that connect different coupled systems across great distances. To do so would seem to be overly ambitious if it were not for the fact that it identifies the flow of commodities across distances as the focus, from which direct and indirect outcomes result, and where spillovers are just as important as the direct results. In a global economy such as is operative today, this is a very promising focus because the trade in commodities drives so many decisions at a number of scales with global and regional consequences. The challenge is to connect the chain of causalities, and to understand under what conditions decisions at one scale cascade, or not, throughout the system bringing about change and restructuring.

Urban ecological transformation: From Individual Lifestyles to Institutional Innovations

The ecological loss caused by unreasonable urban expansion - a case study in Wuhan, China

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In the process of urbanization of China today, along with rapid urban expansion and economic development by leaps and bounds, meanwhile, a big problem, that brought by rapid urban expansion in pursuit of maximizing economic benefits, has become prominent increasingly. The urban heat island effect, air pollution gets worse, besides, water pollution and the shortage of irrigation water in Urban-rural Fringe has influenced the food supply and food safety of urban immediately. Therefore, it is extremely significant for raising the level of urban planning that government grasps the varying pattern of urban spatial configuration and the impact on ecological environment. In this paper, we used the urban construction land of Wuhan in 2013 as the source, on the foundation of minimum cumulative resistance model (MCR), we forecasted the scenario of urban expansion of Wuhan in 2020, which indicates urban construction expands toward the area with minor ecological resistance intensively, compactly, with spatial variation regularly, then, we applied cellular automata model (CA) to the simulation scenario of urban expansion of Wuhan on the basis of present expansion conditions, which represents urban sprawl with massive urban construction land, irregularity. Furthermore, we made the comparative analysis of these two scenarios, some issues in the implementation of land use planning of Wuhan were revealed: the expansion of urban construction land of Wuhan is large, spreading outside like a pancake, what's more, occupying the area with lager ecological resistance for the urban development.

The Trade-off Elasticity between Water and Land Utility in Zhangye city, China

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Water and land resources are both vital important materials to human-wellbeing, especially providing food and construct areas. The trade-off between water and land that reflects water productivity and land productivity. Taking the Zhangye city as the case study area, this study concentrates on the trade-off elasticity between water and land utility, based on the ARIMA model and data from 2000-2012, we estimate the long term relationship between water and land. Also, the elasticity was also investigated. The research results indicate that water and land exist long term relationship, with the increase use of water will induce less land use. But, there exist a turning-point, to which the elasticity will equal to zero. The research result can provide significant references for urban planning, eco-urban management.

Impact of urbanization on ecological security in Jing-Jin-Ji region, China

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Based on ecological footprint, which has been extensively applied in recent years to quantitatively measure human pressure on ecosystems, this paper combined urbanization level with ecological tension index to analysis the impact of urbanization on ecological security. Jing-Jin-Ji region was taken as the study area, which is one of the most rapid economic regions in China. Firstly, the paper analyzed urbanization level selecting per capita GDP, urbanization rate, non-agriculture payroll employment, household consumption, proportion of built-up land and energy intensity and so on. Then, ecological tension index, which was on the basis of the ecological footprint theory, was calculated to assess the ecological security. Finally, the relationship between urbanization level and ecological security was conduct to analysis the impacts of urbanization on ecological security. The result shows that the urbanization has a negative impact on ecological security. Economic structure and consumption structure should be improved so that the ecological security could be harmony with urbanization process. The study will provide academic references of ecological security analysis, sustainable development evaluation to our country and other fast-urbanizing regions in the world. As well as to offer the scientific basis and decision support for ecological construction in these areas.

Management Innovation for the Sustainable Development of Eco-communities in China

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Ecosystem services are substantial elements for human society. The central challenge to meet the human needs from ecosystems while sustaining the earth's life support systems makes it urgent for enhancing efficient natural resource management to sustain ecological and socioeconomic development. Trade-off analysis of ecosystem service can help to identify optimal decision points to balance the costs and benefits of the diverse human uses of ecosystems. Thus our main purpose in this paper is to present the key insights on trade-offs analysis of the ecosystem service at different scale from land-uses' perspective, by comprehensively reviewing the trade-offs analysis tools and approaches that addressed in ecology, economics and other fields. The review will significantly contribute to future research on a trade-off analysis to avoid inferior management options and offer a win-win solution based on comprehensive and efficient planning for multiple, interacting ecosystem services.

Appropriation of Ecological Land by Urban Expansion and Food Safety Based on Scenario Analysis of Yield Gap

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China is in the stage of rapid urbanization, in which the relationship of urban expansion, food security protection and ecological conservation is the principal contradiction of land-use in this stage. As we put a high attention to urban development and cultivated land protection, the problems of ecological conservation are largely invisible. Based on existing land use cover, rational designing urban land and improving crop yield can make more land use space for ecological conservation. Meanwhile, Understanding yield potential and yield gap for major crops is critical for improving crop yield and ensuring food security. Accordingly, taking Wuhan city as a case, this research used LANDSCAPE model to simulate the states of ecological land under the different scenarios of yield gap. The results suggest that: 1) the appropriation of ecological land can be reduced by adjusting yield gap. The smaller yield gap, the more ecological land is. 2) the appropriations of ecological land by urban expansion and by food security are different under different scenarios of yield gap; 3) the appropriation of ecological land remains stable as yield gap is under 20%.

Construction of urban ecological security pattern in Shenzhen City

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We are facing momentous challenges of market competition, climate changes, resource scarcity and improper utilization in current urban development. The urban ecological security has become one of the principal subjects that we must discuss in the urban sustainable development.

Considering the overall demands for natural resources protection and the social economic development, Shenzhen City has been selected for the study. Through the construction of urban landscape ecological security pattern, we proposed a spatial pattern optimization scheme for the ecological security problems of the Shenzhen City, such as decreased urban uniqueness, deficiency of cultural heritage protection, shortage and improper utilization of resources, increased loss from comprehensive disasters, increment in the occurrence of extreme weathers, decreased biodiversity and environmental pollution etc.

Optimizing patterns in Shenzhen City had been into 5 divisions, which were cultural inheritance pattern, disaster prevention pattern, climate regulation pattern, environmental purification pattern and habitat maintenance pattern. By determining the spatial position of the security pattern and the utilization of functional network approach, we secured the key nodes and corridors of the ecological process, and we avoided the restriction of future urban development leading by the economic or ecological problems. We improved flexibility of land utilization and conducted multifunction into urban construction land development process.

Multi-objective and Multi-agent Symbiosis of Rural to Urban Land Conversion and its Influencing Factors

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Rural to urban land conversion involves not only multiple objectives, but also multiple agents. How to realize the common development of multi-agent and symbiosis of multi-objective is the key to decision-making of rural-urban land conversion. This article explored multi-objective multi-agent symbiosis of rural-urban land conversion based on symbiosis theory. The study results are as follows: symbiosis system of rural-urban land conversion is this system in which each symbiotic unit connects with each other at a certain symbiotic mode under the symbiotic environment, the system will change as the environment and symbiotic mode changes. Most symbiotic mode is cooperation-compete mode, symbiotic system gets balance by the completely game of symbiotic units under the institution. However, land invisible conversion abound especially under the influence factors of low-cost of the illegal conversion, higher comparative advantage of land conversion and the unequal status of two kind of property rights, which results in a change in the symbiotic environment, thus causing mutations of the symbiotic system. Finally, the article puts forward some countermeasures to promote the coordinated and stable development of symbiotic system. Rural to urban land conversion involves not only multiple objectives, but also multiple agents. How to realize the common development of multi-agent and symbiosis of multi-objective is the key to decision-making of rural-urban land conversion. This article explored multi-objective multi-agent symbiosis of rural-urban land conversion based on symbiosis theory. The study results are as follows: symbiosis system of rural-urban land conversion is this system in which each symbiotic unit connects with each other at a certain symbiotic mode under the symbiotic environment, the system will change as the environment and symbiotic mode changes. Most symbiotic mode is cooperation-compete mode, symbiotic system gets balance by the completely game of symbiotic units under the institution. However, land invisible conversion abound especially under the influence factors of low-cost of the illegal conversion, higher comparative advantage of land conversion and the unequal status of two kind of property rights, which results in a change in the symbiotic environment, thus causing mutations of the symbiotic system. Finally, the article puts forward some countermeasures to promote the coordinated and stable development of symbiotic system.

Measuring environmental efficiency of industrial sub-sectors in China: a stochastic metafrontier approach

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With the rapid development of urbanization and industrialization, massive resource and energy consumption exert great pressures on urban ecosystem. This paper measures environmental efficiency of China's 39 industrial sectors over the period from 2005 to 2011 and analyze differences of environmental efficiency and technology gap ratios (TGRs) across industrial sectors groups using a parametric metafrontier approach. We divide industrial sectors into three groups using a cluster analysis on carbon intensity. For further analysis, we estimate mitigation potential of industrial sectors. We find that environmental efficiency measured by general SFA is prone to be underestimated due to neglect of technology gaps among different groups. Relative to the metafrontier, the industrial sectors in Group 1 achieve the highest environmental efficiency and TGR, while environmental efficiency and TGR of industrial sectors in Group 3 is still at a low level for lack of advanced production technology. Furthermore, industrial sectors perform significant differences on mitigation potential. We suggest that policies and regulations on industrial technology innovation and control of carbon emissions should be strengthened for eco-efficient and sustainable development.

On the Strategy Orientations of Transformation Development : Land Consolidation in the new period of China

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Based on the macroscopic background of national strategy development, the purpose of this article is to identify the emerging issues and transformation requirements of land consolidation, redefine its essence and functions, and then figure out the strategic orientations of transformation development. Methods of literature review and comparative analysis are applied. The results show that, currently land consolidation is in a new period with transformation requirements. Base on the new definition of essence as "readjustment of human-earth interrelation" and functions as "satisfaction of individuals' improvement requirements in production, life and ecology", ten strategic orientations are put forward in allusion to current problems such as cramped cognitive, low positioning, homogeneous pattern, and lack of innovative concepts, coordination as well as public participation. The conclusion is that land consolidation should be changed from land-only to high-end in position, from number-priority to four-in-one in concepts, from grain production to landscape protection in orientation, from land-oriented to people-oriented in kernel, from protecting farmland to at optimize production, life and ecology in target, from single propulsion to feature generalization in object, from project-carrying to domain-coordination in category, from homogeneity to differentiation in pattern, from top-down to up-down in path, from fiscal burden to multiple model in fund. With the ten strategy orientations, land consolidation can be regarded as the powerful gripper and important platform to balance urban-rural development and service for the new goal of building a well-off society in an all-round way.

“Multiple planning integration” in China: a case study in Yulin

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There are plenty of different plans in China such as urban plan, land use plan, environmental plans, etc. They are compiled and implemented by different ministries and are not well coordinated sometimes. Yulin, a city in northwest China with fragile ecosystem, was chosen as one of the 28 pilot areas by four ministries to carry out the “multiple planning integration”. A comprehensive spatial plan was formed by integrating different government sectoral plans to well balance the environmental protection, farmland preservation and urban development. The presentation takes the case of Yulin as an example to explain the experiment of “multiple planning integration” in China.

Urbanization and Agricultural Land Use: Empirical Evidence, Models, and Policy Implications of Telecoupling

Complex Relationships among Urbanization, Telecoupling, and Agricultural Land Use

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Studies on the impacts of urbanization on agricultural land use usually focus on urban demand for agricultural products, competition for land between agriculture and urban development, and job opportunities for rural-urban migration. However, there are many other important mechanisms connecting urbanization and agricultural land use through telecoupling processes. In this talk, we present three such telecoupling processes: nature-based tourism, payments for ecosystem services, and trade of industrial products. Globally, nature-based tourism has increased substantially and has led to much agricultural land converted to tourism facilities such as roads, hotels, restaurants, and resting areas. Financial resources for many payments for ecosystem service programs in rural areas often come from urban areas, and help convert many agricultural lands into forests and grasslands. Many inputs for agricultural production (e.g., fertilizers and pesticides) are manufactured in urban areas. We illustrate these telecoupling processes, their socioeconomic and environmental effects, and their interrelationships using empirical data and modeling results based on telecouplings between Wolong Nature Reserve in China and the rest of the world. The results indicate complex relationships among urbanization, agricultural land use, and telecoupling. They expand and deepen the understanding of the relationships between urbanization and agricultural land use. They are also informative for better policy-making, management and governance.

Land use systems and urbanization in the Brazilian Amazon

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We argue that in order to understand urbanization in the Amazon it is necessary an assessment of its articulations with rural changes, particularly in terms of the co-evolution between demographic and land use systems over different stages of frontier development. Based on a case study in the Southern Brazilian Amazon using an unique dataset from 1987 to 2010, we use descriptive statistics with paired t-tests, land use classification analysis and Latent Transition Analysis (LTA) to show how the evolution of land use systems become increasingly dependent to off-farm livelihood strategies which by their turn reshapes the rural – urban articulations. Our results show that the likelihood of plot and household “success” (higher welfare and income levels) in the frontier in the long run depends on their ability to diversify sources of livelihoods, with increasing concentration of cattle and pastureland as well as an important share of off-farm income sources. Demographic factors, mostly those related to farm household labor force and composition, become increasingly less important to explain livelihood diversification strategies as the frontier becomes increasingly articulated to regional, national and global markets. By its turn, land consolidation, explained partially by the household ability to increase financial capital from urban employment, migrant remittances and government cash transfers, is key for successful diversification strategies.

Examining the resilience of multi-sited households in the Amazon estuary; an agent based simulation

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Rural households in the Amazon estuary are increasingly multi-sited, maintaining a dwelling in both the farm and in a nearby urban area. These dwellings facilitate the movement of people back and forth between the farm and the city for the purposes of education, moving goods to market, participating in government financial programs, or participating in urban off-farm employment. Non-farm income has become an important component of household livelihoods in this region, contributing to subsistence requirements, diversifying sources of income, and potentially enhancing household and community resilience in the face of changing environmental and agricultural market conditions. However, migration to urban areas can also result in a reduced labour force in agricultural areas, with associated reductions in food security and traditional agricultural knowledge, resulting in reduced resilience. This study utilizes an agent based model to explore the impact of urban off-farm activities on the resilience of agricultural communities in the face of changing environmental and economic conditions. An agent based simulation, parameterized with data from a household survey conducted in the region, is utilized to explore a number of scenarios in which the resilience of rural agricultural communities is evaluated in the face of external shocks. These household's activities, both on the farm and in the city, determine how they respond to these shocks. The contribution of urban activities such as education, employment, and government cash transfer programs to the response and resilience of these multi-sited households is examined and discussed.

Telecoupling, climate change, and pigeon peas for sustainable and resilient agriculture in Malawi

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Pigeon pea is a perennial legume widely distributed across the semi-arid tropics. In rain fed systems it is frequently used in marginal agricultural lands both as an intercrop and sole crop. India is the largest producer and consumer of pigeon pea. However, production has been largely flat over the past two decades and a structural deficit has emerged promoting a dynamic market in southern and eastern Africa. Malawi has long been a significant producer of pigeon pea, though previously much of it was consumed at the household. As late as 2000, the cost of production in Malawi, largely due to the landlocked location, proffered an economic disadvantage for pigeon pea exports compared to Tanzania and Kenya. However, Malawi has expanded production while the other countries have remained flat or declined. This paper combines a discussion of the agronomic advantage of pigeon pea, particularly in a country facing a shifting climate and very small farm sizes with the global pigeon pea market. We integrate a time-series of remotely sensed data, climate and hydrologic models, with on-farm trials and market assessments to explore the telecoupling impacts on land use change in Malawi. We find that these integrated drivers result in land use changes that are resilient to the shifting climate and sustainable in a country with small farm sizes and degraded soils.

Urbanization and the Dynamic Landscape of Future Agricultural Land Use: Poyang Lake Region, China

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Across the developing world, agricultural land use and food production are increasingly affected by macro-level forces and processes amid urbanization and globalization. While nonfarm income has already led to agricultural land-use de-intensification in some areas in China, farmland rental markets can potentially mitigate urbanization's negative effects on agriculture through facilitating larger farming operations, and China also uses a variety of policy instruments to promote agriculture. This paper uses an agent-based model to explore how rising nonfarm income may interact with farmland rental markets to shape future agricultural land use under different scenarios of rice price changes and two policies that subsidize all rice growers and subsidize large farms. We use an empirical study and data from the Poyang Lake Region (PLR) to inform the development of the model. PLR is a major agricultural base in Jiangxi province and China where rice is a dominant crop. The model simulates the majority of rural households in the region that combine nonfarm income and rice cultivation as their major livelihoods and make decisions on planting rice once or twice a year. They also rent in/out land-use rights in a private land market. Our modeling experiments allow us to construct a dynamic landscape of future agricultural land use under the influences of these interacting forces and provide insights into how policies may adapt at different stages of development to maintain agriculture and ensure food security.

Some thoughts on Land Use and Urbanization

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Land use is one of the biggest issues of urbanization. With the advancement of technology and the development of economy, the level of urbanization has constantly improved. At the meanwhile, the land utilization is changing: the agricultural land is keeping being taken; contradiction between supply and demand of land is increasing, etc., which limit the development of city. As the lack of understanding of urbanization, blind development wasted land resources, damaged the environment and blocked the economic growth of city.

Therefore, as a planner, we need find a way to ensure urbanization is rational, such as optimize the development pattern of city, use the land in a sustainable way, etc.

As a new employee of CLSPI with urban planning background, I will express my thinking of conflict between urbanization and land utilization. Furthermore, I will propose some suggestions in my aspect.

Effects of Urban Sprawl on Peri-urban Agricultural Land: a case study of Ikorodu, Nigeria

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Land systems change and availability of peri-urban croplands and forest are pivotal to the food security challenge and sustainability. Therefore, studies monitoring and quantifying agricultural land as well as its governance in local, regional and global context is indispensable for sustainability in a rapidly urbanizing world. The main objective of this research is to establish the relationship between urban sprawl and agricultural land use change with a view of assessing the role of land governance in managing the changes. Remote sensed Landsat imageries and land cover maps for the periods spanning between 1975 and 2015 were analysed to using geospatial technologies. Agricultural land change index of each period was correlated with the development patterns measure by their fractal dimensions. Fractal analysis of developmental patterns between 1975 and 2015 ranges between 0.41 and 1.44, which indicates sprawling development and this explains 78% of the variation in the Agricultural Land Change Dynamic Index. Furthermore, a survey and structural equation model was applied to determine the drivers of peri-urban residential growth indicated that income, vehicle ownership, and leisure, which are major motivation for peri-urban residential growth in developed countries, are not the main drivers in the study area. Fragmented residential development in peri-urban areas is responsible for loss in land zoned for agriculture and it is driven by lack of policy awareness and deficient development control, migration, health, economic and socio-demographic factors for two main reasons. First, there is low policy awareness, which contributes 26% of the total variation explained by residential development on agricultural land and a deficient land management system by planning agencies accounting also for 11% variation explained. The paper is concludes with recommendation of strategies for effective management of land systems change.

Young Scientist Forum on Rural Landscape Sustainability

Entrepreneur-led exurban land system changes during the amenity transition: the case of Hocking Hills, Ohio, USA

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Rural land systems are being transformed by counterurbanization – decentralization and deconcentration of urban residents and businesses. Some rural areas that were formerly dominated by resource extraction are experiencing amenity transitions. During this transition, the environment becomes a consumption asset, which may facilitate forest conservation. What makes this issue more intriguing is that when tourism entrepreneurs spot the forest as a business opportunity and extend market mechanisms to the traditionally nonmonetary environmental and social context in the region, land changes within the burgeoning exurban community can be further complicated. These tourism entrepreneurs are key agents of change, but current literature pays insufficient attention to the impacts of their decisions. This paper fills in this gap by using Hocking Hills, Ohio, USA, as an example to analyze tourism entrepreneur's business strategies and their corresponding ways of capitalizing on environmental and social resources in an amenity-rich rural community. Regional changes such as falling forest commodity prices create opportunities for forest-based business strategies. Individual entrepreneurs forge varying businesses strategize that utilize social and environmental resources. The concrete form of land change will depend upon how past environmental changes (e.g., reforestation) create new opportunities for businesses, and the decisions made by individual entrepreneurs collectively lead to further land changes. This research thus explores this local and regional multi-scale feedback within which the rural land system transformation is rooted.

Spatial conflicts among multiple land uses in rural China: implications for ‘redline’ policies under rapid urbanization

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Land scarcity has become a global challenge for sustainability and this is particularly true for a populous country like China. Rural China is facing severe land-use competition to meet the purposes of urbanization, food production and ecological protection simultaneously. The Chinese government has released two ‘redline’ policies: a minimum area of arable land policy and an ecological redline policy to guide these competing claims. But the implementation of these policies by detailed geographical allocation of areas to be protected is still lacking. This paper aims to identify potential spatial-priority areas for these redlines and examine their spatial conflicts under urbanization. In this paper a possible way of operationalizing these policies was explored. The potential priorities for arable land were set based on Global Agro-ecological Zones model output of potential productivity, while that of ecological land was according to the compiled results of eco-fragile hotspots, eco-service hotspots and biodiversity hotspots. The threats of these areas through urban expansion were simulated with CLUE-s model up to 2030. The results indicate the potential redline priorities for arable land and ecological land respectively and showed that there were potentially significant spatial conflicts especially in South China. We analyzed this conflict in more detail within a case in the downstream region of Zi River and provided responding actions accordingly. The delineation provides a way for the elaboration of ‘redline’ policy to geographic locations and facilitates the identification of potential high-risk areas. This study indicates that ‘redline’ policies need integration of both top-down and bottom-up investigation.

Land Tenure and Agricultural Investment in China: A Meta-regression Analysis

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The existing literature on the relationship between land tenure and agricultural investment in China had given results that are often confusing and contradictory. Based on 208 samples taken from 25 pieces of literature in China, a meta-regression analysis was conducted to research the link between land tenure and each type of agricultural investment (short-term investment, land-attached long-term investment, not land-attached long-term investment and total investment). The results showed that the published, land tenure type, land taxes and off-farm employment or income variables affected selected literature's outcomes in the short-term investment. The published, study area, sample size, consider endogeneity, land reallocation, perception of property rights variables affected their outcomes in the land-attached long-term investment. The study area, consider endogeneity affected their outcomes in the not land-attached long-term investment. The study area, consider endogeneity, land use rights and land transfer rights affected their outcomes in the total investment. We also found that the measures of land tenure and agricultural investment, and the applied research methods could lead to different results.

Understanding land system sustainability: an empirical agent-based model of residential land markets in Kitchener-Waterloo, Canada

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Urban revitalization is a key strategy to improve land system sustainability in North American cities. The study area, Kitchener-Waterloo, is anticipating that the construction of a light rail transit route will promote urban core intensification and curb sprawl. This study aims to better understand how, when, and why such intensification may occur. Based on an ongoing homebuyer and seller survey with a focus on preferences for urban core locations and public transit, this paper develops a nonlinear willingness to pay (WTP) function combining stated and revealed preferences to estimate housing prices, and proposes an agent-based model to represent the housing market. Residential land market models often employ linear hedonic models that rely solely on physical characteristics to predict housing prices. In reality, housing prices are also heavily influenced by households' preferences for location and home characteristics. This study intends to expand the developing field of agent-based empirical land market modeling in two aspects: 1) by including data on buyer and seller preferences and characteristics and 2) by estimating a non-linear WTP function. Our model will thus better represent the bounded rationality and heterogeneous preferences and behaviour of land market stakeholders, leading to improved modelling of the land-use change that emerges from their intricate interactions. This innovative model will increase understanding of the links between infrastructure provision and urban core intensification, contribute to the assessment of public interventions and government policies, and ultimately improve our understanding of land system sustainability in mid-sized North American cities.

Hierarchical determinants of winter wheat abandonment in the North China Plain_A case study of Cangxian County in Hebei Province

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Since the late 1990s, the North China Plain (NCP) has undergone large-scale shrinkage of area sown to winter wheat, accompanying with traditional double cropping system being replaced by spring corns. However, studies on the underlying determinants are rarely found. The goal of this study is to detect the determinants across land parcel, household and village levels on farmers' cropping system decisions. A case study was carried out in Cangxian County of Hebei Province, and multi-level statistic models were constructed using household survey data. Our study reveals that of the variance in farmers' land use decisions, 50% and 30% could be explained at the land parcel level and village levels, respectively, while the remaining 20% could be explained at the household level. We found that the price of labor, the education level of the agricultural policy makers and the price of irrigation electricity were positively correlated with farmers' tendency to choose the spring maize single cropping system or to abandon winter wheat. We also found that soil quality, irrigation conditions and agricultural labor availability were negatively correlated with farmers' tendency to choose the spring maize single cropping system or to abandon winter wheat. The relationship between the labor age and farmers' land use decisions was non-linear, and the influence of farming distance was not significant. In addition, the plot area, agricultural equipment and land fragmentation all significantly influenced farmers' land use decisions. Households with agricultural equipment and lower land fragmentation were less likely to abandonment winter wheat, especially on larger areas of parcels. Overall, our study provides empirical identification on hierarchical determinants of agricultural land use change in the NCP, and encourages policies aiming at adjustment of cropping systems, integration management of both surface and groundwater, and promotion of land transfer, in order to achieve the twin goals of ecological conservation and food security in water-scarce areas.

Managing trade-offs and synergies for sustainable land systems - POSTER SESSION

COMPARED RAINFALL USE EFFICIENCY WITH SOIL MOISTURE USE EFFICIENCY TO ASSESS LAND DEGRADATION IN NORTHEAST ASIA DRYLAND REGIONS

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Abstract: As a proxy for land degradation assessment, rainfall use efficiency(RUE) has been questioned due to the over-dependence on ANPP. Soil moisture, an index of portion of rainfall that is directly available to plants, would be a better indicator of primary production changes than immediate rainfall. In order to assessing vegetation dynamics accurately in Northeast Asia dryland regions(NADR), soil moisture use efficiency, which link soil moisture and vegetation dynamics, was used to evaluate land degradation. Based on GIMMS NDVI data, soil moisture index product from the climate prediction center(CPC) and climate data from Climate Research Unit(CRU), the spatial distribution of dominant factors on vegetation dynamics were obtained by multivariate statistical regression analysis methods. RUE and SMUE were analyzed respectively in NADR, rainfall dominant control regions(RDCR) and soil moisture dominant control regions(SMDCR). The results show that 44.76% and 45.80% regions are rainfall and soil moisture control on NDVI during growing season (May to Sep). 10.83% RUE significant positive trend areas($P < 0.05$) are distributed in northeast of Mongolia, where also show significant positive trend of SMUE (12.74%). However, the negative trend of RUE most are not significant in RDCR, and the significant negative trend of SMUE (34.70%) are distributed in the northwest of China in SMDCR which show similar distribution with NDVI negative trend. Therefore, soil moisture should be integrated with rainfall or other factors (eg. vegetation structure) in assessing land degradation based on the characteristic of study area.

Incorporating geoscience knowledge into land use/land cover classification of high spatial resolution remote sensing image

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To achieve preferable land use/land cover change mapping, high accuracy results of image classification are crucial. This paper tries to solve this problem using the geoscience knowledge to improve the accuracy of image classification, which will be helpful to map land use/land cover change. Taking Jiangxi province as an example, the paper studies acquisition and expression of knowledge and its application in image classification. The first step is to build a set of scientific classification system combining with the characteristics of land use, land cover, gradient, elevation and soil of Jiangxi. Then using methods like cluster analysis and gray level co-occurrence matrix to excavate geoscience knowledge such as regularities of ground objects distribution, topology relationship of ground objects, special index from mass of geosciences data and remote sensing data. According to the properties of various kinds of knowledge, importing them to engineer with the expression of variable, production rule and text respectively, so the knowledge base is constructed completely. Finally using knowledge rule in the base to define the type of block and get the final classification results. This paper, proposing a land use/land cover classification system suitable for high resolution image and trying to solve the problem of the geoscience knowledge blending into image classification, improves the classification accuracy effectively and lays a good foundation for land use/land cover change mapping.

Analysis on Cultivated Land Use Efficiency in The Northeast Black Soil Area

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At present, the soil erosion of cultivated land in black soil area is serious, which results in black soil layer thinning and a decline of fertility. Improving the utilization efficiency of black soil area of cultivated land and protecting the black soil area of cultivated land resources is of great significance. In this paper, according to the results of the interviews of Nenjiang County in Heilongjiang Province, by using Two-stage Method based on data envelopment analysis (DEA), the land use efficiency under different land use pattern and its influencing factors within the study area are analyzed.

The result indicates that:

1)The cultivated land use efficiency of Nenjiang County is 0.874, and the land use efficiency of individual contracting is the highest.

2)There is a big difference between different crops cultivated land use efficiency of different crops in the study area. The income is diminishing along with the increasing of planting scale, in the corn planting area, which shows the opposite trend in the soybean planting area.

3)Amount of fertilizer per unit area, agricultural machine power, and yield per hectare etc. show significant impact on the land use efficiency.

The results can provide scientific basis for improving the utilization efficiency of the cultivated land in black soil area of the Northeast China.

A Resilience Perspective on Valley Oak Landscape Conservation and Land Change

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This poster examines variability in the spatial and temporal dynamics of valley oak at two sites in the Santa Monica Mountains, in the context of resilience theory and landscape conservation. Regeneration failure, climate change, and habitat loss pose challenges for efforts to conserve valley oak ecosystems. A resilience perspective of landscapes as social-ecological systems that are continually changing due to both internal dynamics and in response to external factors such as a changing climate can be helpful in addressing these challenges. The examination of two valley oak stands in Southern California provides an example of the necessity of this systems perspective where each stand is responding differently as a result of interactions with other parts of the landscape. One stand is experiencing regeneration failure similar to other stands across the state. A nearby stand is regenerating well and maintaining spatial and structural patterns, likely due to the availability of imported water associated with upstream urban development. Valley oak stands have a capacity for reorganization as a response to changes in the landscape and environmental conditions. This reorganization can benefit conservation; however, we must ask what limits there are to valley oak's capacity to reorganize and still maintain its ecological function.

Eliciting human cognitive processes as moderators between underlying drivers and proximate causes in land systems

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Understanding drivers in land systems is critical for sustainable environmental management. Previous studies summarized that environmental change and human decisions are, respectively, the underlying drivers and proximate causes of SES change; and environmental change underpins human decision-making but is moderated by human cognition. However, the mechanistic representation on how environmental change leads to variations of individual decision-making is still largely unexplored. We systematically search for literature regarding environmental psychology and land system change. Based on a comprehensive analysis of existing studies, we elicit key elements that are crucial for measuring cognitive processes, and further present a synthesis that illustrates the moderating role of cognition between environmental factors and human decisions. Literature suggests that cognition primarily includes perceiving the environment and forming an attitude before making a decision. Variations in cognitive processes may lead people to behave differently even under similar circumstances, causing discrepancies between the underlying drivers and proximate causes. A perception–attitude–decision (PAD) framework is proposed consequently to understand how human cognitive processes act as moderators. The evidence from agricultural land system change in Northeast China shows that even when certain environmental factors are found to be important to underpin system changes, they may not be perceived and/or regarded as real drivers by decision makers at either the individual or aggregated level, due to the moderating role of environmental cognition. Understanding the cognitive processes of decision-making clarifies the mechanisms and variation of the moderation between the underlying drivers and proximate causes of land system change. Such an understanding can improve the design of scientific studies, inform the development of agent-based models and support the human-centred policy-making.

Simulation and space-time trade-offs of ecosystem services in arid regions: a case study in Altay Prefecture, China

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The research of ecosystem services has become the international frontier of ecology and related subjects. Simulation, trade-off analysis and optimal management of ecosystem services are becoming new research focuses. Long term over-grazing and deforestation have led to serious degradation of ecosystem and ecosystem services, due to the lack of attention to arid region, especially the desert-ecosystem services. Taking Altay Prefecture as an example, InVEST, USLE, SAORES and RWEQ models were used to simulate water yield, soil conservation, crop production and sand fixation in the year of 1990, 2000 and 2010, respectively. Space-time trade-offs of ecosystem services are researched based on spatial correlation and scenario analysis. The results show that: 1) Under the influence of land use and climate change, ecosystem services show a trend of overall increase and local reduction. 2) Water yield and sand fixation have a strong trade-off in mountains, oasis and desert, while water yield and soil conservation show a strong synergy in mountains and desert. 3) Scenarios of valley forests and grass recovery and desert scrub conservation contribute to increasing services of water yield, soil conservation and sand fixation, which are better than scenarios of grazing prohibition or large-scale agricultural activities. In the management of ecosystem in arid regions, we proposed to strengthen monitoring and evaluation of the desert-ecosystem. The traditional way of grazing should be changed and protection zone of ecosystem services should be established to promote regional sustainable development.

Improving biomass estimation methods for the Amazon

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The Amazon Fund supports the project Environment Monitoring via Satellite in the Amazon Biome, managed by the National Institute for Space Research (INPE) and Foundation for Science, Technology and Space Applications (FUNCATE). The project develops studies on land use and cover in the Amazon biome, as well as the expansion and improvement of the environmental monitoring by satellite conducted by INPE. The project has seven subprojects and here we focus on subproject 7 (Sub07): improving the methods to estimate biomass and emissions from land use changes. According to the literature, large-scale biomass maps using satellite data integrated with forest inventory plots data present high uncertainties. However, some recent initiatives using airborne LiDAR systems (ALS) have reduced uncertainties on biomass estimates. In this context, the Sub07 contracted ALS services to scan 626 transects (12.5 km x 0.3 km size) spread over the forested area of the Amazon biome. Most transects were randomly located, although some were located over known inventory plots. Metrics extracted from all transects point clouds will be inputs for modelling aboveground biomass (AGB) and calibrated against forest inventory plots. Combining the resulted AGB with other datasets will provide a new biomass map for the Amazon biome, which we expect to be more accurate. As a whole, Sub07 and the other six subprojects will help implement the National Communication and REDD strategy in Brazil, since they will increase controls on deforestation and forest degradation, by strengthening INPE's monitoring systems and increasing expertise on deforestation and degradation's progress over time.

Variation trend and driving forces of grassland ecosystem services in Xilin Gol league of China

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Understanding the effect of climate change and land use/cover change on ecosystem services provides a guidance in ecosystem management. However, the seasonal driving force of grassland ecosystem service trend have not been fully explored. Our goal was to identify how the variation trend and driving forces of grassland ecosystem services vary with seasons. In this study, we estimated five ecosystem services in Xilin Gol league of China during 2001-2014, including Net primary productivity, water yield, water retention, soil erosion by wind, and soil conservation. The Mann-Kendall test and Sen's method were used to quantify the variation trend and slope of five grassland ecosystem services at the pixel level. The driving forces of ecosystem service trend were analyzed by semi-parametric Geographical Weighted Regression. The results showed that the spatial patterns of ecosystem service trend were distinct in different seasons. Because grazing caused the destruction of grassland in summer, the trends of NPP and SL were respectively downwards and upwards in the most areas of Xilin Gol league in autumn. Wind trend has the strongest positive effect on the SL trend in spring than that in other seasons. The increasing of forest and grassland area percentage has stable positive influence on the trend slope of NPP globally. Due to hydrological condition, the spatial pattern of the effect of farmland area percentage trend on NPP trend is consistent with longitude. The spatial heterogeneity of influence of climate factors and land use/cover types on grassland ecosystem services is important for spatial explicit ecosystem management.

Water resource management – medieval and modern. A case study from Hungary

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The results of historic landscape studies on the Pilis mountains – a karst region, as well as a protected natural landscape (biosphere reserve) – will be presented. Local practices of water management – multiple fishponds and mills, terraced land use systems, protective greenbelts along riverbanks etc. will be explained. Correlations between historic and modern water management will be highlighted. These systems prevented the degradation of lands, minimized waterlogged areas, prevented flashfloods on small watercourses. Long term socio-economic changes will be highlighted, which deteriorated these systems (decreasing buffer capacity). Due to disfunctionality, settlement zones were becoming more prone to flash floods. Recently, ecological restorations of small watercourses have been advanced, e.g. the construction of small reservoirs battling the temporal variability (seasonality) of rainfall. As nature protection policies focus on resilience, they become more integrated (holistic), and the task of restoration becomes more complex. From our perspective of landscape history, and landscape design, the example of the Pilis will be used to illustrate the following challenges: how restoration works make use of past landscape features; how are climatic and hydrological circumstances different from that of the past; how the latter is affected by excessive (industrial and sanitary) use of water resources of modern days, influencing variations of the water regime. Relying on the study of past landscape features is it possible to give a better answer to the problem of hydrological sizing of water reservoirs, calculate flood control capacity, keeping in mind the altered conditions, i.e. not only anthropogenic but also climate induced hydrological changes?

Antecedents of the largest river control in 19th century Europe and its consequences in the land use system

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This study presents the environmental and socio-economic challenges emerging in the 18–19th centuries, which, in our hypothesis, induced social responses leading to the regulation of the River Tisza and its tributaries. Additionally, by exemplifying historical land use reconstructions of a 9931 km² study area using the three maps of Habsburg military surveys (1782–1785, 1858, 1883–1884) we demonstrate the fact that the biggest river regulation of 19th century Europe was linked to a radical change in the land use system of the Great Hungarian Plain. 19th century wetlands that temporarily or constantly covered half of the plain suffered their draining and their transformation into homogenous grain producer lands. The most crucial economic and social factors lying in the background of the expansion of arable lands: nutritional challenge, rising grain and land prices, forms of land ownership and efficiency of transportation. According to our hypothesis the first stage in the process leading to the creation of the ‘modern landscape’ in the Tisza Valley was the 18th century crisis of the late medieval and early modern farming system based on the trinity of animal husbandry–cropland farming–exploitation of aquatic resources and communal land tenure. This communal land use system that adapted to the ecological conditions was built upon a broad cooperation of entrepreneurial groups of market town citizens since the late Middle Ages.

Spatiotemporal patterns of air pollution and their underlying drivers in the Beijing-Tianjin-Hebei region and Agro-Pastoral Transitional Zone of North China

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China's tremendous economic achievements in the past three decades have resulted in a number of environmental problems, including the deterioration of air quality. However, it remains poorly understood what major factors influence the spatial pattern of air pollution in China on different time scales. To address this question, we first quantified the spatiotemporal patterns of air quality in the Beijing-Tianjin-Hebei region and the Agro-Pastoral Transition Zone (APTZ) of North China for comparison, and then examined the relationships of air pollution to several socioeconomic and climatic factors on the seasonal, annual, and decade scales. Statistical analysis was conducted on three time scales, using constraint line analysis, correlation analysis, and stepwise regression. From 1999 to 2011, the most important factors deteriorating air quality were socioeconomic factors, such as energy consumption and GDP in 2nd industry, followed by climatic factors. At the annual scale, the PM_{2.5} was the dominant pollutant in the Beijing-Tianjin-Hebei region. The PM_{2.5} and PM₁₀ were two main pollutants in the APTZ. High wind speed, low relative humidity, and long sunshine duration had strong constraint effects on PM_{2.5} accumulation. Low wind speed and high relative humidity were two important constraint factors to PM₁₀ accumulation. Short sunshine duration and high wind speed showed strong limits on O₃ accumulation. Our analysis demonstrated that multi-scale analysis not only was effective in determining key drivers of air pollution, but also achieved a deeper understanding on spatiotemporal heterogeneity of air pollution and served as the basis of urban planning and environmental protection projects.

Harvest Area Gap: Potential and Limits to Grain Production Growth by Increasing Cropping Intensity in China

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Increasing yield and expanding cropland are two approaches to improve crop production. However, new solutions are urgently required for China as it is experiencing both extensive yield stagnation and severe land pressure. This paper aims to explore a third way for grain production growth: the potential of bringing more annual harvest area within the currently cultivated land by sustainable intensification. We conceptualized harvest area gap to represent the potential cropping area within the current cropland extent by increasing multiple-cropping. We measured China's Intensity Area Gap by subtracting the actual harvested area from the maximum harvest area potential, and further adjusted it to the exploitable Harvest Area Gap giving consideration on water constraint. Harvest Area Gap in China ranges from 13.5 to 36.3 million ha, depending on water allocation scenarios. If such an area gap is fully cropped with current productivity, the total production would increase 23% under the best water allocation scenario. Moreover, South China and Lower Yangtze are the best regions to intensify, owing to their largest Intensity Area Gap, sufficient water and good irrigation infrastructure. Harvest area gap can be of great implications for agricultural intensification and food security. Despite the positive role for increasing grain production, increasing cropping intensity needs to consider multiple constraints that may hinder the full exploration of potentials and to avoid negative environmental consequences in agro-ecosystems. Our study implies that water relocation scheme – which is largely determined by socioeconomic factors – will have great impact on the full intensification of Harvest Area Gap.

A new method for assessing the land carrying capacity: Using emergy analysis and calculation of “land-grabbing” in Beijing-Tianjin-Hebei

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Land carrying capacity is a basic element of regional cooperative development and land use spatial structure optimization. Emergy analysis is an effective method for value analysis of ecosystems, which is based on principles of systems ecology and energy. "Land grabbing" is defined as very large-scale land acquisitions, either buying or leasing, there are many case in Beijing-Tianjin-Hebei. This paper presents a new method of land carrying capacity, an index of land carrying capacity is developed with emergy density and “Land-grabbing” intensity, which was evaluated based on emergy analysis and "Land grabbing" accounting, the integrated evaluation model improve the diagnosis of problems and promote balanced development among Beijing-Tianjin-Hebei. Emergy analysis and "Land grabbing" accounting were evaluated on county scale, and its spatial differentiation pattern ware researched by GIS spatial analysis. The different energy flows between the “grabbed” and “grabbing” counties, respectively, based on the land carrying capacity index, the counties were devised into four classes, namely in good condition, the general state, alert state and crisis state in Beijing-Tianjin-Hebei. The characteristic of spatial differentiation were present the distribution of scattered dot and aggregation belt, and some policy measure were developed to ensure the land resource demand with coordinate development in Beijing-Tianjin-Hebei.

This study showed the importance of land carrying capacity for regional cooperative development, and it is a great significance that the “land-grabbing” were introduced in land carrying capacity assessment on county scale, thereby supporting the formulation of land use spatial structure to make understanding regional balance and sustainability.

Global land-cover and land-use change of the last 6000 years for climate modelling studies: the PAGES LandCover6k initiative

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The goal of the PAGES LandCover6k initiative is to provide relevant, empirical data on past anthropogenic land-cover change (land-use change) for climate modelling (e.g. the CMIP5 initiative). Land-use change is one of many climate forcings and its effect on climate (past, present or future) is still debated. The LandCover6k working group infers land-use data for the past 6000 years from fossil pollen records of lake sediments and peat deposits, and from historical archives and archaeological records. The working group is divided into three activities, i) pollen-based reconstructions and mapping of past land cover using pollen-vegetation modelling approaches and spatial statistics (1, 2), ii) upscaling and summarizing historical and archaeological data into maps of major land-use categories linked to quantitative attributes, and iii) the results of i) and ii) are then used to revise existing Anthropogenic Land-Cover Change (ALCC) scenarios, the HYDE database (3) and KK (4). The products i)-iii) are meant to be suitable for climate modelling. The LandCover6k working group focuses on regions of the world where humans have had a significant impact on land cover through deforestation and diverse agricultural practices, i.e. the Americas, Western and Eastern Africa, Europe, and Asia. In Asia, the emphasis has been placed so far on China, India and Japan.

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InVEST Model based impact assessment of Land Use/Cover Change on ecosystem services in Poyang Lake wetlands

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Assessment of Ecosystem Services (ES) is a forefront issue for ecological research in contemporary era. Considering rich biodiversity and implementation of a number of ecological restoration projects in Poyang Lake area, we have selected Poyang Lake wetland as the study region for this research. In this study, methods of Participatory Rural Appraisal (PRA), and ecosystem services assessment modeling by using InVEST model were adopted. Data was collected based on field surveys on Land Use Cover (LUC), migrant bird habitat data, migrant bird species data and household survey data in the typical villages, in order to assess impact of Land Use and Cover Changes (LUCC) on biodiversity and soil retention of Poyang Lake wetlands in recent 10 more years.

The results shows that: in the recently years, according to the increasing area of forest and grassland, the supply services function had been decreasing while the regulation services, cultural services and support services had been increasing. Among which, the average habitat quality in Poyang Lake wetland had been increasing by 4.53% during 2000-2012, and the amount and species of migrant bird had been increasing obviously. The total soil erosion amount had been decreased 1053.9 thousand tons during 2000-2010 and the soil retention amount had been increasing by 284 thousand tons.

Integrated use of GCM, RS and GIS for the mapping and assessment of land degradation in the Sancha River Catchment

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The black soil region of Northeast China has suffered from severe land degradation due to soil erosion by water. The objective of this research was to integrate use of geographical conditions monitoring (GCM), remote sensing (RS) and geographic information system (GIS) techniques for the mapping and assessment of land degradation and explore spatial coupling relations between hillslope and gully erosion in the Sancha River catchment of Northeast China. The revised universal soil loss equation (RUSLE) model and visual satellite image interpretation were used to evaluate hillslope and gully erosion, respectively. The results showed that (1) although the study area as a whole had slight erosion due to rill and sheet erosion, the catchment suffered more serious gully erosion; (2) GCM contributed to the overall improvement of the soil erosion mapping and assessment, particularly the cover management and practice factor mapping and the recognition of ephemeral gully; (3) analysis of spatial coupling relations revealed that topographical differentiation characteristics of hillslope and gully erosion were not completely similar. The study indicates that using GCM, RS, and GIS technologies simultaneously results in an effective mapping and assessment of land degradation in a considerably short time and at low cost for large watersheds. The findings also promote a better understand the spatial coupling relationships between hillslope erosion and gully erosion. The results might be helpful for decision makers developing sustainable land use plans and comprehensive soil and water conservation management in the study area.

The relationship study between landscape patterns and ecosystem services value in Jianguo coastal zone

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Coastal zone is the ecological fragile area that human activities disturbed seriously, the landscape structure evolution may take a significantly influence on the change of regional ecological service value. Using 1980, 1995, 2000, 2005 and 2010 TM images of Jianguo Province and the method of Canonical Correspondence Analysis (CCA), we analyzed the relationship between landscape patterns and ecosystem services value in this region. The results shows: (1) the ecological service value of Yancheng city is highest, next is Nantong city and Lianyungang city is lowest. (2) the patch density and splitting index of coastal zone shows an increasing trend, and the fragmentation is obvious. (3) There are strongly negative correlation between the splitting index and the total value or partial value of ecosystem services of study area. (4) With time growth, landscape fragmentation index increased and the ecosystem services value reduced in the reclamation area.

Unlock the Potential of Land-Use Modeling for Policy Analysis in an Urbanizing World

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In agricultural land-use systems, often individual households, embedded within local and broader social and environmental settings, make cropping decisions, collectively shaping spatial patterns and temporal changes of land use. As rural households are increasingly integrated with urban economies and markets, policy makers face additional challenges to promote sustainable land use in developing countries and feed an increasingly urbanized world population. This poster presents our attempt at combining different land-use modeling techniques to understand the dynamics of agricultural land-use systems and provide insights into how policies may adapt at different stages of development to effectively promote agriculture in the process of urbanization. With a case study in the Poyang Lake Region, we demonstrate the use of (i) multilevel statistical analysis of household surveys in explaining cross-scale processes behind household cropping decisions, (ii) geospatial data mining and cellular automata model in identifying areas where cropping practice is likely to experience different types of changes, and (iii) agent-based modeling in exploring the dynamic landscape of future agricultural land use under interactive influences of rising nonfarm income, land markets, price changes, and agricultural policies. Our key messages are (i) understanding household decisions and local variations is important because they can suggest policy interventions and provide policy opportunities to promote food production and environmental sustainability, and (ii) examining interactions (rural-urban interactions, human-environmental interactions, cross-scale interactions, and interactions among multiple influencing factors) is critical for understanding household decisions and local variations.

Monitoring the biodegradation of organic inputs from forest systems for sustainable land management

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Litter decomposition has a remarkable role in the C cycle not only for being an important CO₂ source but also for building soil organic matter, with huge influences on soil fertility. Since genus *Pinus* is broadly planted in the temperate zone, studies of the duff layer in this type of forests are abundant, but few assess its ¹³C isotope decay dynamics. Thus, our objective is to evaluate ¹³C changes during pine litter biodegradation to understand mechanisms involved in the incorporation of decaying inputs as a contribution to improve models of land system processes. For that, we determined the organic functional group distribution (by ¹³C-NMR) of different pine plantations and the litter ¹³C composition at different degradation stages. The variability between the pine duff from different forest plantations did not mask some common trends during litter decay and a brief ¹³C depletion was detected at the beginning of the incubation. Yet some dissimilarity can be highlighted, some debris presenting significantly higher instantaneous mineralization rates of the labile C pool as compared with others, possibly related with the specific chemical composition of litter degradable substances, differences on the half-lives and residence times being found. A negative significant correlation between litter ¹³C contents and early C fluxes was also observed, suggesting that the isotopic composition of the O horizon from these ecosystems could be used as a suitable indicator of pine litter biodegradability and CO₂ emission kinetics, which would help to understand mechanisms influencing the terrestrial C stocks in these temperate perennial forests

Temporal and spatial dynamics of soil erosion in North-south Pan River Region in China in 2000-2010

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The North-South Pan River watershed (102°15'-106°22'E, 23°07'-26°51'N) is located in the upper reaches of Pearl River, Southwest China and covers an area of 8.28×10⁴ km². The two main rivers run across Yunan, Guizhou and Guangxi Province. The North-South Pan River region is one of the largest karst areas in China and the ecological environment is extremely vulnerable. In the past few years, owing to the rapid growth of population, and the irrational, intensive land use on this fragile environment, serious soil erosion has expanded at an overwhelming rate. In 2000, the Grain-to-Green project, converting slope croplands into forest or grasslands, was launched to improve soil erosion control in the region. In this study, the techniques of RS, GIS and Revised Universal Soil Loss Equation (RUSLE) were applied to make a temporal and spatial analysis on the dynamics of land cover change and soil erosion. And the effects of Grain-to-Green project on soil erosion control were assessed. The results showed that: (1) After Grain-to-Green project, the cropland decreased a lot, which was mainly converted into forest and grassland, and the converted areas are 134.6km², 42.5km² separately. Much grassland was also converted into forest with a converted area of 86.6km². (2) With the afforestation of sloping cultivated land and degraded farmland, large numbers of rural laborers have become surplus in terms of local needs and moved away to work in large cities. This out-migration has changed the size and structure of the population in this region, which may, in turn, have affected the vegetation dynamics. The vegetation fraction coverage increased a lot with a rate of 0.4%/yr. (3) Vegetation restoration helps to prevented from soil erosion. From 2000 to 2010, the soil erosion rate decreased from 16.8t/hm² to 11.8t/hm², and the soil erosion amount decreased from 1.36×10⁸ t to 0.951.36×10⁸ t. Except the region that fell within minimal erosion category, the area of all the other regions that fell within low, moderate, high and extreme erosion category decreased a lot. The low erosion category decreased about -0.8%, the moderate erosion category decreased about -3.9%, and the higher erosion category decreased about -3.9%. The land cover change from cropland to forest and from cropland to grassland had great impacts on the reduction of soil erosion. From cropland to forest, the soil erosion rate decreased from 18.1t/hm² to 11.5t/hm² with a decreasing rate of -36.5%. From cropland to grassland, the soil erosion rate decreased from 20.9t/hm² to 3.9t/hm² with a decreasing rate of -33.5%. (4) From the above results, the Grain-to-Green project had achieved great effects on soil erosion control in this area. But the ecological environment is still fragile in North-south Pan River Region, so we should keep making more efforts on ecosystem restoration to enhance the achieved good effects.

Research progress in the improvement of severe saline alkali soil

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To guarantee food security, improvement of saline-alkali soil plays significant role. New packages of techniques regarding saline-alkali soil improvement have been developed for rice planting in Jilin Province by professor Shuwen Hu's group from China Agricultural University, and those techniques are Ecological friendly. Integrated technologies were employed to improve barren land comprehensively including following keys: new type polymer soil conditioner, specialized controlled release fertilizers, chelated microelement fertilizer, seeds reagents and other traditional soil fertility improvement methods such as returning straw. The assistive technologies include new type macromolecule soil conditioner, specialized controlled release fertilizers, chelated microelement fertilizer, new seeds reagents and other traditional soil fertility improvement methods such as returning straw.

Improvement of Saline-alkali plays an important role in guaranteeing food security. A series of saline-alkali ecological improvement method for the analysis of the saline-alkali soil characteristics has been developed by the group leading by professor Shuwen Hu from China Agricultural University.

The technology can significantly improve the saline soil structure and soil physical and chemical characteristics. The rice salt resistance had been greatly strengthened throughout the whole growth period, and the yield of rice significantly increased by 4-fold compared to CK in the first year. This saline land improvement can be effectively sustained in the next few years without additional polymer soil conditioner. Both economy and ecology are benefited from this novel technology.

Anthropogenic Biomes: Sustaining Ecology and Development in Human Landscapes

Investigating anthrome landscape dynamics using an agent-based synthesis system approach

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Anthropogenic biomes, or Anthromes, offer a useful classification and heuristic for characterizing the extent and nature of human modification of the natural landscape. It also contextualizes landscape patterns in any given location within a global, systematic classification scheme, which enables cross-site comparative analysis of land use in a global context. However, a similar understanding of Anthromes came to be and change – with their particular land-use and ecological profiles – is lacking. Furthermore, since humans are the proximate cause of all land use, this requires an understanding of the behavioral mechanisms and socio-cultural interactions that produce distinct Anthrome landscape patterns. Towards these goals, we apply the agent-based synthesis system (ABSS) approach. The ABSS uses a ‘building-block processes’ modeling design with a generalized agent-based model (ABM) of land-use decision-making. The pattern-oriented modeling (POM) approach is combined with an innovative hierarchical genetic algorithm (HGA) to simultaneously select and calibrate the ABM at multiple sample sites across Anthromes. The HGA parameterizes scaling relationships between globally available data and local production and consumption factors, and systematically progresses from very simple, generalized model structures to more sophisticated and site-specific formalizations as needed. We attempt to identify the combination of generic (e.g., biome, global market influence) vs. local (e.g., population density, land suitability) drivers that explain current Anthrome landscape patterns and explore scenarios of change that produce transitions between Anthrome categories. Together, these innovative methods support a ‘generative modeling’ approach for disentangling which processes are important at each application site and across Anthromes.

Anthromes: new tools for understanding the global ecology of human landscapes

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By uniting the social and environmental sciences at the core of land system science, anthromes (anthropogenic biomes) provide an essential global framework for understanding the increasingly anthropogenic landscapes of the Anthropocene. This presentation will review some of the main ways that anthrome-based analyses have already enhanced global understanding of the causes, consequences and dynamics of human transformation and use of landscapes, with the goal of highlighting new opportunities for anthrome-based research, applications and education. Strategies for combining free online anthrome datasets with other free online data to generate novel research results on the global human ecology of the Anthropocene will be presented. The utility of anthromes for teaching environmental science and geography will be demonstrated with examples from university level to kindergarten and public outreach. While existing work has already established anthromes as a key framework in land system science, the most important and ambitious research and applications of anthromes are yet to come. New theory on the coupled social-ecological drivers of anthrome change (anthroecology theory) has the potential to inspire new global models of coupled social-ecological change from the beginning of the Anthropocene into the deep future.

Agromes – mapping the Agricultural Biomes of the world

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Given that we live on a human-dominated planet and that agriculture is the largest human use of land - and expanding on the concept of Anthromes developed by Ellis & Ramankutty (2008) - we argue that we should be describing the Earth's land surface in terms of 'Agricultural Biomes' (Agromes) rather than natural biomes that would have been there without human influence. Such Agromes can take many different forms - from low-input, diverse agroforestry homegardens in Kerala, India, to large-scale high-input corn-soybean systems in Iowa, United States - with very different environmental, social and economic outcomes. For analytical and policy purposes it is therefore crucial to understand the spatial patterns and characteristics of these different Agromes. In this project we develop a global classification of Agromes, characterizing the different types of farming systems of the world using newly developed global sub-national agricultural management datasets. Such a global map of farming system types will allow not only to highlight the ubiquitous influence of agriculture on our planet, but it will also provide more useful analytical units for the analysis of the global terrestrial biosphere than traditional natural biomes, and it will allow the assessment of the environmental, social and economic outcomes of different types of farming systems. Here we present first results from the global Agromes mapping project, as well as results from a European pilot project where we examined the relationship between European Agromes and different types of environmental (agricultural nitrogen loss and agricultural greenhouse gas emissions) and production (food, feed and biofuel delivery) outcomes, hypothesizing that structurally similar Agromes will behave in functionally similar ways.

Anthromes 12K: Mapping Long-Term Human Transformation of the Terrestrial Biosphere

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For millennia, humans have been altering landscapes across the terrestrial biosphere. Global estimates of direct human transformation of ecosystems vary among studies, but it is increasingly clear that humans have now transformed ecosystem pattern and process across most of the terrestrial biosphere. Anthropogenic biomes, or anthromes, characterize this global transformation by classifying and mapping the full spectrum of anthropogenic landscapes produced by human populations and their use of land, from dense settlements to villages, croplands, rangelands, seminatural lands and wildlands. Anthromes have been mapped globally for a limited number of time increments up to 8,000 years into the past. Here we introduce Anthromes 12K, the first global mapping of anthromes at high temporal resolution over the past 12,000 years, from 10,000 BCE to 2015 CE based on gridded global data for human population density and land use from the new HYDE 3.2 database. While historical data represent model outputs with considerable uncertainty, these new data enable the first spatially explicit global assessment of the emergence and long-term dynamics of human transformation of the terrestrial biosphere. Preliminary results demonstrate profound regional differences and diverse temporal trajectories of anthropogenic transformation of Earth's terrestrial ecology, ranging from massive early alterations followed by millennia of recovery to recent, rapid, intensive and accelerating transformations. The Anthromes 12K and HYDE 3.2 datasets are being released as open access data for use in assessing the consequences of long-term anthroecological changes across the biosphere.

Beyond land sparing or land sharing? Converging opinions in science vs actual implementation of land policies

Aligning agricultural production and biodiversity conservation in heterogeneous landscapes

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How to align agricultural production with biodiversity conservation remains a grand challenge. Optimization can help to assess the trade-offs between yields and biodiversity, and to identify alternative land management strategies that would mitigate these trade-offs. This is typically done assuming homogenous landscapes and thus that each location has the same production and conservation value, which is unrealistic for larger landscapes where yields and species' communities typically vary. Here we use optimization methods to identify optimal land management strategies for agricultural production and biodiversity conservation using synthetic, simulated landscapes. We then apply our framework to the assess trade-offs between meat production and bird conservation in the Dry Chaco in Argentina. Our results indicate that excluding landscape heterogeneity in management decisions leads to sub-optimal outcomes. Likewise, when landscape heterogeneity is accounted for, optimal landscapes typically have elements of both land sparing and land sharing. The actual arrangement of optimal landscapes is strongly influenced by whether species abundance is positively or negatively correlated with areas of high or low yield. Our analyses highlight that considering landscape heterogeneity is essential when identifying strategies to harmonize agricultural production and conservation goals.

Land sparing policies may not result in spared forest and could eliminate shared mosaic landscapes

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Recent scientific debates on land sparing (keeping nature pristine and intensifying other land uses to limit their extent) and land sharing (maintaining mosaic landscapes with a mix of nature and other land uses) have largely converged on the need to consider specific contexts when managing landscapes for ecosystem service provision. Nonetheless, in many developing countries land sparing remains directly or indirectly a development goal as illustrated by distinct (and often disconnected) policies on forest conservation and agricultural intensification. As several case studies indicate that these policies often have unintended outcomes, I reviewed the scientific literature to explore the hypothesis that land sparing policies may not achieve the aim of actually sparing any forest. Moreover, they may also result in the disappearance of traditionally shared mosaic landscapes as agriculture becomes increasingly commodified and profitable. The analysis shows that there is a large diversity in how land sparing is approached in different countries, but frequently the outcome is neither land sparing nor land sharing. Wholesale conversion to agricultural landscapes, perhaps with the exception of islands of ‘flagship’ national parks with high protection status, is common. The need to link the scientific debates on the pros and cons of land sparing and land sharing to actual land use policy processes and implementation is emphasized.

Effects of livelihood diversification on land use change in developing countries: Diversification or simplification?

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Livelihood diversification is a commonly selected strategy by rural households in developing countries. However, how livelihood diversification affect land use change in developing countries is not clear, which also contribute to rapid changes in biogeochemical cycles, hydrologic processes and landscape dynamics. A number of studies examine the land use intensification or agricultural intensification, particularly for the definitions, measurements, driving forces and effects. However, very little research has been done on land use diversification, which is also an important issue in land use science. In this paper, we examine how livelihood diversification affect land use diversification using Meta-analysis and systematic literature review based on a global assessment. Firstly, the concept and description of land use diversification/simplification are defined, which is a new perspective for synthesis studies in land use science. Secondly, we review and summarize the manifestations and drivers of livelihood diversification selected by households in developing countries. Thirdly, the manifestations, assessments, environmental and social-economic impacts of diversification and simplification of land use are discussed. In different regions, there are different manifestations in land use change and livelihood diversification. Land use diversification may be affected by complex drivers from many aspects in social-ecological systems. Fourthly, we provide a framework coupling livelihood system and land systems (Coupled livelihood-land system, CLLS) comprehensively and theoretically. Finally, we propose a hypothesis that land use becomes diversification from the subsistence agriculture to commercial cash crop plantation, then simplification adapting to de-agrarianization stage, and finally diversification coping with modern agriculturle.

Land use allocative efficiency for supplying multiple ecosystem services

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In land systems, policy and governance responses are required to ensure the efficient supply of multiple ecosystem services given growing competition for land between multiple land uses and ecosystem services. Managing competition between land uses requires efficiency in land allocation. Using the LUTO model of Australian land use and ecosystem services, we modelled the potential competition for land and the efficiency in supplying multiple ecosystem services in Australia's agricultural land under global change from 2013 to 2050. We created production possibility frontiers (PPFs) for carbon sequestration and agricultural production, water resources, and biodiversity services. The presence of markets for agricultural commodities and carbon produced efficient outcomes for agricultural production and emissions abatement. However, land use allocations did not efficiently supply either water resources or biodiversity services due to weak price signals. When two objectives were considered as is typical in efficiency assessments, efficiency improvements could be achieved through alternative land use configurations. However, significant unintended trade-offs occurred for the other objectives, and substantial opportunity costs were incurred. When multiple objectives were considered simultaneously, land use arrangements were identified that were efficient across multiple ecosystem services. By adjusting the metric used to combine multiple services, efficient land use arrangements could be achieved that meet society's preferences for ecosystem service provision from land systems. Market incentives are needed that effectively price multiple ecosystem services to increase the efficiency of land use arrangements and effectively manage competition for land.

Biomass monitoring and modelling in the context of land system change

Spectrum of the index landsat satellite on defining area covered by forest

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ABSTRACT:

Objective: Define vegetation cover changes of the logging area use normalized difference vegetation index (NDVI) with the Landsat satellite data. Remote sensing is the art and science of obtaining information about a logging area without being in direct physical contact with the Mongolian vast territory. Remote Sensing can be used to measure and monitor develop environmental policies and plans of the research areas.

For the estimation of forest biomass, a regression model linking Normalized Difference

Vegetation Index (NDVI), to forest biomass in the regions where precipitation is the predominant variable for vegetation growth season was developed.

Results: we determined vegetation cover change between 2000 to 2014 in August using NDVI and described future monitoring of forest. We have selected random 250 points from satellite images then collected NDVI values in August of 2000, 2007 and 2014. NDVI values were 0.56 in 2000, 0.58 in 2007 and 0.3 in 2014. As result shows that vegetation decreased in 2014.

In the future we will analyze for forest management using satellite images and improve the forest monitoring.

Nationwide modelling of tree biomass across Swiss landscapes

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Within the context of the United Nations framework convention on climate change (UNFCCC), 196 Nations are committed to reporting annual greenhouse gas emissions including reporting on carbon stocks and the above ground biomass (AGB) component. Tree cover is generally a large proportion of AGB, and, a significant proportion of total tree cover is often found outside forests (across Switzerland over 6%). Detailed quantification of AGB for trees however, is usually limited to forest areas. In many cases, including Switzerland, GHGI biomass reporting for areas outside forests is based on land use type, estimated based on research studies or expert knowledge. The significance of tree biomass on non-forest land use types is becoming more recognised and the ability to model AGB separate from land use type more and more relevant with changing land uses and shifts to more complex land systems. This research takes advantage of nationwide airborne laser scanning (ALS) data and derived structural information to create a Swiss-wide model of above ground woody biomass, both inside and outside of forest. The modelling approach is applied across a large nationwide heterogeneous area and offers a more nuanced model of biomass than current nationwide GHGI models, allowing for greater spatial variability especially in non-forest areas. Our model accounts for a significant amount of biomass (up to 7% of the total biomass) that is unaccounted for in current estimates used for the GHGI and carbon accounting, on land use types previously considered to have no woody biomass (e.g. settlement areas).

Modeling changes in the biomass stock and carbon emissions due to forest degradation and clear cut deforestation in tropical regions

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Forest degradation carbon emissions are still poorly quantified, although climate change mitigation schemes, such as the UN-led Reducing Emissions from Deforestation and Forest Degradation (REDD+), will require accurate estimates of carbon emissions following forest disturbance. In this work we present a first attempt to estimate greenhouse emissions combining the three deforestation-related processes (*clear-cut deforestation, secondary vegetation dynamics and old-growth forest degradation*), using the spatially-explicit INPE-EM carbon emission modeling framework. INPE-EM is a spatially-explicit version of the book-keeping model proposed by earlier work, modified to better represent the secondary vegetation dynamics and forest degradation processes in tropical regions. Biomass in each cell is dynamically updated (increases or decreases) as the result of subsequent forest degradation events (fires, selective logging), post-event regeneration, clear-cut deforestation and agricultural abandonment - giving way to secondary vegetation regrowth. The results obtained for the Brazilian Amazon confirm the potential impact of forest degradation in the regional carbon balance: the average gross emission due to degradation was estimated to be 47% of the clear-cut deforestation gross emissions from 2007 to 2013 - although the aggregate effects of the post-disturbance regeneration can partially offset these emissions. The INPE-EM model has also been coupled to a spatially-explicit land use change model to generate alternative emission scenarios until 2050 for the Brazilian Amazon. The scenario results indicate both processes (secondary vegetation and forest degradation) need to be better understood as they potentially will play a decisive role in the future regional carbon balance.

How three decades of land use change affected carbon dynamics in Pará and Mato Grosso, Brazil

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Tropical deforestation is inherently linked to climate change and the global carbon cycle. Satellite-based land change monitoring in the tropics is accordingly of core importance and has benefited from open data policies, ubiquitous computing power and algorithmic advances. Archived satellite imagery now allows reconstructing 30-40 years of land change, wall-to-wall and at appropriate scales.

However, numerous challenges in tropical land change monitoring and modeling persist. Reconstructing deforestation since the 1980s at high spatial resolution is crucial for understanding the effect of policies and quantifying carbon dynamics, but such datasets are still missing. Also, our understanding on the role of secondary forests on carbon dynamics is incomplete. Datasets on secondary forest age or residence time are lacking, both of which are crucial variables for assessing long term carbon dynamics, and ultimately for setting baselines for REDD+ or similar payment for ecosystem services frameworks.

We address these research gaps focusing on land use change in the Brazilian Amazon. We reconstruct 30+ years of deforestation and post-deforestation dynamics from Landsat data. Results include wall-to-wall maps on the distribution and age of secondary forests. Annual deforestation decreased after 2004, coinciding with increased federal effort to reduce forest clearing, but increased again in recent years. Our 30+ years of annual, fine-scale maps allow new insights on forest system dynamics in Southern Amazonia and related drivers. One novel insight, among others, is that edge-related carbon losses increase in relevance since 2004, as deforestation and forest degradation patterns change in response to anti-deforestation monitoring and related policies.

Quantifying implications of past and future forest cover on carbon stocks: case studies from the Alps and the Carpathians

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Our study presents an assessment of historical and future forest cover dynamics and the implications for terrestrial carbon pools (forest soil and aboveground biomass) in two large mountain areas in the Swiss Alps (25 000 km²) and the Polish Carpathians (20 000 km²). National forest inventory data were backcasted using available forest harvesting reports and historical forest maps in order to reconstruct forest area and wood volume for the periods of 1850- 1880, 1880-1940, and 1940-2010 for Switzerland, and 1850-1930, 1930-1970, 1970-2010 for Poland. Forest carbon pools for these periods were subsequently assessed following IPCC methodology by applying region-specific values for typical tree species composition, stand densities, biomass expansion factors and measurements taken from soil profiles. A similar assessment was used to predict carbon stocks in forest soil and aboveground biomass for three scenarios of future forest cover change developed up to 2060 modelled within the Dyna-CLUE modelling framework. Our results identify important effects of change in two mountain ranges with similar bio-geographical characteristics but that were shaped differently by multiple historical events (WWII, market orientation vs. central planning, trade liberalisation and globalisation). The resulting spatially explicit maps of carbon stock related to future change of forest areas provide valuable insights into likely consequences of different trajectories of future landscape development and potential for trade-offs, particularly in the context of carbon accounting.

Modeling vegetation height and biomass in Hulun Buir grassland ecosystem by using unmanned aerial vehicle discrete lidar

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Local, accurate and real-time vegetation structure data sets are need to monitor grassland health, available forage and provide the validation data to satellite productions, yet most emerging remote sensing techniques, such as optical remote sensing, are incapable of measuring vegetation structure parameters directly. In this study, the ability of UAV discrete light detection and ranging (lidar) to estimate grassland vegetation height and biomass in Hulun Buir grassland ecosystem is investigated. Two positioning devices with different accuracy are employed to collect the geographic coordinates of field quadrats include. Although vegetation heights tend to be underestimated from lidar data especially for those areas with high vegetation coverage, strong correlations are observed ($r > 0.76$) between field-measured biomass, vegetation height, and lidar-derived metrics. These strong correlations suggest that UAV discrete lidar is a promising technique for estimating vegetation height and biomass in arid and semi-arid grassland ecosystem. The experiments also show using RTK GPS can obtain higher correlation coefficients between field measurements and lidar-derived metrics.

Bringing Sustainable Land Management into Land System Science

Developing landcare – land system science interactions: showcasing methodological advances in European research

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Upscaling sustainable land management (SLM) needs information from land system science, and vice versa, soil and landcare science can contribute to land system science research agendas. In this presentation, we will give an overview of activities developed within a number of European research projects and related global initiatives hosted in Wageningen, the Netherlands. Firstly, in order to better understand the scope for applying different SLM measures across the world, a crucial source of information is global soil mapping innovations. Mobile phone applications such as ISRIC's SoilInfo provide 3D soil type and property information at a spatial resolution of 250 m. And mapping tools – e.g. for soil organic carbon contents – are now becoming available for those stakeholders that prefer to use their own data for analysis. Besides soil information, scenarios of restoring soils, maintaining soil quality and preventing soil threats should be considered in global impact assessments. Benchmarking soil quality ranges for specific farming systems and pedo-climatic zones can show the improvement potential for soils in each location. This two-way process is the core of the EU Horizon2020 iSQAPER project, which is developing a soil quality app for Europe and China. A framework for assessing land management effects on ecosystem services has been developed in the EU FP7 RECARE project and can inform further benefits of land management. Within RECARE, we are developing an integrated assessment model of land use and land management change at European scale, for the first time dynamically integrating land use and land management decisions. The presentation will close with an example of integrating the assessment of the global potential of SLM to contribute to climate change mitigation.

Upscaling SLM by proving overall benefits and improving knowledge sharing and evidence-based decision making

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Even though SLM is at the core of global issues with regards to food security, climate change adaptation and mitigation, disaster risk reduction, biodiversity, water conflict resolution and even migration, its value and importance is not being duly recognized by policymakers and the broad public. This is hampering the allocation of sufficient resources to combat land degradation and scale up SLM. Despite the fact that information and data on land degradation and SLM is growing worldwide, there is not enough proven evidence on the overall impacts as well as the benefits of SLM. This poses a major constraint for SLM to be recognized at the local, national, and global level. Land system science must take this challenge and provide more evidence about the overall benefits of local land use transitions such as SLM. While the Land System Science has so far focused on observation of change and understanding the drivers of these changes, it is currently trying to integrate the design of sustainable transformations. Sustainable Land Management can thus be considered as a solution from practice to Land System Science developments.

Apart from insufficient knowledge about on- and off-site impacts there is also a constraint in knowledge management and sharing and using it for informed decision making. However, there is a wealth of knowledge about sustainable land management practices world-wide, but this valuable knowledge has not been sufficiently evaluated, shared and channelled into evidence-based decision-making processes. Indeed, proper knowledge management is crucial for SLM to reach its full potential.

Development of an interdisciplinary framework using gis and remote sensing to analyse coupled socio-ecological systems on various scales

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Land Degradation (LD) is a global problem and one of the major threats to socio-ecological systems. Getting better insights in the coupling of these systems therefore is needed to understand processes of global change and achieve sustainable and thereby stable productivity of land. Here, the development of an interdisciplinary framework using GIS and remote sensing helps to get insights in the interplay of socio-economic and biophysical variables on multiple scales. Analysis on the national scale takes place in whole Kenya while a local analysis is conducted in western Kenya. As many drivers are known to trigger processes of LD this study aims to find a certain set of indicators that explains decreasing, stable and increasing degradation trends. Besides biophysical variables such as rainfall, among the socio-economic factors poverty is often related to LD while also indicators such as education, health or certain policies play key roles. Biophysical data used in this study is based on remote sensing, including LD analysis using the Normalized Difference Vegetation Index (NDVI) as well as the Enhanced Vegetation Index (EVI). Socio-economic information is derived from census data and household surveys for 47 counties of Kenya. For the local study in western Kenya furthermore a panel-household dataset was integrated conducted in four waves between 2000 and 2010. This data allow further insights in the complex interplay of land management strategies and livelihood structures. This study shows that the understanding of the interlinkages of socio-economic and biophysical structures helps to achieve land degradation neutrality.

Spatial identification of multifunctional landscapes and rural development zoning: A case study in mountain areas of Northwestern Yunnan, China

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Multifunctional landscape has become a new discipline growth point in landscape ecology. However, few studies has considered in mountain areas where low-slope hilly lands are widely distributed, and research methods are restricted to the spatial identification of hotspots of multiple landscape functions ignoring the analysis of relations between landscape function pairs. Taking Dali Bai Autonomous Prefecture as a case, five typical landscape functions (net primary productivity, soil retention, water conservation, crop production, and residential support) were quantified and mapped based on grid images in mountain areas of Northwestern Yunnan, China. Meanwhile, hotspots of multiple landscape functions were identified by using spatial overlap tools and interaction between each landscape function pair was discussed using Spearman's rank correlation coefficient. The results showed: (1) approximately 61.3% of this region had at least one hotspot of landscape functions, but only 2.7% of the region had multifunctional landscape hotspots, i.e., able to maintain three or more types of landscape function at a high level; (2) conspicuous trade-offs or synergies existed between all pairs of landscape functions except the pair of net primary productivity and residential support; and (3) with the application of Self-Organizing Feature Maps (SOFM) method, the study area was divided into four types of development, namely, Ecological Shelter, Ecological Transition, Suburban Development, and Urban Agglomeration. The study could provide references for formulating strategies and policies to coordinate multiple landscape functions according to local conditions.

Land use transition

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Land use transition refers to the changes in land use morphology including dominant morphology and recessive morphology of a certain region over a certain period of time driven by socio-economic change and innovation. In general, dominant land use morphology refers to the quantity, structure and spatial pattern of land use, and recessive land use morphology includes land use features in terms of aspects of quality, price, property rights, management mode, input and productive ability, and function. This paper puts forward the theoretical model of regional land use transition as the following: with the socio-economic development, the transformations between different land use types during a certain period of time arise the changes of regional land use morphology pattern from strong conflict to weak conflict, i.e., coordination, which enable a new balance between different land use morphology patterns reflecting the development trend of different economic departments, and then realize the transformation of urban-rural land use system from quantitative change to qualitative change. Then, the mechanism of mutual feedback between land use transition and land management was probed based on a three-fold framework of natural system-economic system-managerial institution system. Generally, land use transition is affected by land management via economic measures, land resources engineering, policy and institution. Land use transition can also contribute to the adjustment of land management measures via socio-ecological feedback. Therefore, policy-makers need to adjust their land management policies taking into account the continuous change of land use morphology and different phases of regional land use transition.

China Land System Observation and Research Network: A Strategic Framework

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This paper builds the strategic framework for China Land System Observation and Research Network (CLSORN), putting forward the ideas to construct land system observation organizational framework, cooperative innovation mechanism, technologies system, network distribution and data management system. The purpose of this study are to support stereoscopic land science research by innovations of theory, technology, platform and mechanism of land system comprehensive observation, to strengthen the land system scientific cognition, support land science and technology corporative innovation and enhance the scientific, systematic, ganged and effective land management decision and coordinative control. The results show that : (1) Land system is a regional and dynamic system of human-land relationship, composed of human, land, industries, rights and water, soil, atmosphere, heat and other human and natural factors. The core of the land system research is the interaction mechanism among factors and the coupling and control mechanism between human and land. (2) Land system has hierarchical, dynamic and comprehensive characteristics, and implementing continuous observation is an effective way to enhance the land system scientific cognition. (3) CLSORN needs construction of field scientific observation and research bases with the functions of data observation, scientific research, policy innovation, scientific research resource sharing, staff training, education, and popularization of science. Construct observation system with hierarchies of nation, region, city/county, village and sample plots. Innovate policies for CLSORN operation and mechanisms of joint construction, staff exchange, synergic research, sustainable investment, data sharing, joint investigation. Study indicators and technologies system for land use comprehensive observation. Construct land system integrated observation network platform, optimize the distribution of observation bases, extract main scientific questions and research fields, enhance collaborative innovation, and jointly promote the development of land system science. (4) CLSORN is an important part of the national scientific research capacity. Continuous observation can provide important support for land system scientific research and supply important support for land use decision.

Challenges for modelling global land use futures

Land use and other constraints on negative emissions technologies

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Efforts to date to curb greenhouse gas (GHG) emissions have failed to prevent continued increases in emissions, with the rate of emissions growth higher during the 2000s than in the 1990s, and with GHG emissions reaching an all-time high of ~50GtCO₂-eq. in 2010. This failure to reduce emissions over the 20+ years since the United Framework Convention on Climate Change (UNFCCC) came into being, now makes limiting increases in global warming to <2°C extremely challenging, and the <1.5°C target almost impossible without removing carbon from the atmosphere using Negative Emission Technologies (NETs). NETs include: bioenergy with carbon capture and storage (BECCS), afforestation, soil carbon sequestration, biochar, direct air capture (DAC) of CO₂ using sodium (or calcium) hydroxide or monoethanolamine, and atmospheric CO₂ removal by enhanced weathering of magnesium oxide-bearing rocks (EW).

These technologies have a very different land footprint – and differ also in their impacts on greenhouse gas emissions, water use, nutrient use, physical climate forcing (e.g. albedo) as well as in terms of their energy requirements and investment costs. In this presentation, I will outline the main land related limitations to implementation of NETs, and identify future research challenges to meet the post-Paris climate agenda.

Drivers for global agricultural land use change: the role of diet on human appropriation of land for food

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Human appropriation of land for food production has fundamentally altered the Earth system, with impacts on water, soil, air quality, and the climate system. We explore how past and present developments in diets impact on global agricultural land use. An index for the Human Appropriation of Land for Food (HALF) is introduced and used to analyse the effects of diets on agricultural land use areas, including the consequences of shifts in consumer food preferences. We show that the land use footprint per capita arising from current diets varies 14-fold across the countries of the world. Furthermore, the type of food commodities consumed plays a more important role than the quantity of per-capita consumption in determining the agricultural land requirement, largely due to the impact of animal products. Average diets in the USA and India provide a framework for exploring land use impacts from different food consumption habits. If the world adopted an Indian diet 55% less land would be needed to satisfy demand, while global consumption of a USA diet would necessitate 178% more land than today. Waste and over-eating are also important issues, with the results suggesting that the land used to produce the food wasted, including over-consumption, by the average person in America could provide the food for more than two people consuming the average diet in India. Therefore, measures to influence future diets and reduce food waste could contribute towards global food security, and provide climate change mitigation options.

Integration of Carbon Sequestration in an Integrated Land-Use Model Considering the Long-term Aspect of Sequestration

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Human induced land-use changes and land-cover changes (LUCC) are a major driving force of global environmental change. That has far-reaching impacts on ecosystems and ecosystem services. To develop an improved scientific understanding of the mechanisms and effects of LUCC models and scenarios are important tools. The integrated model LandSHIFT was developed to study LUCC under different biophysical and socio-economical scenarios. It is a spatially explicit modelling system that aims at simulating and analysing land use dynamics and their impacts on the environment at global and regional level. The model design is based on modules, which allows the integration of various functional model components. The current version of LandSHIFT has modules for the land-use activities “Infrastructure and Housing”, “Agriculture” and “Grazing”. Forests are a very important nexus for a multitude of ecosystem services, therefore adding “Forest” land-use activities to LandSHIFT will enable us to study options for implementing carbon sequestration, reforestation and forest management (e.g. in the context of REDD policies) and assess possible trade-offs and co-benefits with other land-use activities and ecosystem services. Land-use activities in LandSHIFT are allocated depending on processed demands and suitability values for every land-use activity. We developed a new biophysical suitability map for carbon stocks and for long-term carbon sequestration (2015-2100), compared robustness of carbon sequestration under different climate scenarios and analysed spatial competition between carbon sequestration, food production and biodiversity conservation.

Optimization of land use and analysis of ecological and economic benefits evaluation

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purpose: Land use is a combination of natural and humanistic factors, as an important part of terrestrial ecosystem and the carrier of production activities, it can provide huge ecological service value and economic value. Research on land use structure optimization can support sustainable development of land resources.

methods: By land suitability evaluation, we coupled CLUE-S model and TESIM model(the ecosystem process model). Based on the land use map in 1995, 2000, 2005 and 2008 and social economic statistical data, the study set up five scenarios including optimal economic, optimal ecological optimal comprehensive, present situation and the future forecast; Using the Coupling model, the space patten was decided, the ecological and economic benefits were analyzed and some policy suggestions were provided.

results and conclusions: The main results include: (1) The spatial optimization results of different scenarios show that the 2008 land use can be optimized to a large degree. By comprehensive optimal target optimization, cropland, forest land increased by 9.13% and 18.9% respectively, the grass decreased by 9.81%. The proportion of cropland, grassland and other land is 30.34%, 35.33% and 12.48%.

(2) The ecological and economic benefits optimization results of land use show that the optimized by aimed at the comprehensive benefit, ecological benefit, economic benefit and the comprehensive benefit of land use increased by 6.2%, 2.1% and 6.2% respectively. Compared with other optimization scenarios, only aimed at the comprehensive benefit of land use can made the greatest increase in benefit and realized the sustainable development of land resources.

Trade-offs between carbon storage, crop yield production and water supply at the global scale

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Through land-use, humans affect natural ecosystem functioning and ecosystem services (ES). The present pattern of land-use types developed over the last millennia in response to a complex interplay of natural-system constraints and socio-economic pressures. However, the current land-use pattern might not be considered optimal in terms of its provision of a variety of ES. We evaluate the global configuration of different land uses under the sole premise of optimizing for carbon storage, crop yield production and water supply. The LPJ-GUESS dynamic vegetation model is used to simulate the ES provision of global land under different allocation of land use (potential natural vegetation and 5 major crop types) considering today's conditions of climate, atmospheric CO₂ levels, irrigation water availability, and the distribution of protected areas. Land use is optimized globally by varying the configuration at the level of 762 units (food producing units intersected with major water sheds and biomes) using a multi-objective genetic algorithm. Optimality is thereby defined as Pareto optimality, i.e. the configurations that do not allow an increase in the provisioning of one ES without losing provisioning of the other services. Determined optimal land-use configurations that appear possible considering the global demand for these services are contrasted with the ES provision for the current land use. We highlight opportunities in land management and possible pathways to adapt current land use to increase ES provision towards higher performing allocations. We identify several major regions where significant changes in current land-use practices would be required to approach optimal ES provision.

Coupling Dynamic Land-Change Models with Ecosystem Service Evaluation

Modelling the species composition, age structure and biomass of pine-fir plantations in South China under different harvesting intensities

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In China, plantations have been developed for decades to ensure timber requirement, while leading to poor quality, simple structures and weak ecological functions. Sustainable forest management strategies are indispensable approaches for structure optimization and function improvement. This study aims at determining the optimal harvesting management approach. We used LANDIS-II and PnET-II models to simulate long-term changes in species composition, age structure and aboveground biomass (AGB) of the plantations under a factorial experiment. We simulated structure and function on plantations at landscape scale of Taihe County over 100 years considering major controlling factors. Results show that the harvesting age and cut-block size have little impacts on forest area, while great influence on AGB. The harvesting area ratio and frequency are the most important factors influencing both forest area and biomass. For the most appropriate forest management in our study, following aspects should be adopted, including 20% harvesting area ratio, 5ha cut-block size and 10year harvesting frequency. And on harvesting ages, different species should be harvested at 21-year-old on Chinese fir, 26-year-old on pine and 41-year-old on broad-leaved forest. On practical viewpoint, this study provides a feasible harvesting strategy for plantation management in red soil hilly region of South China.

Potential of land use change to compensate climate change impacts on the provision of ecosystem services - A modelling study

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Rice is the staple food for more than half of the world's population, but land-use and climate change pose major threats to sustainable production of rice in the future. In order to simulate potential changes in crop production, water balance and natural vegetation in Southeast Asia, we apply the vegetation and hydrology model LPJmL in seven study areas in the Philippines and Vietnam and quantify the synergies and trade-offs of ecosystem services under different climate and land-use scenarios.

Our projections indicate that climate change will lead to a decrease of rice yields as well as fruit and vegetable production towards the end of the century under the current land-use pattern. However, land management strategies have the potential to balance out negative effects of climate change through the intensification of rice production either by increasing crop area or by changing land management. Water provisioning for irrigated rice fields is likely to be maintained but climate change might shift the months of high water availability. In the natural vegetation, climate change induces a decrease of net primary production and an increase of heterotrophic respiration for most of the study areas, leading to lower carbon sequestration in the region. However, vegetation is able to adapt to the changed conditions. Under severe climate change conditions, forest composition in mountainous areas will shift from the dominance of temperate trees to a more heterogenic structure including tropical trees. Under moderate climate change, forest composition will maintain the structure required for pest control in rice.

The future of ecosystem service provisioning at the urban fringe: What have we learned from simulating urban growth strategies using the FUTURES model?

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Increasing global population is accelerating urbanization and rapidly transforming natural systems to impervious built environments. Emerging development challenges include: where (and how) can people live without compromising the natural resources and land systems needed for sufficient food, water, and energy production, and how do we minimize the ecological footprint of cities for maintaining wildlife habitat and special places for outdoor recreation? Despite the important role urbanization plays in altering ecosystem services, few recent studies have examined the long-term impacts of urban growth on ES provisioning. Further challenges remain for accurately simulating urban growth patterns at social and ecological scales relevant to ES provisioning. We couple the open source FUTURES (**FUT**ure **UR**ban-**R**egional **E**nvironment **S**imulation) model with different models of ES delivery to explore alternative scenarios of ES provisioning at multiple spatial scales. FUTURES simulates landscape change based on demand for development, local site suitability factors, and a stochastic patch-growing algorithm. Recent advances to the model leverage parallel computing to produce multi-level projections at high resolution over large spatial extents. We present case studies for the Asheville and Charlotte metropolitan areas in North Carolina and for a multi-state region in the southeastern United States. Results highlight the challenges, opportunities and outcomes of coupling land-use change models with ecosystem service models at different scales. We conclude that FUTURES simulations of alternative growth strategies that mimic urban patterns make it a suitable platform for ES evaluation.

Spatial-temporal analysis of land Use and ecological system services value change in qinghai lake area

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Changes in land use from year 1900 to 2010 were analyzed for Qinghai Lake area in Qinghai province using land use dynamics model and transition matrix model. Land use scenarios in 2020 was predicted using cellular automata model. Based on the modification of the ecosystem service value coefficient published we estimated the ecosystem service value and its changes of the study area. Then, we analyzed the relationships between the changes of land use and ecosystem service value. Result show that area of grass-land, water and construction-land increased in different degrees, while area of unutilized-land and wetland decreased largely. Large amount of unutilized-land, wetland, forest-land and farmland transformed into grass-land. Land use extent and degree enhanced obviously. The decline of ecosystem service value was generally in an accelerating trend with a loss of 9.0 million yuan. The ecosystem service value of the north of these areas is relatively higher compared with that of the south and east area. The rapid decline of wetland imposed great influence on the ecosystem service value, especially on the function of water conservation and waste treatment. It is predicted that the study area will continue to maintain rapid growth in grass land area. The ecosystem service value will increase slightly as well. Generally, changes in land use have imposed big impact on the ecosystem service value in Qinghai Lake area, in the future, the regional government should take measures to control the exploitation of unutilized-land and strengthen the protection of wetland and forest-land.

Alternative land use futures: land systems and ecosystem service provisioning

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Societal change and the necessity to mitigate and adapt to environmental change have led to increasing claims on land resources. The targets agreed upon in the Convention on Biodiversity, the Sustainable Development Goals and the Climate Convention all pose additional claims on land. Competition for land may lead to land use decisions and landscapes that are different from historic periods. However, most land change models only account for food demand as a driver of land use change, ignoring the many other claims on land resources. Therefore, in the CLUMondo land use model the demand for different ecosystem services is included as a driver of land use change. We will show how, at regional and global scales, the inclusion of demand for ecosystem services affects the outcomes of future scenarios. Scenarios analyzed differ in the assumptions on the demand for ecosystem-based mitigation and adaptation to climate change, demands for nature conservation and cultural services. The development of such demand is dependent on societal choices and its reliance on ecosystems to provide well-being. At the same time, such demands conflict with prime objectives to secure food production and residential area for an increasing population. The simulation experiments and scenarios indicate the importance of including multiple demands in scenario simulations of land use change and the alternative trajectories that may arise from the multiple claims. Careful consideration of the implications of implementing the targets is required to avoid tradeoffs of achieving the targets.

Effects of Cultivated Land Use during the New Stage of Grain Production Increasing in China Based on LMDI Model

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Cultivated land resource is the key factor to ensure regional food security. It is very important to analyze the influencing factors of cultivated land using in grain production. Accounting to the second national land survey data, the paper used the LMDI (logarithmic mean weigh division) model to analyze the new stage of grain production increasing in China during 2004-2013 in the three functional areas of grain production. The article reduced the cultivated land using efficiency to four contribution factors concluding grain yield, cultivated land resource, grain and crop acreage proportion, multiple crop indexes. The results show that there are significant spatial differences between the three functional areas of grain production during the last ten year of grain's growth. The grain production turns to centre to the main production area, accounting for a proportion of 88% in national grain production increasing. The grain yield contributes most to the grain production increasing, which has arrived at 60%. It has become the main contributor in the three major grain production areas, especially the main market area. Then the paper discussed the key point of the development of three major functional areas of food. The paper offers a proposal about the next step of further enhancing the arable land quantity and quality, adjusting grain and crop acreage proportion, stabilizing the grain yield and improving the multiple crop indexes, to ensure the sustainable development of China's food security.

Ecosystem services and integrated land change modeling

Mitigating and adapting to climate change in semiarid grassland via ecosystem service optimization

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Ecosystem services are influenced by many factors, such as human preference, land use/cover change, and climate change. Much work has been done to optimize ecosystem services, however, few studies have concerned about the feedback of the land system to the atmosphere. Current studies have shown that regional climate can be sensitive to even small changes in land surface. Assessing the impacts of land use and land cover change (LUCC) on regional climate is essential for understanding land–atmosphere interactions and for designing climate adaptation and mitigation strategies. Using the weather research and forecasting (WRF) model, we examined how different land use and land cover patterns affect regional climate in the agro-pastoral transitional zone of North China, whose environmental and socioeconomic conditions are sensitive to climate change. We parameterized WRF using land use and land cover maps corresponding to 2001 and 2010 conditions, which differ in the representation of four land surface biophysical parameters: vegetation fraction, leaf area index (LAI), albedo, and emissivity. Our findings demonstrate that LUCC in Northern China has altered the regional climate over the past decade. The magnitude and spatial patterns of temperature changes quantified by our simulations provide useful information for understanding the impacts of LUCC on climate and for developing mitigation and adaptation strategies in arid and semiarid regions. Finally, we suggested a framework to optimize the ecosystem services from the joint consideration of meeting human requirements, and meanwhile mitigating and adapting to climate change.

Assessing the potential impact of climate change on urban landscape dynamics by linking LUSD model and CMIP5 data

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Climate change has become an important factor influencing urban sustainability. Assessing the impact of climate change on urban landscape dynamics (ULD) is the foundation for adapting to climate change and maintaining and increasing urban landscape sustainability. This paper demonstrates an alternative future analysis (AFA) by coupling Land use scenario change (LUSD) model with the climate change data from the Coupled Model Intercomparison Project, phase 5 (CMIP5). By implementing the AFA in the Beijing–Tianjin–Tangshan megalopolis cluster area (BTT-MCA), the potential impact of different climate change scenarios on ULD from 2009 to 2030 was simulated and evaluated. The results suggested that the integrated model had the strengths of spatial quantification and flexibility, as it combined the advantages of both LUSD model and the CMIP5 data. It was capable of effectively assessing the impact of climate change on ULD. Meanwhile, the scenario simulation results showed that climate change would considerably affect ULD, and the influence would become more severe over time. In 2015, the potential urban area to be affected by climate change was 6.22~267.83 km², accounting for 0.15~6.27% of the total urban area, as projected by the business-as-usual (BAU) scenario. In 2030, the affected area increased to 343.60~1260.66 km² (0.19~10.82% of the total urban area, as projected by the BAU scenario). Therefore, climate change is becoming an important factor for assessing sustainable urban development in the BTT-MCA, which should not be neglected when managing urban landscape in the region.

Modelling ecosystem service demand as a driver of land use change

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In most studies ecosystem services are studies are being impacted by land use change. However, often the demand for ecosystem services is an important driver of land use change. We will show how demand for ecosystem services may be quantified as a driver of land use change at a global scale. These demands are then used as an input to a global land change model to simulate a range of scenarios that account for different ecosystem service demands. Results indicate that including demands for climate mitigation or ecosystem service protection will lead to a stronger intensification of agriculture in the agricultural areas while multi-functionality of landscapes is reduced. This polarization of functions can be explained by the high land pressures that lead to an intensive use of the best areas for a particular function.

Understanding land system change through scenario-based simulations: A case study from drylands in northern China

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The drylands in northern China (DNC) are expected to face dramatic land system change in the context of socioeconomic development and environmental conservation. To assess the ecological and environmental consequences and improve landscape sustainability, the spatiotemporal patterns of land system change need to be explored. Recent studies have studied changes of land cover under socioeconomic development in the DNC. However, the changes in land use intensity and the potential role of environmental conservation measures are yet to be adequately examined. Given the importance of land management intensity to the ecological conditions, our study projected land system change in Hohhot city in the DNC from 2013 to 2030. Land systems are here defined by combinations of land cover and land management intensity. Using the CLUMondo model, we simulated land system change in Hohhot under three scenarios: a scenario following historical trends, a scenario with strong socioeconomic and land use planning, and a scenario focused on achieving environmental conservation targets. Our results showed that Hohhot is likely to experience agricultural intensification and urban growth under all three scenarios. The agricultural intensity and the urban growth rate were much higher under the trend scenario as compared to those with more planning interventions. Dynamics of grassland depend strongly on projections of livestock and other claims on land resources. In the trend scenario, the intensively grazed grassland increases whereas a large amount of grassland with livestock converts to forest under the scenario with strong planning. Strong conversion from grassland with livestock and extensive cropland to natural grassland was estimated under the conservation scenario. The findings provide an input into discussions about environmental management, planning and sustainable land system design for Hohhot.

Spatial dynamics of biodiversity and ecosystem services in Vermont, USA

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Mounting evidence suggests that ecosystem services provide valuable benefits to people, and that conserving these services improves human well-being. However, conservation efforts are currently limited by a lack of information about where ecosystem services are generated, and how allocating resources to conserve ecosystem services will impact other conservation targets such as biological diversity. In order to manage landscapes sustainably so that they support both human populations and biodiversity, we need to understand where tradeoffs between ecosystem services and biodiversity occur, and under what circumstances win-win outcomes are most likely. Here, we use spatially explicit models to identify ecosystem service priorities in Vermont, USA, and compare these against already identified biodiversity priorities. We locate win-win areas where conservation benefits both ecosystem services and biodiversity, but also identify tradeoffs between these two conservation targets. Further, we assess factors that potentially affect the spatial overlap in conservation priorities for each, including the number of taxonomic groups and services used in identifying priority areas, the role of beneficiaries in shifting the spatial dynamics of ecosystem services, and the common influences of cost and risk. This research informs management of the Vermont landscape to maximize ecosystem services and biodiversity, and also illustrates dynamics relevant to tradeoffs between ecosystem services and biodiversity more broadly.

Global land use datasets – challenges and opportunities emerging from innovative approaches and newly available data sources

Forests key to mitigation in Paris, but science needed to underpin efforts

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In the lead up to the Paris Climate Agreement, countries submitted their Intended Nationally Determined Contributions (INDCs), including mitigation targets. While these targets represent an important deviation from previous pledges, there is still a significant ‘emission gap’ to stay within the 2°C limit.

Forests contribute to greenhouse gas emissions through deforestation, and are part of the solution to climate change, through the carbon sink. Yet the inclusion of forests in international climate agreements has been complex, often considered a secondary mitigation option or treated separately.

Based on country information, we quantified the expected mitigation role of the land use sector in the INDCs to the year 2030. We focused on CO₂ emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) where most of the INDC land use sector contributions lie. We analyzed the LULUCF mitigation contribution for 67 countries, including the major forest countries, representing around 78% of global net emissions in 2012.

We show that countries expect a significant mitigation contribution from land use, with a clear focus on forests. Assuming full implementation of INDCs, forests emerge as a key component of the Paris Agreement: by turning globally from a current net source to a net sink of carbon in 2030 and by providing about a quarter of planned emission reductions, forests are essential to close the current emission gap. However, to realize and track this mitigation potential, more confidence in numbers is needed. This represents both a challenge and an opportunity for the scientific community.

Global tree- and water-cover estimated by fusing optical and SAR satellite observations

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The science and sustainable management of terrestrial ecosystems require global, time-serial maps of land cover. Satellite observations have been recognized as an essential data sources for estimate land cover characteristics and detect land cover changes. The variety of satellite measurements now globally available to Earth scientists include, among others, data streams from multi-spectral and Synthetic Aperture Radar (SAR) sensors at moderate- (i.e., 1- to 100-m) resolution, as well as targeted acquisitions by commercial high- (i.e., sub-meter) resolution multi-spectral and Light Detection And Ranging (LiDAR) sensors. Observations of land—especially forest—cover based on large volumes of precisely calibrated multi-spectral (e.g., Landsat and MODIS) measurements are becoming increasingly routine. However, most of the algorithms responsible cannot be directly applied to assimilate other forms of measurement. We developed an approach by emerging statistics, machine learning, and information theory to retrieve seamless and consistent, sub-hectare resolution estimates of land cover variables from multiple satellite data sources at global scales. The approach has been adapted to produce prototype percent-tree and water-cover layers globally in 2000, 2005, and 2010 from passive-optical and SAR measurements. Development of data layers at global scale demonstrates the efficient use and seamless combination of multiple data sources and will develop the capability for periodic satellite-based inventories of land-cover and land-use change using high performance computing facilities at University of Maryland (UMD) and NASA.

Land management: Identifying research challenges to improve the understanding of a largely overlooked land-use dimension, employing a socioecological perspective

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In light of the daunting sustainability challenges, improving our understanding of the complex dynamics of society-nature interactions is crucial. Land use, i.e. the way and purpose of using land to harness terrestrial ecosystem services, plays a central role for many of the sustainability challenges. Improving our understanding of land use, its drivers as well as impacts across various spatio-temporal scales, is thus central for the identification of pathways towards sustainable societies. While a relatively robust body of knowledge exists on the effects of land-cover changes, e.g. change in forest-cover or cropland extent, the more subtle changes induced by land management (also denoted “land conversions”) remain much less studied. Advancing the current state of process understanding and data availability on land management, however, is a key and timely undertaking, as research results indicate that management impacts can be of a similar magnitude than land cover changes. This presentation discusses the intricacies related to the construction of global land management datasets, as well as key criteria such as uncertainty, comprehensiveness and consistency, from a socio-ecological perspective. Drawing from examples on, e.g., quantifications of the human impacts on key variables of ecosystem functioning, such as terrestrial carbon stocks, Net Primary Production or biodiversity, or land-use efficiency, it provides an overview of the current state of data availability and process understanding related to global impacts of management. It concludes with a strategic prioritization of research efforts for advancing the current status of understanding of land management’s role in the Earth system.

Combining global datasets to explore drivers of deforestation in Latin America

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Combining global datasets to explore drivers of deforestation in Latin America

Using global datasets provides a comparatively quick way to gain detailed, spatially-explicit information on land use and land-use change. In this study, we explore the potential and limitations of combining available global datasets to perform a spatially-explicit assessment of forest-loss drivers in Latin America.

We use GlobeLand30-2010 data to attribute deforestation detected by the GLAD (Hansen) annual tree cover loss dataset to cropland, pasture, and other drivers. We also use alternative global and Brazilian land cover/use datasets to test the robustness of our results. Our analysis shows that land uses following tree cover loss are, on average, ~30–40% pasture, ~20–30% cropland, and ~30–45% other drivers.

However, results also point to some challenges in attributing deforestation, resulting from limited spatial resolution; differences in temporal coverage between and within datasets; and dealing with semantic and methodological differences between datasets. For example, we needed to adapt GlobeLand30's land cover classes (e.g. grassland and cultivated land) into pasture and cropland. Furthermore, different definitions of forest and forest/tree cover loss clearly yield different results. Whilst this presents challenges, there is information to gain from combining datasets. For example, datasets can confirm or contradict each other; e.g. GLAD tree cover loss followed by GlobeLand30 forest, seems less reliable than loss followed by agriculture.

These spatially-explicit results provide a first step towards combining further datasets, e.g. for quantifying which commodities drive forest loss or assessing impacts on biodiversity.

Who claims the land sink? Bringing new data into the policy process

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There are now many improved data sets and methods for estimating land use change emissions. These include recent scientific and technical advances in satellite based land cover change and biomass estimates and in modelling capabilities. They also include country-based estimates of land cover change and carbon stock change and related emissions estimates that are reported and accounted through the UNFCCC greenhouse gas inventory process as well as by the FAO (Food and Agricultural Organisation).

There is a large difference in net carbon flux estimates between the different approaches. In particular, there is a disconnect between the information feeding into different parts of the policy process. This disconnect is traceable to the sink in extant forests (Forest Land Remaining Forest Land, including “Secondary” or “regrowth” forests). This sink is in part due to past reforestation/afforestation, part due to planned activities of forest managers (eg. changing species or harvest cycle) and part due to environmental effects on forests (CO₂ and climate) and has historically been difficult to attribute.

Here we examine what can science bring to bear to increase transparency, accuracy and comparability.

Global Long-term Dynamics and Drivers of Land Cover, Land Use and Land Systems for sustainable land systems today and tomorrow

Zonal assessment of environmental driven settlement abandonment in the medieval Trans-Tisza region, Central Europe

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This investigation focuses on the transformation of the settlement pattern of a lowland landscape (4125 km²) as a response to the hydrological challenges emerging in the overture of the Little Ice Age (LIA). Using zonal analysis suggested that the elevation means of archaeological sites in the deserted zones proved significantly lower than those in zones with permanent settlement pattern (t-test $p \leq 0.01$). Additionally, the late medieval (14th–mid-16th centuries) site group was situated significantly higher than the high medieval (late 10th–13th centuries) site group within the permanent zones (t-test $p \leq 0.01$). These outcomes statistically confirm that the settlement pattern in lowland areas shrank significantly (~40%) and displaced vertically in the early LIA. The proportion of areas with excellent agro-ecological suitability proved much higher in the permanent zones than in deserted and uninhabited zones (Chi-square $p = 0.01$). Finally, we presumed that if hydro-climatic changes increased water levels, they must have changed the plant composition of the studied landscape as well. The statistical investigation of macrofossil plant remains indicated that the second part of the 13th c. saw growing humid habitat types (Chi square $p = 0.047$). Comparison of shrinkage of settlement pattern and the increasing proportion of plants with humid environment tolerance during the second part of the 13th century indicates a broad synchronism and the beginning ‘longue durée’ structural transformation of the landscape and may contribute to answering the question why the relatively dense settlement pattern of the deserted zones was abandoned almost completely by the end of the 13th century.

Impacts of shifting cultivation on global environmental change

Impacts of shifting cultivation on global land-use forcing for Earth system models

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Despite the importance of shifting cultivation for millions of people and their environment, there is very little global, spatially and temporally explicit data on this agricultural practice. Consequently, shifting cultivation is either poorly represented, or absent completely, from almost all carbon-climate models. We incorporate a new algorithm for shifting cultivation land-use transitions into the Land-Use Harmonization 2 (LUH2) project for the CMIP6 and LUMIP model intercomparison analyses. The challenge for representing shifting cultivation within a global land-use dataset lies not only in deriving maps of shifting cultivation extent, but also in how to represent the sub-grid-scale processes of shifting cultivation within a modeling framework that is primarily designed to harmonize multiple historical and future datasets and produce a set of global, annual, gridded land-use states and transitions for climate models. Our new shifting cultivation algorithm is implemented across much of the tropics, with a domain based on a hand-drawn map from c.1980, and uses Landsat-based forest change data to give the current patterns of shifting cultivation. These patterns are extended forwards and backwards in time based on regional trends from an expert opinion survey. We evaluate our shifting cultivation algorithm against various metrics. The LUH2 algorithm estimates shifting cultivation cultivated area (excluding fallow) of about 0.3 Mha in 2000 (when total cropland area was about 15 Mha). We quantify the magnitude of land-use transitions due to shifting cultivation and the amount of secondary forest generated by shifting cultivation, and discuss the potential implications for carbon-climate model land-use forcings.

A global view on shifting cultivation: Recent, current, and future extent

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Mosaic landscapes under shifting cultivation, with their dynamic mix of managed and natural land covers, often fall through the cracks in remote sensing-based land cover and land use classifications, as these are unable to adequately capture such landscapes' dynamic nature and complex spectral and spatial signatures. But information about such landscapes is urgently needed to improve the outcomes of global earth system modelling and large-scale carbon and greenhouse gas accounting. This study combines existing global Landsat-based deforestation data covering the years 2000 to 2014 with very high-resolution satellite imagery to visually detect the specific spatiotemporal pattern of shifting cultivation at a one-degree cell resolution worldwide. We estimate the current global extent of shifting cultivation and, based on an expert survey, make a first attempt at estimating past trends and predicting possible future trends in the global distribution of shifting cultivation until the end of the century. With 62% of the investigated one-degree cells currently showing signs of shifting cultivation—the majority in the Americas (41%) and Africa (37%)—this form of cultivation remains widespread, and it would be wrong to speak of its general global demise in the last decades. We estimate that shifting cultivation landscapes currently cover roughly 300 million hectares worldwide, including both cultivated fields and fallows. While only an approximation, this estimate is clearly smaller than some of the figures cited in the literature, which range up to 1,000 million hectares. Our expert survey indicates a possible strong decrease in shifting cultivation over the next decades, raising issues of livelihood security and resilience among people currently living on shifting cultivation. Indeed, this age-old, globally important form of human crop cultivation may be gone by the end of this century.

carbon stocks across managed and unmanaged forest types

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Changes among broad classes of land-use systems has taken place for centuries and have gained pace during the past century with increasing globalization. In Southeast Asia, both deforestation and land use transitions from shifting cultivation to other systems have been substantial and much research has focused on the drivers and outcomes of these transitions, including consequences for local livelihoods and ecosystems. A prominent outcome is the dynamics of ecosystem carbon stocks.

Here, we elucidate potential gains and losses in carbon stocks following land use transitions by providing an overview of selected carbon sequestration studies. We subsequently discuss potential implications for local livelihoods of these transitions.

The studied land use systems covered primary forest, various types of secondary forests, shifting cultivation, rubber plantation and agroforestry located in China, Indonesia, Malaysia, Thailand, and Vietnam. The expected trend of decreasing stocks with increasing land use intensity was confirmed, with primary forests holding the most carbon and short-rotation systems the least. We call for acknowledgement of the co-production of services and goods beyond carbon when evaluating land-use systems.

Surprises in the soil: exploring carbon in shifting cultivation and rubber plantations in Laos

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Today 10-15% of anthropogenic CO₂ emissions are derived from land use changes and 90% of these changes are taking place in the tropics, with Southeast Asia as a hotspot. Conversion of shifting cultivation to rubber plantations is one of the dominant land use changes in montane mainland areas of Southeast Asia, with the area of rubber expected to quadruple by 2050. However, the impacts of this transition on total ecosystem carbon stocks are poorly quantified.

We undertook a chronosequence study to quantify changes in ecosystem carbon stocks following conversion from shifting cultivation to rubber plantations in Northern Laos. We developed new allometric equations for above- and belowground biomass of fallow tree species by destructively harvesting and excavating 150 trees. We measured aboveground biomass stocks and collected volume specific soil samples across rubber plantations from 2 to 20 years (n=10), fallows of 3-25 years (n=15) and active fields (n=8). The carbon stock in the upper 40 cm of the soil was almost 20% lower after 20 years of rubber than in fallows - equaling a SOC loss of 0.750 Mg ha⁻¹yr⁻¹. Rates of biomass accumulation in fallows and rubber plantations were very similar - 1.93 and 1.94 Mg C ha⁻¹yr⁻¹ respectively.

The time averaged ecosystem carbon stock of a shifting cultivation system with a rotation time of 15 years corresponds to that of rubber plantations with rotation times of 30 years. Therefore, we conclude that the replacement of shifting cultivation with rubber leads to soil carbon losses, but gains in aboveground biomass, that are roughly equal, suggesting this land use transformation will not be a major source of GHG emissions in the future.

Integrating findings from place-based research on land use and social-ecological dynamics across scales

Understanding decision making of local land-change actors in a global context

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The processes that drive land-use change are context-specific and vary across scales. To minimize undesirable impacts on the environment at regional or global scale it is important to understand direct and indirect drivers as well as human decision-making on land use at local scale.

Within land use-change case studies a wealth of information about underlying driving forces, social-ecological dynamics and human decision-making is available. A synthesis of available land-use change literature is a way to detect general patterns across scales and helps to distinguish factors that cause specific cases to behave differently. To understand the role of different decision-making mechanisms in land-use change, this study draws on synthesis and meta- study techniques to generate global patterns from local case studies.

A systematic search in Thomson Reuters' Web of knowledge resulted in 5016 studies that have been systematically assessed. 251 case studies of this sample, which reported on drivers and decision-making in land-use change, have been coded and further analyzed. A representativeness analysis has been carried out to detect which regions in the land-use change literature are over- and underrepresented. The application of the hierarchical cluster analysis revealed six distinct clusters of decision-making structures in land change showing different behavior and decision strategies across the globe. Clusters of decision making relate to actors with high or low social, financial or natural capital and diverging economic objectives. Examples of types are isolated poor traditionalists, inventive survival-oriented shifting cultivators, progressive agricultural diversifiers or rich, growth oriented actors with an indifferent view towards their environment.

Smallholder's land use decision making and the maize boom-and-bust in Laos. A conceptual model built from contextualized games

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In Southeast Asia, rapid expansion of boom crops, like hybrid maize, rubber, oil palm or banana, has brought about major shifts in land systems with tremendous environmental and socio-economic impacts such as deforestation, soil degradation and indebtedness. Why do individual farmers and whole villages engage in and keep on pursuing such farming strategy despite the potential adverse effects on their land and livelihoods? To investigate this question in the context of extremely rapid changes in the northern uplands of Lao PDR we developed an innovative approach to get insight into decision making in real pace and place. Using a set of participatory methods we developed a series of contextualized games that addressed the key issues smallholders face at each stage of the maize boom, e.g. adoption, expansion, intensification, diversification and abandonment. We applied the method in seven villages located in four provinces along a gradient of market integration, population density and land degradation. The knowledge gained from the contextualized games was integrated into a conceptual model of the maize boom on the regional level. The resulting game named 'Mahasaly' captures path dependency of decisions made at the successive stages of the maize-driven land use trajectories. We found that short term resource exploitation and land degradation is accepted by smallholders for the sake of long term goals such as re-investment into paddy terracing and children's education. Considering time-scales of decision making is essential to better understand and manage socio-ecological trade-offs across spatial scales.

Geographic comparisons of smallholders agricultural practices and forest cover change in the Indonesian provinces of Aceh and East Kalimantan

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The complexity of environmental change in globalized tropical forest landscapes poses challenges for assessing the sustainability of smallholder land use practices. Smallholder agriculture may have substantial aggregate impacts on forest cover and biodiversity, but analysis of these impacts must be situated within a consideration of broader processes of socio-ecological transformation involving heterogeneous political and economic actors. This study examines the relationships between smallholder agricultural practices and land cover change in the Indonesian provinces of Aceh and East Kalimantan. We draw on household and village-level surveys and interviews carried out in two phases in each province to construct temporal and geographic comparisons along gradients of agricultural intensification and forest cover change. We situate household forest clearing decisions and land use portfolios within local and regional policy processes and socio-ecological transformations. We find that community agricultural practices are secondary to industrial land uses in driving deforestation in both provinces, but distinct mixtures of agricultural land uses and intensification strategies result in significantly different dynamics of agricultural production and forest change across our cases, despite commonalities in crop choice (e.g., rice, rubber) and institutional frameworks. These findings contribute to debates on the relationship between agricultural intensification and forest transitions, as well as the broader literature on the political ecology of tropical land use change and trajectories of agrarian transformation.

Investigating potential transferability of place-based research in land system science

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Much of our knowledge about land use and ecosystem services in interrelated social-ecological systems is derived from place-based research. While local and regional case studies provide valuable insights, it is often unclear how relevant their research is beyond the study areas. Drawing generalized conclusions from local observations and applying them to other places in the world requires that we identify patterns of land systems that are similar to those represented by the case study. Here, we utilize the previously developed concept of land system archetypes to investigate the transferability of research from twelve regional projects that focus on issues of sustainable land management across four continents. For each project, we characterize its project archetype, i.e. the unique land system based on a synthesis of more than 30 datasets of land-use intensity, environmental conditions and socioeconomic indicators. We estimate the transferability of project research by calculating the statistical similarity of each location across the world to the project archetype, assuming higher transferability in locations with similar land system characteristics. Using specific examples from the local case studies, we highlight the advantages of our approach and discuss the differences between local realities and information captured in global datasets. The proposed method provides a blueprint for large research programs to assess potential transferability of place-based studies to other geographical areas and to indicate possible gaps in research efforts.

Global climate change, land degradation and local livelihoods: hotspots of socio-ecological pressure in Ethiopia

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Ethiopia is experiencing significant environmental changes, including climate change, land cover change and land degradation. Given high population densities in rural areas together with large dependencies on local natural resources rural livelihoods are highly vulnerable, which has been demonstrated by the devastating drought in 2015. Farmers adapt to environmental pressure by applying various livelihood strategies, amongst others out-migration. Yet, the linkages between environmental changes, natural resource availability and human migration is only little understood.

The aim of this study is twofold: First, to systematically identify regions at the country level in which socio-ecological pressure may arise from high population densities, land degradation, and rainfall variability. Second, to analyze the local consequences of environmental pressure on livelihoods, including the role of migration. We combined population census data at the district level with remote sensing data on rainfall variability and net primary production (NPP) to identify districts in which high population densities are coupled with a steep increase in land degradation and large precipitation variability. The results show that affected regions are located in the northern highlands and in the Great Rift Valley. At village level, we conducted a household survey and focus group discussions to disentangle the relationships between environmental change, natural resources and population development, particularly with respect to human migration. The results show that local communities actively engage in a range of migration strategies to secure livelihoods. Yet, migration in response to extreme situations, like the 2015 drought, is only intensified if alternative household strategies are impossible.

Afforestation Plan to Curb the Beijing Air Pollution in Decision Support Analysis

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Sustainable land use means to take social, economic and environmental consideration into land use planning. However, the mega cities, especially high population density in China are facing the challenge of sustainable land use to mitigate the pressure on the living environment. Take Beijing for example, the way of city planning and lifestyle has caused serious environmental problem, such as air pollution. In order to curbing the air pollution, Beijing government has implemented a five years afforestation plan. The paper tries to use a decision support analysis to study if the plan is wise to improve air quality in Beijing and meet the sustainable urban development goal. Cost-benefit analysis, risk analysis and life-cycle analysis are using as a method in the report. Cost-benefit analysis reveals how the afforestation action would alleviate the air pollution. Risk analysis anticipates the potential risks of the afforestation plan on stakeholder's interest and farmland decrease. Life-cycle analysis points out that it will take long time scale to achieve forest's carbon sequestration eco-service. The conclusion of the this report is that decision support system can help decision makers to evaluate the decision effects according to its sustainable goal and better understanding the social-ecological system in sustainable land use.

Integrating the landscape concept into land change science

The Impact of Land Use on Nutrients of Surface Runoff in upper catchment of Miyun Reservoir

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Land use closely relates to water nutrient concentrations, previous studies majorly concern the quantitative structure of land use, and lacks a comprehensive consideration for the comprehensive information of land use. Taking the upper catchment of Miyun Reservoir as the study area, based on the eco-hydrological processes affecting the export, migration and transformation of water pollution, this study systematically analyzed the impact of land use on water nutrient concentrations. It portrayed and explored the land use information influencing water nutrient, which includes land use intensity, slope of land use, distance of land uses to the river and monitoring sites, and spatial arrangement of land uses. This study coupled above four aspects of information to construct multiple linear regression models between land use and total nitrogen, total phosphorus and COD concentration. Without considering the above four aspects of land use information, the coefficients of determination of three multiple linear regression models are 0.294, 0.471 and 0.223, respectively. Taking above information into consideration, coefficients of determination of three multiple linear regression models are 0.532, 0.685 and 0.489, respectively. After quantifying the contribution of land use on nutrient concentrations of monitoring sections in each spatial location, this study compared the mean cumulative contribution rates of land use to nutrient concentrations and the corresponding cumulative area percentage at different distances to river. Finally, it suggested that the distance to the river in 1 kilometer range would be the key area to control water eutrophication in the upper catchment of Miyun Reservoir.

Adaptive characteristics in landscape ecological systems

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Global change owing to the impact of climate, social development, land use, and other effects from natural and anthropogenic effects and their interactions has become the one of the important driving forces in landscape ecosystems. The adaptability of landscape ecosystems comprises absorbing the consequences of global change and maintaining its principal functions. With global change regarded as the main driving force, the landscape ecosystem has become the main objective to alleviate and adapt to the risks and transformations of global change. Here, we summarize the current adaptability characteristics of the landscape ecosystem by integrating relevant research about agriculture, urban areas, and so on. Over the course of the adaptability process, landscape ecosystems show the following characteristics: (1) The effects of complex factors and interactions between natural and anthropogenic factors are emphasized; (2) The internal geographic characteristics of landscape types are assimilated, and the diversity and uniqueness of landscape ecosystems are decreasing; (3) Landscapes with the same functional classes are much more hierarchical, demonstrating clear division of responsibilities and cross-regional linkages in different spatial-temporal scales; (4) A clear spatial boundary exists between different functional landscape types, and the functional degradation of transition or buffer zones has become more serious. Future work should focus on improvements in various aspects, including quantifying the characteristics of landscape adaptability at different scales and identifying the range of the adaptive threshold and illuminating the limitation or relationship between the adaptability and features of landscape ecosystems.

Linking Land, Ecology and Human Wellbeing: The Landscape Sustainability Science Paradigm

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Landscapes provide a common stage for ecological plays and human actions, and couple regional/global scales from above and ecosystem/local scales from below. Landscape sustainability is the capacity of a landscape to consistently provide long-term, landscape-specific ecosystem services essential for maintaining and improving human well-being. Landscape sustainability science (LSS) then is a place-based, use-inspired science of understanding and improving the dynamic relationship between ecosystem services and human well-being in changing landscapes under uncertainties arising from internal feedbacks and external disturbances. While LSS emphasizes place-based research on landscape and regional scales, significant between-landscape interactions and hierarchical linkages to both finer and broader scales must not be ignored. To advance LSS, spatially explicit methods are essential. In this presentation, I will discuss the key concepts, methods, and examples of LSS, illustrating how biodiversity, ecosystem function, ecosystems services, and human wellbeing can be linked in dynamic landscapes, so that ecology is not only relevant to, but also an integral part of, the science and practice of sustainability.

The relevance of the landscape approach in land management

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There is increasing awareness that land management at the pixel, field or farm level has to be complemented with the notion “landscape” in order to grasp the respective trade-offs in ecosystem services that different development trajectories entail. That acknowledgement has led to increased attention for integrative socio-ecological system and landscape approaches to obtain sustainable development, e.g. in the International Association for Landscape Ecology (IALE) (<http://www.landscape-ecology.org/>), the Global Landscapes Forum (<http://www.landscapes.org/>) or the FAO-Initiative Landscapes for People, Food and Nature (<http://peoplefoodandnature.org/>).

The landscape approach finds its expression in a set of notions and paradigms, which aim at evaluating the interconnectedness of societies and their environment as expressed in the landscape. These are: (1) the resilience-approach, (2) the socio-ecological system (SES) analyses, (3) the ecosystem service paradigm, (4) the driving forces – actors analyses, and (5) integrative planning, modeling and up-scaling. The latter is the overarching technical paradigm of the landscape approach. It claims that land use does not only depend on the site conditions at the patch scale but rather on the spatial context of this patch, i.e. the landscape excerpt. These contextual properties continue along geographical gradients, e.g. every landscape depends on various properties of neighbouring landscapes and vice versa.

In our presentation we will show examples on how the landscape approach and its sub-paradigms can be applied in a case-study from Switzerland. A critical evaluation of the results shows pros and cons of the landscape approach and whether it improved good practice in land management and spatial planning.

Measuring landscape characteristics for biodiversity conservation of the Eastern Qinghai-Tibetan Plateau

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On the Eastern Tibetan Plateau over 60% of the land is used for pastoralism. Tibetan nomads have developed livestock management strategies adapting to the sensitive carrying capacity of the alpine grassland. This traditional pastoral land use mobilizes the dynamics of land cover, e.g. yak grazing regulates process of the grass-to-shrub succession at the farm scale. At the landscape scale, the uneven spatial distribution of land use intensity increases habitat heterogeneity which creates diversified ecological niches and fosters a rich number of species to coexist. To understand landscape-biodiversity relations we measured key landscape characteristics and tested their relations with the avian species composition in Nyanpo Yutse from 2014 to 2015. To measure the natural landscape characteristics we used remotely-piloted aircrafts to produce high resolution ortho images and derived 2-D/3-D environmental features. To measure the cultural landscape characteristics we conducted oral history interviews and mapped the categories and intensities of land use. We carried out two bird surveys in the mapped 45km² using the standard point count method. The pCCA analysis results showed that all landscape characteristics contributed to the variations in the species distribution (land cover 31%, habitat structure 8%, topography 19%, land use 12%). Although conventional conservation planning often aims at minimizing human disturbances, our findings demonstrated that bird species composition varies among different land use types. Certain Tibetan Plateau endemic species particularly prefer heavily-used pastures as breeding habitat, e.g. Ground tit (*Pseudopodoces humilis*). Therefore, we suggest conservation managers integrate the holistic landscape perspective into biodiversity preservation of the highland.

Landscape approach to REDD+ implementation in Nepal

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The study Compares the scope of REDD implementation at different geographical levels from the national experiences and the current data generated on the bio-physical and landscape functions of ecology of the resources. Nepal has gained long experiences of resource management at community level and has piloted REDD+ at watershed level since 2009. Now the country is moving towards experimenting with the sub-national and national level REDD+ implementation. Considering to the global discussion on the scope of implementation of REDD at different geographical units, the current study explores the prospects of the Landscape approach of REDD implementation. It compares the landscape scenario of ecosystem services of the forest mainly with currently available at spatial domain. There is also scope to include more social and demographic information for further refinement of the comparison. The comparison includes the topography, carbon storage, biodiversity, forest types, deforestation as a function forest cover change and LULC change, hydrological function, soil erosion, forest fragmentation as a forest degradation parameter. It is concluded that the landscape approach could include the wider theme of ecosystems which could be the basis of comparison of ecosystem services generated at different geographical scale. It also clumps the geographical distributions of the functions of the forest ecosystem.

Land system modelling for achieving Land Degradation Neutrality

Knowledge on dynamic ecosystem regimes is vital to achieve land degradation neutrality

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Land Degradation Neutrality is one of the Sustainable Development Goal targets, requiring ongoing degradation to be balanced by restoration of land ecosystems. However, land degradation cannot be easily decreased everywhere at acceptable cost requiring decisions on where and when best to invest in restoration. Although Land Degradation Neutrality provides an effective opportunity for research and policy, the close relationships between sustainable land management and key ecosystem dynamics related to thresholds and regime shifts, are currently poorly acknowledged in operationalising Land Degradation Neutrality. We present a decision-support tool based on dynamic ecosystem regimes to guide economically sustainable restoration. It explicitly considers degradation severity, hysteresis thresholds and suitable management timings. Applying this tool to Mediterranean rangelands, we assess investment and maintenance costs as well as benefits (e.g. pasture productivity and cover) dependent on stability domains and windows of opportunities. The chance of success is greater and returns on investment are higher in a bi-stable domain when interventions (e.g. seeding, manuring) coincide with an ecological window of opportunity. This decision-support tool is widely applicable enabling the development of generic restoration principles. It provides a new way of analysing costs and benefits of action and inaction, allowing land managers to focus their restoration and monitoring efforts on situations for which they are likely to have the greatest effect.

Drivers of Land degradation in Umnugobi Province

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Remote Sensing and GIS were used to monitor interactions and relationships between land use and land cover changes in the regional ecology area of Umnugobi province (South Gobi). This study aims at determining the land degradation conditions in 15 soums (administrative units) of the study area, Umnugobi province. Using GIS processing of data climate drivers (precipitation, air temperature) vegetation data and socio-economic drivers (livestock numbers, population figures, mining activities) were analyzed. We focused on developing a modeling approach for monitoring land degradation using GIS and Remote Sensing tools by integrating natural and socio-economic data. The Moderated Soil Adjusted Vegetation Index (MSAVI) from SPOT/VEGETATION was used to determine vegetation cover change for the period 2000 to 2013. Landsat data for the years 2000, 2010 and 2013 were analyzed to derive and classify “hot spot” areas of land degradation. GIS conditional functions were used for mapping and analyzing climate and socio-economic driving factors, both of which affect land degradation. Conditional functions such as MAP-Algebra from ArcGIS were developed using ground truth data and data from National Statistics. Our study documents that 60 percent of the study area is affected by land degradation caused by human and climate drivers.

Impacts of land cover changes on water yield and soil erosion based on SWAT model in Karst region of China

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Abstract: Land use/cover change showed an important influence on the hydrological process, and affects eco-sustainable development of river basins. This study was conducted to investigate the impacts of land use/cover change on water yield and surface soil erosion in the Sanchahe river basin (SCH), the typical Karst region of Southwestern China. SWAT (Soil and Water Assessment Tool) was used to simulate runoff (including total flow, surface runoff and groundwater) and soil erosion. Several relative sensitive parameters were calibrated based on the observed hydrological data, the Nash-Sutcliffe Index and coefficient of determination as the evaluation criteria. The result showed that the calibrated SWAT reliably simulated the runoff and soil erosion in SCH. Further, different land use/cover scenarios were set for this study, and the hydrological effects of vegetation cover changes from the aspects of temporal and spatial can be found. This study has significant contributions to land system science and could provide scientific basis for rocky desertification containment and ecosystem restoration.

Erosion gully information extraction based on remote sensing images with different resolution

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In this study, based on multi-resource remote sensing images, combined with DEM data, using qualitative method, characteristics of erosion gully extracted from each remote sensing image are analyzed comprehensively, and two investigation units are selected in survey area for field verification. The results obtained are compared with the results of visual interpretation of remote sensing images. The results show that: (1) Although Pleiades remote sensing image with the highest spatial resolution and DMC image can express the information of gully erosion clearly, the increasing of spatial resolution of remote sensing images will increase internal details of erosion gully, which can cause interference for extracting information. (2) Different types of erosion gully can be extracted from different remote sensing images. Compared with Pleiades remote sensing image and Alos remote GF-1 satellite images, as the ideal images, can express the information of dissected gully and gulch that need to be researched mainly. (3) When resources satellite three and GF-1 images extract the information of quantity, length and width of dissected gully and gulch, which need to be investigated mainly, the results close to the field verification results, so they are more appropriate images.

The BonaRes Centre – A virtual institute for soil research in the context of a sustainable bio-economy

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Fertile soils are central resources for the production of biomass and provision of food and energy. A growing world population and latest climate targets lead to an increasing demand for both, food and bio-energy, which require preserving and improving the long-term productivity of soils as a bio-economic resource. At the same time, other soil functions and ecosystem services need to be maintained. To render soil management sustainable, we need to establish a scientific knowledge base about complex soil system processes that allows for the development of model tools to quantitatively predict the impact of a multitude of management measures on soil functions. This, finally, will allow for the provision of site-specific options for sustainable soil management.

To face this challenge, the German Federal Ministry of Education and Research recently launched the funding program “Soil as a Natural Resource for the Bio-Economy – BonaRes”. In a joint effort, ten collaborative projects and the coordinating BonaRes Centre are engaged to close existing knowledge gaps for a profound and systemic understanding of soil functions and their sensitivity to soil management. This presentation provides an overview of the concept of the BonaRes Centre which is responsible for i) setting up a comprehensive data base for soil-related information, ii) the development of model tools aiming to estimate the impact of different management measures on soil functions, and iii) establishing a web-based portal providing decision support tools for a sustainable soil management.

Land use and ecosystem services

Assessment of Ecosystem Service Importance in Yan-Long-Tu Region

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This paper used analytic hierarchy process and comprehensive index method to evaluate the regional ecosystem service function of YanLongTu region. It was Analysis of the importance of water resources conservation, carbon fixation and oxygen release, biodiversity protection, regulating micro-climate, agricultural products supply and landscape visual retention of Yan-Long-Tu region and showed its spatial distribution. It was analysis the comprehensive evaluation of regional ecosystem services. The results showed that the most important areas of ecosystem service were 72.03% of the total area of Yan-Long-Tu region. More important areas and important areas were 13.57%, 10.69% of the total area, respectively. Generally important areas were only 3.21%. It provided scientific basis for the scientific management of regional ecosystem and ecological function zoning. And it played an important role in the maintenance of regional ecological security of Yan-Long-Tu region.

The urban land ecological suitability evaluation of Yan-Long-Tu region

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The resistance evaluation system of this paper included 12 factors which were from the natural geography, social economy and ecological limit three aspects. This urban land ecological suitability evaluation of Yan-Long-Tu region primarily used GIS spatial analysis method which was based on the resistance model and minimum cumulative resistance model. The results showed that: the urban land ecological suitability of Yan-Long-Tu region can be divided into the key construction area (538.55km²), the optimized construction area (743.53km²), the restricted construction area (1887.46km²) and the forbidden zone (1919.16km²). This paper made the space distribution of all different levels clear and put forward some suggestions correspondingly in order to provide the theory, technology, decision-making and other support for the urban land ecological planning and management of Yan-Long-Tu region.

Quantifying impacts of landscape change on ecosystem services and human beneficiaries: a case study of moose hunting in Vermont, USA

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What drives changes in ecosystem services and how are the costs and benefits of these changes distributed among human beneficiaries? Answering this question is crucial for sustainable land management, yet few studies fully demonstrate how ecosystems are linked to human wellbeing. In this paper, we provide insight with a case study of moose hunting in Vermont, USA. We used 20 years of spatial data to analyze changes in ecological factors supplying hunting opportunities, and determine the consequences of these changes for human beneficiaries. We found many ecological factors supplied hunting opportunities, namely those related to moose habitat suitability. However, changes in the number moose harvested each year were instead due to permit allocations, since demand for permits surpassed their availability and moose habitat remained relatively stable over time. We also found moose were harvested from a small number of towns in Vermont, but supplied hunting opportunities to people all across the state. This suggests that ecological or institutional change in one part of the state could have widespread consequences for human beneficiaries. Finally, we found moose hunters were diverse in their social demographics—having variable household incomes, education and unemployment levels. However, changes in permit allocations over time disproportionately impacted the most vulnerable of these hunters (e.g. those with lower household incomes), suggesting the consequences of ecosystem service change are unevenly distributed among different hunters. Our results demonstrate implications for managing moose hunting in Vermont and illustrate important factors to consider when linking ecosystem change with human wellbeing.

Temporal and Spatial Disparities Analysis of the Economic Contribution of Land in China - Based on the View of Resource Curse

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This paper aims to analyze the spatial-temporal heterogeneity of the contribution of land to China's economic growth. It establishes a new "resource curse" framework within which to build the resource value theory system into the establishment of land resource abundance. To ascertain whether there is a "blessing" and/or a "curse", provincial panel data analysis is conducted by means of two specific models, i.e. time dynamic panel data model and spatial recursive panel data model. The major findings are threefold: 1) the "resource curse" phenomenon exists on time scale of land resources in China, but not spatially; 2) its land resource curse mainly transmits through construction land resource abundance, urbanization rate, cultivated land resource abundance, social fixed investment, and college employment ratio; 3) after analyzing the transmission pathway of resource curse, it is concluded that 73.46% of the resource curse phenomenon of land resource on economic growth is caused by the "curse" result of construction land, and 26.54% of it is caused by the "blessing" result of cultivated land. This study helps fill knowledge gaps and shed light on policy implications. This paper aims to analyze the spatial-temporal heterogeneity of the contribution of land to China's economic growth. It establishes a new "resource curse" framework within which to build the resource value theory system into the establishment of land resource abundance. To ascertain whether there is a "blessing" and/or a "curse", provincial panel data analysis is conducted by means of two specific models, i.e. time dynamic panel data model and spatial recursive panel data model. The major findings are threefold: 1) the "resource curse" phenomenon exists on time scale of land resources in China, but not spatially; 2) its land resource curse mainly transmits through construction land resource abundance, urbanization rate, cultivated land resource abundance, social fixed investment, and college employment ratio; 3) after analyzing the transmission pathway of resource curse, it is concluded that 73.46% of the resource curse phenomenon of land resource on economic growth is caused by the "curse" result of construction land, and 26.54% of it is caused by the "blessing" result of cultivated land. This study helps fill knowledge gaps and shed light on policy implications.

The environmental and economic impacts of crop-livestock integration in a changing climate: evidence from a whole-farm model in Brazil

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Integrated crop-livestock systems (iCL) are being promoted in the tropical world as a strategy to achieve sustainable agricultural intensification, particularly of ruminant livestock systems. In the Brazilian agricultural frontier, where land use transitions are relevant for food security and climate change mitigation around the world, integration is expected to increase by 4 million ha by 2020. However, limited knowledge about the net private benefits and environmental impacts associated with integrated systems poses a crucial barrier to their wide-scale adoption and compromises policy design. We employ a whole-farm model of a representative farm in Mato Grosso, Brazil to assess the environmental and economic impacts of iCL adoption at the farm level under climate change. We compare an integrated soy-cattle system to an extensive and an improved beef cattle system. We find that the extensive system is associated with the lowest costs and revenues of all systems, whereas the integrated system shows the highest costs and revenues. The improved system yields negative economic returns, indicating that the mere incorporation of crops does not always lead to higher profits and that the degree of diversification and the choice of different species matter. Finally, iCL is associated with the highest overall GHG emissions but lowest emissions per US\$ produced. Besides offering concrete evidence of the economic feasibility of integrated systems where large-scale specialized agriculture is well-established, our results show that the transition to low-carbon agriculture is desirable both from a private and societal perspectives.

Getting the biodiversity right in integrated land use – biodiversity models

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Global changes in land-use and in biodiversity and associated ecosystem services are tightly linked. Various integrated land use – biodiversity models attempt to decipher or represent those links to inform conservation and sustainability actions. However, all these models are severely hampered by issues concerning the underlying biodiversity information, including data gaps, biases, uncertainties, and scaling issues. Because these issues are typically not appropriately accounted for, many contemporary land use – biodiversity studies are methodologically flawed, and may ultimately lead to biased conclusions. Based on an integration of >300 million biodiversity records for terrestrial vertebrates and land plants with independent taxonomic and distributional information, I carried out the most comprehensive analyses of limitations in global biodiversity information to date. Drawing from these analyses, I present an overview of the diverse biodiversity data issues and critically discuss prospects and future directions for improved land change – biodiversity models. I will end with a plea for improved collaboration between land change scientists and biogeographers to more routinely address biodiversity information-related issues for ultimately more reliable models.

Impacts of climate change adaptation scenarios on ecosystem services in large scale agriculture – a case study from Germany

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The one-sided orientation of agricultural management towards economic returns may compromise ecosystem services and can lead to depletion of groundwater resources, soil and water quality, biodiversity and socio-cultural services. These services become evident at landscape level although decision-making takes place at farm levels.

We conducted integrated impact assessments of climate change adaptation and agricultural intensification scenarios for the federal state of Brandenburg/Germany in 2025. One Irrigation scenario and one Energy scenario were contrasted with a Business As Usual (BAU) scenario. Ecosystem service effects were analyzed at district landscape scale.

We found positive effects of the Energy scenario on bio-electricity production to 41% of the demand of Brandenburg coupled with CO₂ savings of up to 3.5 million tons. Negative effects were related to loss of biodiversity, landscape scenery, increased soil erosion risk, and increased area demand for water quality protection. Water demand for irrigation was estimated to be conflicting with other water uses in some areas. Spatial differentiation of ecosystem service impacts showed that landscapes with medium to low yield potential were more affected by negative impacts than those with high yield potential.

In this first comprehensive impact assessment of agricultural intensification scenarios at landscape level we showed that a considerable potential for agricultural intensification exists in Brandenburg. It is accompanied with adverse ecosystem service impacts. The novelty of the assessment lies in the multiscale integration of comprehensive, agricultural management simulations with regional level impact assessment, which was achieved with use of indicators. It provided relevant evidence for policy making.

The impact of cropland balance policy on ecosystem service of water purification--a case study of Wuhan, China

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Urban expansion results in huge loss of cropland worldwide, while China suffers more because of its great population and rapid urbanization. Consequently, China implements policies such as Cropland Balance Policy to guarantee its food security. Nevertheless, as an inevitable way to fulfill the policy, reclaiming new cropland costs loss of ecological land and degradation of ecosystem services. Evaluating impacts of Cropland Balance Policy on ecosystem services will support policy improvement by alleviating its side-effects.

Taking Wuhan as the study area, we analyzed the impacts of Cropland Balance Policy on water purification service. Firstly, a CA-based model LANDSCAPE was employed to project land use pattern in 2020 for both scenarios with and without Cropland Balance Policy. Subsequently, the Integrated Valuation of Ecosystem Service and Tradeoffs (InVEST) model was applied to assess provision of water purification under different scenarios.

The results show that: (1) both the amounts of load and export of nutrients are obviously higher in policy-interference scenario than that without policy. (2) the negative impact of Cropland Balance Policy on water purification is greater in rural area than that in urban area. (3) the negative impact is mainly resulted from the load increase and decrease of assimilation capability.

This research demonstrates the harmful impact of Cropland Balance Policy on water purification in Wuhan, especially in its rural area. To ensure synergy of urbanization, food security and ecology conservation, land use policies should take ecological impacts into account in China, rather than focusing on single objective of cropland protection.

Trade-offs between urban expansion and coastal wetland protection along the Jiangsu coast, China

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Urban expansion requires China to find new land to compensate for the loss of agricultural areas. Along the eastern coast this agricultural land displacement has led to large-scale wetland reclamation over the past decades. These reclamation activities have increased the pressure to the coastal environment, and reduced biodiversity and the provisioning of associated ecosystem services. Because rapid population growth is expected to lead more urban expansion, coastal wetland reclamation is expected to continue in the foreseeable future. In this study, we quantify the spatial-temporal land changes related to urbanization, and its consequences for coastal reclamation processes along the Jiangsu coast, China, an area that is characterized by tremendous land reclamation from wetland conversion. Based on these historical analysis, a novel evaluation about coordinated relationship between inland urbanization rate and coastal wetland ecosystem services caused by reclamation is going to build. In addition, we evaluate four scenarios, which differ in population growth and economic development rates. Under these scenarios, different land use plans about future urban land expansion and coastal wetland reclamation can be evaluated. This study may serve as a scientific reference regarding decision-making in coordinating inland and coastal development and in protecting the wetland resources of China.

Land use change in north Australia's savanna woodlands: trade-offs between clearing, greenhouse gas emissions and agricultural production

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Australia's tropical savannas are 12% of global savanna extent and are largely intact; however there is currently a focus on agricultural expansion across northern Australia involving clearing for primary production. Eddy covariance and soil chamber methods were used over almost 2 years to quantify CO₂ and non-CO₂ fluxes from savanna that was cleared and prepared for agriculture (CS). Fluxes from an uncleared site (UC) were also monitored. Carbon fluxes from both sites were similar (NEE -0.23 Mg C ha⁻¹ month⁻¹) for the 5.4 months prior to clearing. Fluxes were monitored for a further 17 months through a clearing event and a debris curing phase, followed by burning and soil preparation for cropping. Over this period the CS site was a source of +0.43 Mg C ha⁻¹ month⁻¹ compared to a net sink at the UC site of -0.05 Mg C ha⁻¹ month⁻¹. Woody debris from clearing (30.9 Mg C ha⁻¹) was removed from the site via burning in the late dry season and emission factors were used to calculate emissions of CO₂, CH₄ and N₂O which totalled 138.0 Mg CO₂-e ha⁻¹. This land transformation resulted in an emission of +9.7 Mg CO₂-e ha⁻¹ month⁻¹ compared to a sink of -0.27 Mg CO₂-e from the UC site. LUC scenarios at catchment to regional scales suggest proposed clearing for agriculture could significantly increase the region's fire-dominated GHG emissions. These data are essential for both land-atmosphere models and decision support tools that inform trade-offs between greenhouse gas accounting, conservation and development goals.

Land comprehensive carrying capacity of island cities and its trend evaluation based on system dynamics: taking zhoushan as the example

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With the rise of national marine strategy, land comprehensive carrying capacity of island cities is paid more and more attention. This paper constructs the revised model suitable to evaluate land comprehensive carrying capacity trend of island cities, taking Zhoushan city as the example. Land comprehensive carrying capacity of the island city and its development trend are calculated and simulated. The conclusion is that Zhoushan city's land comprehensive carrying capacity in 2012 is 1389940 persons, compared with population of that year, the city has great development potential; from 2012 to 2021, Zhoushan's land comprehensive carrying capacity trend changes across different development programs, and the number under economy-priority mode is the biggest in 2021.

Land use efficiency in a dynamic context: Sparring, sharing, environmental heterogeneity and land use trends

MODERNIZATION-DRIVEN LAND USE REDISTRIBUTION, AND LAND USE EFFICIENCY.

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Land use and land cover changes in Latin America include both intensive agriculture expansion in the lowlands and reforestation in steep areas. Thus, reforestation and deforestation occur, in general, at different ecological zones. The consequences of such redistribution of forests over ecosystem services and biodiversity are complex, and cannot be simply assessed by evaluating net cover change. We analyzed 20 years of land cover change in a 280000 ha watershed from northwest Argentina, and its consequences over forests carbon sequestration, food production, soil retention and the diversity of large mammals and birds. Net forest change was <1%. However, while 6% of mountain forests expanded over natural grasslands, 7% of dry forests were converted to agriculture in the lowlands. Carbon sequestration in forests also showed a redistribution, with carbon losses due to deforestation and degradation occurring in dry forests; and carbon gains through regrowth and forests recovery involving moist forests. Soil losses in the lowlands were also compensated with increased soil retention in montane forests. The responses of biodiversity to land use change were not homogeneous, since mammals were more sensitive to changes within forests, such as livestock density and carbon change; while birds responded strongly to forest cover loss and fragmentation. Overall, these changes derived in higher food production with comparatively minor changes in biodiversity and other ecosystem services and biodiversity. However, important qualitative changes can be expected from these trends, since the potential of different forests types for delivering ecosystem services and preserving biodiversity is not homogeneous. Land use and land cover changes in Latin America include both intensive agriculture expansion in the lowlands and reforestation in steep areas. Thus, reforestation and deforestation occur, in general, at different ecological zones. The consequences of such redistribution of forests over ecosystem services and biodiversity are complex, and cannot be simply assessed by evaluating net cover change. We analyzed 20 years of land cover change in a 280000 ha watershed from northwest Argentina, and its consequences over forests carbon sequestration, food production, soil retention and the diversity of large mammals and birds. Net forest change was <1%. However, while 6% of mountain forests expanded over natural grasslands, 7% of dry forests were converted to agriculture in the lowlands. Carbon sequestration in forests also showed a redistribution, with carbon losses due to deforestation and degradation occurring in dry forests; and carbon gains through regrowth and forests recovery involving moist forests. Soil losses in the lowlands were also compensated with increased soil retention in montane forests. The responses of biodiversity to land use change were not homogeneous, since mammals were more sensitive to changes within forests, such as livestock density and carbon change; while birds responded strongly to forest cover loss and fragmentation. Overall, these changes derived in higher food production with comparatively minor changes in biodiversity and other ecosystem services and biodiversity. However, important qualitative changes can be expected from these trends, since the potential of different forests types for delivering ecosystem services and preserving biodiversity is not homogeneous.

Making sense of the connections between forest conservation policies, forest transition and land use displacement: The cases of Bhutan and Costa Rica

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National-scale forest transitions are often associated with land use displacement through an increase in net imports of agricultural and forestry commodities. Such displacement may correspond to leakage in response to forest conservation policies.

We used the cases of Bhutan and Costa Rica to analyze the multiple linkages between forest conservation policies, forest transition and land use displacement. We first assessed the changes in land use and forest cover that occurred along with recent conservation policies, and quantified the effectiveness of forest land zoning policies in Bhutan.

Bhutan has imported increasing quantities of charcoal for its emerging chemical industries, which reflects functional upgrading in the value chain rather than externalization of consumption-based environmental costs. In Costa Rica, decreasing beef exports led to a contraction of pastures, freeing an area equivalent to 80% of the reforested area. Simultaneously, Costa Rica has become a major exporter of pineapple and banana. Nevertheless, increasing imports of cereals, soy and forestry products turned the country into a net importer of land use. In conjunction to this displacement, intensification and land use redistribution within the country accounted for 76% of land spared during the forest transition. Fruit exports triggered unexpected feedbacks on the forestry sector through the demand for wood pallets.

For both countries, the net international-level environmental impacts of land use displacement may be considered as positive. However, in Costa Rica, forest increased mainly in regions with a low ecological value, while export-oriented cropland expanded into the most ecologically valuable forests.

In both cases, land use displacement resulted from complex interactions between forest conservation policies and the broader socio-economic context, questioning simplistic visions of leakage.

Certification design to meet future oil palm demands with minimal biodiversity loss

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It is attractive to recommend the complete removal of forest from the oil palm food chain. However, the certification of palm oil as sustainable comes at a cost and if certification is to become more stringent, the costs are expected to grow.

We assess the impacts of increasingly stringent land-use regulation (or certification schemes) on the production costs of oil palm that meets future demands. We compare these costs to the area of forest land that would be spared and the bird biodiversity that could be saved, compared to an uncertified (business-as-usual) scenario. We do this by modeling the expansion of oil palm from Southeast Asia into Africa and Latin America using a spatial economics model combined with species area relationships for critically endangered and endangered tropical birds.

We find that future oil palm demand by 2020 could be easily met without further deforestation and minimal threat for endemic bird species by focusing conversion of grassland and pasture land mostly in Latin America (e.g. Los Llanos in Colombia and Venezuela). This scenario would increase production costs by \$2.24 billion (equivalent to an increase of \$0.034 in a Mars chocolate bar). Intensification of beef production or multi-crop oil palm–cattle landscapes could absorb the leakage generated by such a stringent oil palm certification scenario. Our results thus suggest that decoupling oil palm and deforestation might be an affordable strategy in the short term.

Ecological footprint in Inner Mongolia 1987-2013: Examining the temporal and spatial dynamics

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One of the greatest challenges of our time is to address the rapidly growing human demands on ecosystem services and the consequent pressure on resources and the environment. Ecological footprint (EF), proposed by Rees and Wackernagel in 1996, measures the productive area required to provide the renewable resources which humanity is using and to absorb its waste. Ecological footprint is widely used especially to assess regional sustainability along with socioeconomic indicators. This study aims to 1) calculate major EF in Inner Mongolia, China from 1987 to 2013 to examine the temporal change and driving force; and 2) investigate the spatial distribution of residential water use footprint in 2010 in major cities of the study area.

Inner Mongolia is located in the drylands of northern China, bordering with Mongolia and Russia. It has a population of 24.7 million in 2010 with an area of approximately 1.2 million km². As in the rest of China, the past three decades witness dramatic changes in Inner Mongolia, including industrial structure, economic growth, land use, as well as people's lifestyle. We examined EF's temporal change for the entire Inner Mongolia in three aspects: food, water, and CO₂ emission. We calculated the food footprint by estimating the annual residents consumption from 11 types of renewable products (i.e. crops, vegetables, processed oil, beef, lamb, pork, poultry, eggs, dairy products, and aquatic products) and the bioproductive land occupied by human (e.g. cropland, pasture, forest, and fishery). Water footprint includes residential, agricultural, and mining water use. We calculated CO₂ emission based on energy use including coal, fossil oil, and gas. Then, we focused on the 12 major cities in our study area to investigate their water footprint and the spatial patterns of area required to provide the water supply.

Our results show: 1) During 1987-2013, the food footprint increased 24%, residential water use decreased 9%, total water use increased 222%, and CO₂ emission increased 1052%. 2) Water use increase was mostly due to agricultural water use increase before 2000 and mining water use replaced irrigation accounted for the major water increase after 2000. The rapid CO₂ emission increase during 2000-2013 is consistent with the expansion of mining industry. 3) The spatial patterns of urban water EF indicate that the water supply area gets close to the administrative boundaries. Considering the fact we did not take agricultural and industrial water use into account, the overall urban water use would require a much larger area for supply.

Our study shows that residential EF (food and water) increased at a moderate rate or even decreased despite of the dramatic improvement of living conditions during 1987-2013. Major EF increase (water and CO₂) in the study area is a result of increased agricultural irrigation and more importantly, the rise of mining industry. While bringing in huge economic benefits, mining may exhaust the precious water resource in this dryland. This result has important implications for future landscape sustainability studies and planning.

Emergy analysis of urban metabolism at county level in Beijing

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Urban metabolism is a self-organizing system within materials, energy, money and human labor flows, which can be used as an index of urban sustainable development. Based on the emergy theory, we analysed the structure, intensities, environment pressures and output efficiencies of urban metabolic emergy system at county level between 2005 and 2013. The primary results are as follows, the import and export emergy growth contributed mostly to the emergy consumptions of Beijing metabolic system. Emergy use intensities of Beijing had increased with the rapid rise in the non-renewable resource emergy and import emergy, which resulted in the increasing environmental pressures and gradually declining of output efficiency and sustainability. Facing the growing resource and energy shortage, Beijing should encourage the exploitation and utilization of renewable resources and energy, increase the consumption efficiency of non-renewable resources and energy, establish the mechanism to re-use wastes of resources and energy to promote the urban metabolism in Beijing.

Land Use, Ecosystem Service and Management

Effects of land use and cover change on terrestrial carbon stocks in Uganda

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Land use/cover change, especially conversion and degradation of forest land, is the key factor causing terrestrial carbon stocks declines in Uganda. How local ecological assemblages are responding is less clear—a concern given their importance for many ecosystem functions and services. The main objectives are to assess status and variation in carbon stocks across terrestrial land covers and quantify spatial distribution and dynamic variation of terrestrial carbon stocks in response to land use/cover change. This paper presents a methodology for quantifying and assessing changes in carbon stocks as a result of land use change using the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model. The model was used to map and quantify carbon stocks for Uganda for 2006 and 2010 land use conditions. Result indicate negligible increase in forest carbon stocks ($3,260 \text{ t C yr}^{-1}$) in the period 2006-2010 when compared to the emissions due to deforestation and forest degradation ($2.67 \text{ million t C yr}^{-1}$). Finally, we suggested potential policy measures to mitigate negative effects of land use and cover change on carbon stocks in Uganda.

What does land use change bring to the ecosystem services values of agricultural land in Hubei Province?

MIN MIN, Jiaying Chen, et al.

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The conflict of urban sprawl and agricultural land conservation is unavoidable during the undeveloped area. The land use changes resulting from the urban sprawl will significantly influence the distribution of agricultural land values. With the world-wide acceptance of the multi-function of agricultural land, the importance of non-market value of agricultural land has been paid more attention. However, how to evaluate the effect of land use change on the ecosystem services value is still under discussion. In this paper, our objectives are to analyze the urban sprawl and calculate the value of these changes in terms of the lost ecosystem services values of agricultural land in Hubei province, China. Therefore, we try to use a spatially explicit model in conjunction with the benefit transfer method to estimate the comparable economic values of the ecosystem services values. The benefit transfer method will provide a cost-effective way to evaluate the ecosystem services values from the large volume of previous case studies and the spatially explicit measure provides a mechanism for incorporating spatial context into ecosystem service evaluation. Based on this integration of spatial analysis method and the economic valuation method, the suggestion and implication for local agricultural land conservation were extensively discussed. The work was expected to be helpful for the local government to make decisions on the future land resource allocation.

Mapping landscape service provision of cropland in the urban fringe - the case of Wuhan, China

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People benefit from cropland through food production and a variety of environmental and recreational benefits. However, the provision of the different functions offered by agricultural landscape deteriorates as a consequence of ongoing urban development, especially in urban fringe. To help define sustainable management strategies we developed and implemented a method to map characteristic patterns of current provision of these landscape services.

Field interviews were conducted in Wuhan, a rapidly urbanising Chinese city, to study the degree to which different functions are present in its urban fringe. The questionnaire was designed following the evaluative dimensions of agricultural land-use systems proposed by Gómez Sal and González García (2007) with necessary adjustment into local conditions and scale. In total, 25 land functions are distinguished, namely, productive, ecological, economic, social and cultural dimensions of its agricultural land-use systems. Based on the result of 768 farmer households, four typical patterns of land function provision were categorized using a k-means clustering approach.

The results show that: (1) social and productive functions dominate the typical agricultural land-use patterns that were distinguished; (2) the values of cultural functions remain low in all locations, suggesting the potential of promoting the cultural assets of the area; and (3) the synergy between provision and regulation functions performs differently at different locations while only 17% of the total sample shows relatively high-level synergy.

The presentation will demonstrate the typical provision patterns of ecosystem services of cropland in the urban fringe of Wuhan and discuss its potential implications for land planners and managers.

Impacts of Land use and land cover change on Ecosystem services in Pakistan

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Ecosystem services research is a hot and key issues at home and abroad. With the intensification of human activities, the structure and function of ecosystem affected by the human activities are more profound. Land use and land cover change is one of the important factors that affect the ecological system. With land-use change, domain of landscape types and the landscape structure inevitable great changes, also inevitable of regional geophysical processes and earth chemical process and biological process produced a corresponding impact. It will inevitably affect the quality of the regional ecosystem services. Pakistan is located in South Asia, is China's land neighbors, and is "The Belt and Road" construction in key areas and start, also the target area of "Pakistan Economic Corridor" construction. With the implementation of "The Belt and Road" and Pakistan Economic Corridor", Pakistan will face a huge infrastructure construction and land use and land cover change. Under this background, the research is of great significance to influence of Pakistan's Land use and land cover change of Pakistan ecological system. So this paper chooses Pakistan as the study area, using GIS as a platform, predict Pakistan land use change by DLS model. At the same time, application the InVEST model and combined with land use types and other factors, conduct an in-depth investigation on ecosystem services in Pakistan and realizes spatial quantitative assessment of ecosystem services.

Ecosystem Service Trade-offs and Sustainable Land-use Management

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Ecosystem services are substantial elements for human society. The central challenge to meet the human needs from ecosystems while sustaining the earth's life support systems makes it urgent for enhancing efficient natural resource management to sustain ecological and socioeconomic development. Trade-off analysis of ecosystem service can help to identify optimal decision points to balance the costs and benefits of the diverse human uses of ecosystems. Thus our main purpose in this paper is to present the key insights on trade-offs analysis of the ecosystem service at different scale from land-uses' perspective, by comprehensively reviewing the trade-offs analysis tools and approaches that addressed in ecology, economics and other fields. Our review paper will significantly contribute to future research on a trade-off analysis to avoid inferior management options and offer a win-win solution based on comprehensive and efficient planning for multiple, interacting ecosystem services.

Effect of land use and cover change on ecosystem service value ——taking Chengdu as an example

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Chengdu plain is an important commodity grain production area in China, which has a prominent contradiction in the ecological environment and food security. And it also facing a huge challenge between economic development and ecological construction, which is the location of a national economic and technological development Zone, especially. It has a strong practical significance to study the influence of land use and cover change on ecosystem service value in Chengdu. In this study, we through the interpretation of remote sensing images of Chengdu in 1999-2014 to obtained the data of land use and cover change. On the basis of the analysis, according to the ecosystem service value equivalent factor table which is proposed by Xie Gaudi, we using the CPI accumulation coefficient and the marginal value coefficient to modified the evaluation model of ecosystem service value, and calculated the ecosystem service value in Chengdu city. The results show that the ecological service value of Chengdu was increased from 4.267×10^9 RMB yuan in 1999 to 5.973×10^9 RMB yuan in 2014. It also means that the development of Chengdu 1999-2014 is sustainable, and the land use of Chengdu is reasonable.

Biodiversity conservation as facilitator of development: The Côte d'Ivoire example

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Côte d'Ivoire is a West African country that is characterized by an outstandingly high biodiversity, which is heavily threatened due to its socio-economic development since independence. The importance of this biodiversity is indicated, on one hand, by the fact that most of the protected areas of the country belong to the global priority zone for the conservation of biodiversity in West Africa (the Upper Guinea biodiversity hot spot); and on the other hand, by the presence two important UNESCO Biosphere reserves and World Heritage Sites in the country (Taï NP with the last continuous primary moist rain forest in West Africa, and Comoé-NP as largest savannah NP in the region). However, from 1958 to the present, the country lost nearly 90% of its original forest cover (at a rate of 7.6% per year), as well as many species due to exploitative land use practices and conversion of large proportions of natural habitats into cropland triggered by its unprecedented economic growth. Aware of the environmental and long-term socio-economic consequences of such a development, the country has recently committed itself to a sustainable development policy for an emerging economy by 2020. It involves all business actors including those of economy, environment, higher education and scientific research. To achieve these objectives, the country has launched a five years National Development Plan (NDP). What are the foundations of this new development policy? How can the particular biodiversity of the Côte d'Ivoire contribute to achieve this goal? What is the contribution of scientific research on biodiversity and climate change in order to enhance sustainable development and a green economy by 2020? These are the questions addressed in this presentation, which represents the vision of the Research Unit on Ecology and Biodiversity of the Research Pole in Environment and Sustainable Development of the University Nangui Abrogoua in Côte d'Ivoire.

Modeling and delineating the impacts and drivers of land use change

Identifying economy-wide land multiplier for land use management

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Land is a critical input for production of every sector in the economy. With a pro-growth economic mindset, sectors in the Taiwan economy compete hard for the scarce land resources. Yet the highly specialization in economic production implies that producing sectors are inter-dependent on each other. As such, it is important to factor in the inter-industry dependency in the decision of resource allocation between sectors. Land management policy is key in guiding the economy towards efficient utilization and optimal allocation between various land uses. In this paper we used the Input-Output Analysis approach and an environmentally extended Input-Output Account to reveal the interdependence between the productive sectors of the Taiwan economy and the associated demand for land. Based on this economy-wide framework, we identified the “key sectors” in driving economic growth and derived land multiplier of all the sectors. The two sets of results are combined to reveal by order the potential economic benefits of land allocation between uses. Our results offer important insights for land management policy in the contemporary economy of specialization.

Detecting the temporal relationship between temperature, precipitation and vegetation cover in the eastern Alai Valley, Kyrgyzstan using MODIS-EVI

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According to the seasonal grazing activities, the eastern Alai Valley, southern Kyrgyzstan, can be classified as spring & autumn (SA-type) pastures, summer (S-type) pastures and all-season (A-type) pastures. To predict the response of the vegetation cover to the climate change, it is necessary to understand the temporal relationship between temperature and precipitation and vegetation cover. These relationships were examined by using monthly maximum composite values of MODIS-EVI between 2000 and 2015. EVI of three types of pastures were positively related to both temperature and 1-month lagged precipitation. Compared to precipitation, temperature had a greater predictive power and had more consistent effects on EVI at monthly intervals. The relationships between the long-term trend component of EVI and the trend component of precipitation and temperature between 2000 and 2015 were examined by STL decomposition procedure. The trend component of EVI of SA- and S- and A-type pastures had a significant positive linear relationship with 2-month, 2-month and 3-month lagged temperature, respectively. Meanwhile, the trend component of EVI of SA- and S- and A-type pastures had a significant positive linear relationship with 23-month, 24-month and 25-month lagged precipitation, respectively. The R² of linear relationship suggested that precipitation was the major control of the change direction of the trend component of EVI in the long term in the valley. The vegetation cover reacts to the effect of temperature immediately, while the lagged effect of precipitation on vegetation cover was realized by the soil moisture and evapotranspiration dynamics over the long term.

Modeling national and transboundary protected area effectiveness to avoid deforestation and its relation to governance structures in Central America

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Protected Areas (PAs) are a prominent conservation approach to minimize land use change (LUC) impacts on ecosystem services, resilience, and the landscape. Understanding PA effectiveness to prevent LUC and how this is affected by governance structures (e. g., centralized versus decentralized levels in decision making and management) is of central importance. We draw on qualitative interviews and quantitative impact evaluation methods to evaluate how land governance relates to LUC in 20 PAs across Trifinio; a transboundary area in El Salvador, Guatemala, and Honduras. Major events in Central America affected LUC and forest protection during the 1980s and 1990s. This area experienced high deforestation rates between 1990 and 2010. Whether PAs were able to avoid these high rates of LUC and why is thus an important regional and global question. Using 12 interviews with key informants we created a PA governance index and classified them by levels of decentralization. We measured forest cover and LUC over six epochs between 1986 and 2016 and used matching and difference-in-difference methods to estimate the impact of PAs in avoiding deforestation and the relationship with governance structures. By using key biophysical, socioeconomic, and governance indicators we identified causal explanations and compared governance and LUC outcomes within and across PA and across Trifinio countries. This study contributes broadly to land use and governance theories by assessing assumptions around LUC drivers and conservation policy effectiveness. Our findings are important to inform policy and advance theory and methods that explore how governance affect LUC outcomes at multiple scales.

Biodiversity impacts of modelled land use change in Brazil

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Brazil is committed to preserving its biodiversity, as well as reducing deforestation as part of climate change mitigation and continued sustainable development. It has established national targets aligned to the Convention on Biological Diversity's Aichi Targets for achievement by 2020 and, in its Nationally Determined Contributions (NDCs) to the UNFCCC, the Brazilian government has pledged to strengthen policies and measures to reach zero illegal deforestation within Amazonia by 2030.

Land use related policies are often developed to meet a range of objectives, including biodiversity conservation, climate change mitigation, sustainable development and food security. Brazil's Forest Code is one example of a national policy that can be used to meet multiple objectives; the details of its local implementation are currently being determined. Global land use change models can be tailored to help in developing a holistic understanding of the range of impacts that different local policies, such as the forest code, can have, and so strengthen the development of effective policies.

Model projections developed by our team in the REDD-PAC project, show that the full implementation of the provisions of Brazil's revised Forest Code (FC) will contribute to conserving biodiversity in Brazil. They further highlight the importance both of implementing the Environmental Reserve Quota (Portuguese acronym, CRA) mechanism quickly and effectively, and of putting in place additional measures to protect those areas, such as the Caatinga forests, Cerrado grasslands and non-forest vegetation in Amazonia, that may suffer increased land use pressures as a result of the revised FC.

Introduction on the 2nd Round National Land Survey in China

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This report comprehensively introduces the 2nd round national land survey and the national land use change survey in China. Firstly, the report introduces general information on land management system in China, and its main responsibilities and organizational structure. The challenges of land management in China and the possible solutions by using latest data are also pointed out.

Secondly, the report systematically introduces the methods and outcomes of the 2nd round national land survey. The 2nd round national land survey adopted the top-down and bottom-up communication processes and supported by spatial technology. Through the survey, we clearly identified the nationwide land use situation and knew the land area by different classification. At the same time, we built the national basic land use database to monitoring the land use change. Through the 2nd land survey data, we analyses the current situation on farmland, built-up land and ecological land in China.

Finally, the report briefly introduces the working procedure, the methods of database updating and the new technology application in the national land use change survey.

Modelling future land use: advances and challenges

Simulation of spatiotemporal urban development using agent-based model: a case study of Beijing-Tianjin-Hebei economic region

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In most of the developing countries, increasingly intensive urban land-use is causing huge pressure on environment and nature resources under the population growth, rapid economic development and globalization trends. Simulating urban development in various conditions can help regional planners and policy makers to prevent unrestricted city expansions and ensure balanced regional development. However, relevant studies are insufficient. This research applies an agent-base model to simulate urban land-use change in Beijing-Tianjin-Hebei economic region – the largest municipal economic zone in China established by the central government to promote integrated regional development. Three agent groups are defined for the analysis, namely citizen agent, farmer agent and government agent. The model is calibrated with the land-use data of 2000, 2005 and 2010 respectively and is then used to predict the city development in the coming 20 years till 2030. To compare the impact of different policies, three scenarios are defined. The first scenario is “business as usual”, i.e., urban area grows as the current trends. The second scenario focuses on the "population ceiling", reflecting the population distribution and corresponding urban sprawls around the city areas while controlling the total number of people in the capital city of Beijing. The third scenario depicts the growth of city areas with restricted population and protected arable land simultaneously. This model gives insight into the drivers and factors of land-use change processes and can also be used in other cities to predict future urban land-use and provide references for policy making.

How to achieve optimal future land-use development: combining scenario analysis and optimization

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Combining scenario analysis and optimization has been proposed as a way to provide efficient options for sustainable land use. However, only very few studies have outlined methodological details on how to combine scenario analysis and optimization and have provided results for real-world applications. We show how scenario analysis and multi-objective optimization can be combined for modelling urban growth in a case study region in Switzerland. We focus on modelling urban growth scenarios and using an evolutionary algorithm for optimizing two objectives, which are minimizing the consumption of fertile soils and maximizing compactness of urban growth patterns. Outlining methodological details we will show how so-called non-dominated solutions produced during multi-objective optimization can be compared to scenario solutions in the objective space (loss in soil quality, compactness) as well as in the decision space (location of urban areas). Our results exemplify the advantages of combining scenario analysis and multi-objective optimization: 1. After identifying robust optimal land-use configurations using multi-objective optimization, it is possible to test which scenarios (e.g. using different policy instruments) can approximate these patterns. 2. Using predictions of future land-use as a starting point for a multi-objective optimization, it is possible to show that delayed policy action will increase the gap between non-optimal and optimal land-use development. 3. Comparing optimal land-use configurations with non-optimal scenario-based configurations can help us quantify the effect of optimally configuring a landscape in comparison to the effect of trading-off one land-use class against another (i.e. addressing land-use composition), which can be very important when designing efficient land-use policy instruments.

Modeling the future of Mediterranean land systems: understanding changes to diversity, multifunctionality and intensity in a dynamic region

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Understanding and exploring future land use change in strongly heterogeneous regions with complex land use systems and strongly diverging cultural and economic condition is a major challenge for land use science. An example of such a region is the Mediterranean. The Middle Eastern and North African part is subject to dramatic population growth and high dependency on food imports. The European part hosts high-input intensive agricultural systems significant for regional food security, which have been affected by the recent financial crisis. The region is extremely vulnerable to fluctuations in food supply and prices, with expected climate and socio-economic change possibly contributing to regional instability and conflicts. Moreover, the region is one of the global biodiversity hotspots with vast multi-functional mosaic areas. To investigate different aspects of anticipated global change, we simulate changes to Mediterranean cropland, forest, grazing, urban and agro-silvo-pastoral mosaic systems using the CLUMondo model. With the model, we can spatially allocate future changes to land systems, taking into account their management intensity and potential to fulfill our demands for different ecosystem services. A set of different scenarios is based on demands for annual and permanent crops, wood, livestock and space for urban expansion. Furthermore, we can explore consequences of intensifying traditional and extensive land systems, and improving the agricultural efficiency. Finally, we are able to study the tradeoffs of different land use processes in the region: intensification and water use, abandonment of traditional land systems and biodiversity loss, urban expansion and increased pressure on coastal areas...

Measuring and mapping threats to forests: issues and opportunities

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Spatially explicit tools for prioritizing conservation and land-use in human-dominated landscapes are becoming common in recent years. Such efforts are also efficient in minimizing management costs and to provide future possible scenarios to aid management decisions. We propose and develop a spatially explicit framework and novel tool for simulating scenarios for future forest management actions. We integrate both forest/vegetation characteristics, selected ecosystem services provided by corresponding forest/vegetation and eighteen possible threats and/or disturbances to forests that are either anthropogenic or occurring naturally, and may influence forest/vegetation characteristics and desired outcomes from the forest. Our modelling framework provides options for necessary future actions either from conservation or from production forestry perspectives, and to ensure sustainable forest management in an area. In addition to that, our threat assessment and mapping tool are useful in identifying vulnerable zone of forests to specific anthropogenic, natural or other threats, and to take precautionary actions against each identified threats. We applied our modelling framework and spatial tool for measuring and mapping threats to a Bangladesh forest, with recommended actions to ensure sustainable forest management and to spatially prioritize zones for special management needs. We finally discuss issues and opportunities that our spatially explicit framework and tool may offer.

Bayesian network modeling of land use change decisions in northern Laos

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Agricultural systems in northern Laos are undergoing a rapid transformation from subsistence-based to export-oriented production of cash crops such as rubber, banana, and sugarcane, with important consequences for livelihoods and ecosystem services. Our work aims to understand the local and distal drivers of this transformation. We focus on the socioeconomic and biophysical processes that enable the integration of the local system into a global value chain, as well as on the dynamics of land use (LU) change resulting from increasing market integration. In this research, we developed a Bayesian network (BN) of land use change drivers in two regions of northern Laos characterized by different levels of market integration and export focus. We present how participatory methods – including workshops at provincial, district and village level, focus groups, transect walks, as well as interviews with diverse stakeholders – were used to characterize factors influencing LU decisions within the last 10 years, and develop a causal map and BN of the “micro” (local or proximate) and “macro” (distal or underlying) drivers of land use change. Preliminary results show which are the most important drivers of LU change decisions in the case study regions, as well as site-specific enabling conditions that ‘connect’ the local system to the export market, and which ultimately lead to local LU change.

Mountain futures: Can sustainable agroforestry systems manage the trade-offs between food security, climate change mitigation, biodiversity conservation in the Asian Highlands?

Imperative in agroforestry for mountain future

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The world's mountains are home to twelve percent of the world's population and half the global biodiversity hotspots. They are the sources of vital waters, energy and food including forest products. They provide refuge for endangered species and cultures. They are hotspots of global environmental change, with adverse but also potential positive consequences. Mountains are areas of environmental, biological and cultural diversity; they may serve as repositories of global learning and testing grounds for adaptations to global change.

Among the many trade-offs that sustainable landuse systems in these highly diverse and heterogenous environments must address are included, notably, maintaining and improving food security for mountain communities, conserving watershed functioning and slope stability for downstream users, increasing carbon sequestration for climate change mitigation, and biodiversity conservation. Agroforestry systems seek to fulfill many of these functions through multi-functional approaches and the inclusion of multi-purpose trees in mountain farming systems. This session will evaluate several case studies from the Asian Highlands, and a recent regional analysis of trees and biomass carbon on agricultural land, to highlight these trade-offs and identify the policy relevant lessons.

Modeling Ecosystem Service Values in Xishuangbanna: Considering the relative roles of land sharing and sparing for biodiversity conservation

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In China rubber is an economically important plant, and has expanded rapidly to occupy considerable land area, including highly diverse rainforests in Xishuangbanna. It provides considerable income to villagers, who have few alternative income sources. Conversion of traditional land management systems to rubber, which supports very low levels of forest-dependent biodiversity, means the loss of ecosystem services, availability and diversity of local food sources, and changes the traditional food consumption patterns.

Identifying strategies for enhancing rubber production is crucial for uplifting local livelihoods and contributing to the nation's development, however, this need to be balanced by strategies that preserve ecosystem services and maintain sustainability. The objectives of this study were to model ecosystem functions and services focusing on water, greenhouse gases, soil fertility, and biodiversity conservation, and to explore the impact of different future scenarios on ecosystem functions and services with particular attention to landscape configuration. This research should enable us to suggest policy interventions aimed at optimizing ecosystem services and rubber income, and to develop methods for measuring the impacts of interventions on both biodiversity and rubber income.

The model will characterize land use and agricultural decisions, and capture the effects on these decisions on institutional influences such as environmental, zoning, transportation, and agricultural policies. It may be developed to discuss how human activity and its impact on the ecosystem differs under different regulatory regimes.

Agroforestry, Tree Cover and Biomass Carbon in the Asian Highlands

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Tree cover on agricultural land can make an important contribution to climate change mitigation, but is not systematically accounted for in either global carbon budgets or national carbon accounting. The regional role of agroforestry within the mountainous regions of Asia is investigated, assessing both tree cover and biomass carbon on agricultural land, documenting recent change between the years 2001-2009. Globally, results based on MODIS 250m remote sensing data show that in 2009, 43% of all agricultural land globally had at least 10% tree cover (i.e. corresponding to the FAO definition for forest), and that this increased by 2% over the previous ten years. Combining globally stratified IPCC Tier 1 default estimates of above- and below-ground biomass carbon storage with a tree cover analysis, we estimated 45.3 PgC on agricultural land globally, with trees contributing >75% of this, compared to 11.1 PgC using default Tier 1 values. Between 2001 and 2009 there was an increase of 3.7% tree cover, resulting in an increase of >2 PgC (4.6%). On average, globally, biomass carbon increased from 20.4 to 21.4 tC ha⁻¹. Regional and country-level variation in stocks and trends are been mapped and tabulated for the Asian countries, and specificallyt mountains, illustrating results of national policies and regional differentiation. Results show that tree cover and biomass carbon on agricultural land already make a substantial contribution to regional and national carbon stocks. Benefits from increasing tree cover require that biomass carbon on agricultural land should be systematically accounted for within national carbon budgets, allowing for enabling incentives to be promoted in meeting national mitigation and adaptation targets, and formulating effective national policies.

Traditional and contemporary agroforestry systems host a rich variety of ecosystem services and decrease susceptibility to climate change

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Multipurpose agroforestry systems have a large potential for climate change mitigation and adaptation due to their multi-functional role in providing income and ecosystem services while decreasing pressure on natural forests. This study analyzed the socioeconomic and biophysical similarities and differences between two agroforestry systems in Vietnam - traditional home gardens and more recently established forest gardens. In addition, we investigated how the allocation of degraded forestland and establishment of agroforestry can assist land restoration and benefit livelihoods and the environment. Building on empirical field data, we used carbon sequestration, agrobiodiversity and food security and livelihood as indicators for ecosystems services. A total of 38 home gardens were sampled and the result show a carbon storage of 34.1 Mg C ha⁻¹ in above and below ground biomass, as well as hosting 224 different usable plant species. Comparable numbers for forest gardens were 59.7 Mg C ha⁻¹ and 19 different species. Both garden types shared ecosystem services associated with agroforestry, such as erosion prevention, soil fertility improvements and microclimate regulation. While the high number of species in home gardens provide a diversification of risks related to crop failure, forest gardens species are targeted towards the market and provide an additional cash income. Combined, the two systems represent a robust land use strategy against impacts of climate change and fluctuating crop market prices and could be a viable adaptive practice for smallholders across the tropics.

Northern Eurasia in a telecoupled world: agricultural potentials and ecosystem tradeoffs

Drivers of agricultural abandonment in Europe

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Agricultural abandonment is an important process of land change worldwide as a response to policies, polarisation trends, and the displacement of agricultural production. Assessing environmental impacts of agricultural abandonment and identifying suitable potential areas for recultivation requires sound knowledge of the most important drivers leading to agricultural abandonment as well as their spatially varying influence, especially across large scales. We addressed this issue by applying a spatial boosting model that considers spatial data features to explain the patterns of agricultural abandonment across Europe (Atlantic Ocean to Ural Mountains) between 2000 and 2012 with a set of environmental and socio-economic explanatory factors. Therefore, we used a recently published map that identifies agricultural abandonment at 250m resolution by combining satellite imagery and post-classification rules. We found that agricultural abandonment was strongly influenced by climatic and edaphic conditions as well as location characteristics. Agricultural abandonment occurred in areas where soil pH and organic carbon content was low and in the vicinity of forests and permanently fallow agricultural areas. Further, higher probabilities of agricultural abandonment were related to high unemployment ratios and to unfavourable thermal conditions with cold and hot climates. Our analyses of the spatial determinants of agricultural intensity also provided insights into the non-linear target-predictor relationship with the detection of threshold values and local extrema that provides a more nuanced picture on where and how these drivers influence abandonment. Our study provides important information for policy makers to design and implement tailored and targeted measures to manage abandoned agricultural areas efficiently.

Land-use changes across former Soviet Union countries are major soil C sink in 21st century

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Land-use change is a major contributor to carbon (C) fluxes from soil to the atmosphere and significantly affects C balance in Northern Eurasia. We evaluated the impacts of multiple trajectories of land use change (crop and livestock production) after the collapse of the Soviet Union on soil organic carbon (SOC) dynamics across fifteen former Soviet Union (FSU) countries. We developed cropland and grassland masks using remote sensing products to backcast annual land use to 1990 based on cropland suitability and grassland productivity and using sub-national statistics on sown areas and livestock numbers. We used a bookkeeping approach to assess SOC dynamics based on the spatial distribution of major soil types and SOC field measurements. Our study showed that 64 Mha of cropland and 39 Mha of grassland were abandoned from 1990 to 2010 across the FSU, primarily in Russia, Kazakhstan, Ukraine, and the Baltics. Since 2000, we also observed modest abandonment and cropland expansion. In total, about 4 out of 60 Mha of abandoned cropland and 2.5 out of 39 Mha of abandoned grassland were already reforested by 2010. The region represented a C sink with sequestration on abandoned lands of 46.3-60.5 Tg C yr⁻¹ from 1990 to 2010. Abandoned croplands contributed about 80% to the total SOC gain, while abandonment of grasslands provided the remainder. The drastic institutional changes in the FSU and their effects on land use shifted the region from being a source of C emissions from soils to a globally relevant terrestrial C sink.

Patterns and Drivers of Cropland Abandonment in China: a Study Base on National Household Sampling Survey

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As the wages for migrant workers increase rapidly in China since 2003, more and more farmers uproot themselves from the farm and move to urban areas for urban jobs and higher income. Therefore, the size of agricultural labor forces of China has been shrinking quickly. The substitution of intensively use of agricultural machinery for the shrinking farm labor force is hardly possible for croplands in the mountainous regions of China where mechanization is difficult to achieve due to small field size and the rough terrain in these areas, which eventually has led to the abandonment of croplands in these regions. In this study, we try to understand the current situation of cropland abandonment in Chinese mountain areas, and to analyze what factors affect the abandonment rate at village level through a national household survey in 2015 and 2016 including more than 120 counties and 200 villages. The results show that the abandonment rate is 12.29%. And if counting in croplands which were replanted trees via Grain for Green Project, the abandonment rate reach 25.91%. Villages with high abandonment rate were mainly distributed in southwest of China. Statistical analysis indicated that natural and socioeconomic conditions of the villages, such as location, terrain condition, agricultural mechanization level, opportunity cost of farming, circulation rate of cropland were related to the cropland abandonment rate. Finally, drivers and mechanisms of Chinese cropland abandonment would be discussed.

Agricultural land dynamics in the agro-pasture ecotone of Northeast China from the early 1950s to 2015

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Aim: Under the background of global climate change, what were the causes of the changes of agricultural land in the sensitive and vulnerable agro-pasture ecotone? We try to find out based on the processes of land abandonment and land reclamation and the spatiotemporal relationship with the climate change, other natural influencing factors, institution and human activities from the early 1950s to 2015, taking the agro-pasture ecotone in Northeast China as a representative area.

Methods: Multi-seasonal Landsat MSS/TM/ETM satellite images centered 1976, 1988, 2000 and 2015 were used to obtain land use data by interactive human-computer interpretation. The land use data of the early 1950s were reconstructed based on the contemporaneous topographic maps with the scale of 1:100000 by the frame of CLUES model.

Results and conclusions: The results showed that the agro-pasture ecotone in Northeast China had experienced an increasing dramatically process of agricultural land during the recent 60 years. The 90% of loss of agricultural land was mainly transformed to built-up land during 1976-1988. And 70% was to grassland and forestland from 2000 to 2015. Desertification and salinization were important influencing factors causing land abandonment in this area. While institution and project of "Converting of farmlands back to forests or grasslands" was another crucial factor. Climate change played an indirect and double faced role in the processes of land abandonment and land reclamation. The area with more and more warmer climate was reclaimed gradually. While the region with more and more drier climate was abandoned obviously.

Designing sustainable land use transformations - from knowledge to action

Bridging and bonding social capital: tradeoffs and synergies in changing agricultural water management under Everglades restoration

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Everglades restoration presents tradeoffs in water management priorities between farmers and other stakeholders. The 1994 Everglades Forever Act created a collective action challenge for farmers by requiring them to jointly reduce phosphorus loads in their drainage water. These enriched flows can cause species invasions or disrupt Everglades trophic dynamics. Effective implementation remains largely with farmers, who must cooperate to reduce phosphorus enrichment and maintain group compliance, though they also interact with agricultural researchers and regulators for monitoring and training. Over the past 20 years, water quality has improved dramatically, while farmers have maintained compliance consistently.

Social capital is theoretically important in enabling cooperation. Conceptually, social capital consists of relationships where shared norms, trust, and expectations of reciprocity help maintain cooperation over time. Social capital can facilitate cooperation of within-group priorities (bonding) or between-group priorities (bridging), which may act synergistically or create tradeoffs. This research examines the strategies employed by farmers to implement best management practices to restore Everglades water quality. It provides an empirical contribution to whether farmers cooperate with other farmers to improve water management practices or work with regulators and agricultural researchers to achieve phosphorus reduction. However, bonding social capital may undermine bridging efforts. Thus, it also analyzes whether strategies of one type either strengthen or diminish the other. By examining bridging social capital, this research also addresses how government actors and scientists can incorporate their knowledge and priorities alongside those of land managers to achieve desired environmental outcomes.

Analyzing the possibilities of transformation towards sustainability in various contexts

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We analyze land use changes and associated water related risks and their reduction in three areas exposed to flooding and inadequate or deteriorating water quality: part of Grijalva basin in Mexico; parts of Xe Bang Fai and Mekong basins in Laos and Vantaanjoki basin in Finland. In these areas, we organized participatory workshops in which participants constructed future scenarios concerning water governance, voted for the most desirable one and sketched strategies on how to achieve the most desirable scenario. We link these possible developments to participant perceptions on land use–water nexus and drivers of change as well as to remote sensing analysis of past land use changes. Although the most desirable scenario both in Finland and Mexico was a transformative shift towards sustainable future, participants proposed few transformative risk reduction strategies to achieve the desirable scenario. Moreover, in these areas, it was acknowledged that past land use changes and other developments have drastically increased current risks. In Laos, urban and agricultural expansion have been fast in the recent past and the land use – water related risk nexus was poorly understood. The most desirable scenario was a one with continuing growth in foreign investments and land use change coupled with better safeguards. We analyze how the local context and land use history affects the potential future changes and identify barriers that inhibit transformations towards sustainability. Finally, we discuss how a shift towards a more sustainable future can potentially be achieved in the three study areas.

New approaches to modelling human-environment interactions for sustainable coastal city development

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There is increasing acknowledgment that low-lying coastal cities are the most densely populated urban settlements and are growing very rapidly, yet these coastal cities are also vulnerable to risks resulting from global climate change and intensive human activities. While there is a long tradition of modelling in geography on urban land use changes, there is an urgent need for modelling that works from the fundamental principle that it is people and their interactions with each other and with the built environment that shape our cities. Apart from modelling the physical elements and the obvious socio-economic drivers and processes, there has been little modelling of how human behaviours and the decisions of land developers and urban planners effect the urban growth process. This paper responds directly to that demand. It presents novel approaches based on human behaviour-driven complex systems theory that integrates spatial complexity, cellular automata and agent based models to simulate the human and environment interactions in coastal city development, using case studies from both developed and developing countries to empirically test and advance our knowledge of how cities grow as complex systems built out of the interactions between humans and their living environment at individual scale and in a cross-jurisdictional context. The outcome of this research will provide a spatially explicit understanding of the development of coastal cities as well as new science-based decision tools to aid and optimize policy-making.

Sustainable at what scale? Integration of social values in sustainable landscape design.

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Sustainable landscapes should be designed in ways that the landscape can provide the ecosystem services demanded by society. On the one hand, this often concerns trading off interests between different stakeholder groups and different ecosystem services. On the other hand, what is locally optimal may be far from a sustainable option if one takes a regional or global perspective. In this short presentation I will show a study in Scotland where stakeholder values have been integrated in trading off alternative options for compensation of increased built-up area. Based on the results I will discuss if such local solutions are also achieving their objectives when analyzed at larger spatial and temporal scales.

Navigating the impact of land use trends on ecosystem services in the Chittagong Hill Tracts region of Bangladesh

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Land uses and land use changes can have profound impacts on food productivity and conservation in the south-east Chittagong Hill Tracts (CHT) region of Bangladesh. This mountainous region is distinct in terms of landscape, biodiversity and ethnicity. Land uses include annual crop field (swidden agriculture and valley lands), mixed fruit garden, natural and planted forests. The diversity of land types determines different ecosystem services in the region. The study aimed to navigate the land use impacts on ecosystem service provisions with implications for livelihoods and conservation. We carried out structured interviews with individuals to identify ecosystem services to understand the relationships with land uses and livelihoods in four villages in Bandarban district of CHT region. Focus group discussions using habitat valuation exercises were also conducted to examine the relative importance of different land uses that deliver the most important ecosystem services at landscape scale. The study found that diversity of land uses provides multiple ecosystem services. But respondents perceived land use has the most effects on provisioning and regulating services as these largely affect their livelihoods. Among the land uses, forest provides the maximum types of ecosystem service benefits to local, regional and national scale. Despite the fact, there are synergies and trade-off among the ecosystem services due to land use types and changes. The study highlights understanding the trends of land uses is essential for building knowledge and supporting policy to sustain ecosystem services. Most importantly drawing ecosystem service approach may support local and regional decision-making for sustainable land uses.

Integrated function zoning in key-developing areas in the Tibet Plateau— A practice in Haidong City

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As an important ecological barrier with fragile environment, the Tibet Plateau possesses special status in China's land spatial strategy. Considering the trade-off dilemma between utilization and protection of this area, integrated function zoning appears to be more cautious. Based on a practice in Haidong City, this study summarized and discussed the encountered problems, processing experience, related theories and methods during integrated function zoning in key-developing areas in the Tibet Plateau. We conclude that spatial zoning in these prefecture-level areas, where are ecology-vulnerable, multi-ethnic and regional different obviously in geography and economy, should (1) be guided by the "pole-axis" theory, human-land relationship theory and location theory based on the inner concept of space-optimizing for "production, life and ecology", (2) and adopt 3-level division into town group, town unit and geographical parcel unit combined with schematic spot. (3) Human-computer interactive partitioning method based on the Arcgis platform, compiling multi-layer information for dominant factor identification and comprehensive analysis, may be suitable. (4) Ecology construction, protection of plateau-brand agriculture, and traffic-oriented economy should be embodied and highlighted in the integrated function zoning to effectively coordinate exploitation with protection of the vulnerable areas.

Socio-ecological trade-offs and synergies for sustainable agricultural intensification

Global, multi-scale telecoupling of smallholder land use and livelihoods: Social-ecological analyses of trade-offs, risk, and vulnerability

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We develop and apply a new social-ecological model to the global telecoupling that is presenting new opportunities and challenges to the environment-food systems of smallholders in the forms of income enhancement and changes of risk and vulnerabilities. We use this telecoupling model with reference to the human-environment interactions of smallholders interacting with global socioeconomic and environmental changes. Globally the agroecosystems and landscapes of 2.0-2.5 billion smallholders are increasingly telecoupled to urbanization and expanding peri-urban areas, human migrations, market integration, environmental governance, and food security. This telecoupling is producing novel social-ecological systems. We identify and examine diverse examples of specific environmental benefits and limitations involving the global telecoupling of smallholders that include: (i) food biodiversity-producing agroecosystems amid international migration and peri-urbanization; (ii) certification-based coffee agroforestry; (iii) organic dairy production; (iv) niche commodities; and (v) agroindustrial expansion. These examples illustrate a model of multi-scale interactions in globally telecoupled smallholder agroecosystems and landscapes. Understanding the roles of smallholder livelihood diversification and social organizations are used to generate specific insights for policymaking and environmental management supporting sustainability.

Cultural and institutional determinants of agricultural intensification: evidence from survey research on pasture to crop conversion in Brazil

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Promoting tropical agricultural intensification can help to balance economic development and forest conservation. Brazil is a setting where the potential benefits from agricultural intensification are high due to its combination of inefficient rangeland use and substantial pressures on forests. Benefits can stem from either intensification of cattle grazing or from conversion of pastures into cropland (P2C). This paper provides the first evidence on the influence of cultural and institutional factors on P2C. We use a series of behavioral experiments and survey research conducted with the more than 500 agricultural producers from the state of Mato Grosso in Brazil to construct individual-level measures of non-financial benefits from cattle grazing (a cultural factor) and transaction costs encountered in land markets (an institutional factor). We then document the correlation between these cultural and institutional indicators and the decisions to convert pastures into cropland. We also distinguish between conversion by the farmers themselves or through sales and leases to other farmers. Our results indicate that the non-financial benefit from cattle grazing – our cultural measure – reduces conversion. This effect operates through the effect of this variable on self-conversion and not through land sales or leases. These results are consistent with the idea that cultural factors that decrease the relative value of crop cultivation compared to cattle grazing reduce conversion. These cultural factors might be connected to cultural perceptions regarding additional risks and effort that exist in crop cultivation. But, we find no evidence that risk itself explains this relationship.

Ecological mechanisms underpinning adaptation process of grassland ecosystem services in Inner Mongolia, China

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Grassland degradation intensifies human-environment conflicts and adversely affects local residents' livelihoods. To reduce grassland degradation in Inner Mongolia, China, the government has enforced (since 1998) a series of grassland conservation and management policies that restrict the use of grasslands. To ease the impact on the local ecosystem and residents' livelihoods, the national and regional governments have offered a series of top-down arrangements to stimulate sustainable use of the grasslands. Simultaneously, local households spontaneously developed bottom-up countermeasures. To determine the effects of these processes, we interviewed members of 135 households using a mix of qualitative and quantitative methods. We analyzed the effects on household adaptive farming activities on local grasslands. We found that implementation of the grassland conservation policies significantly affected household livelihoods (nomadic life to sedentary grazing), which in turn affected household use of natural resources (primarily the land) and their agricultural assets (farming and grazing activities), resulting in fundamental transformation of the local grassland services. The households developed adaptation measures to reduce the influence of their use of natural resources on local ecosystems by initializing strategies such as seeking off-farm work, leasing pasture land, increasing purchases of fodder for stall-fed animals, and altering their diet and fuel consumption to compensate for their changing livelihoods. And the provision services (NPP and Biomass) and regulation services (Species diversities and Soil nutrition contents) shows the opposite trend in different degree of grasslands usage.

The Role of Landless Households in the Sustainable Agricultural Intensification of Myanmar

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Land use systems in Myanmar are traditionally built on cooperation of landholders and landless. In a survey among agricultural communities in the Central Dry Zone and the Ayeyarwaddy Delta we found that up to 50% of agricultural households were landless (without title). Traditionally, landholders provide employment to landless labourers. More recently, however, these linkages seem to be unravelling, which accelerates socio-ecological change.

Although 70% of Myanmar's workforce is in agriculture, industrial growth and international migration create new opportunities outside the agricultural sector. While development schemes encourage intensified production, infrastructure development remains at low levels. In this process, smallholders tend to diversify on-farm (varieties, crops, agricultural activities) and the landless move into non-farm labour. Mechanization of farms is increasing, albeit mostly among larger farmers. Both of these processes lead to labour scarcity in agriculture, depriving farmers the possibility of sustainable intensification.

Our data shows that only a small proportion of landless households in either region rely on agricultural labour. Instead we observe a shift towards diverse livelihood portfolios. This confirms the dilemma of Myanmar's development process: while agriculture is the economic backbone of the country and most people depend on it, agriculture is closely correlated with poverty and the source of a highly mobile labour force. In addition to a slow and complicated process of land titling, labour scarcity remains a major hindrance to sustainable intensification. This paper highlights the importance of landless households in land use development and argues for increased consideration of their role in agricultural development.

Solving land use conflicts and identifying trade-offs in land management – from theory to implementation in practice

Pareto efficiency, violent resource conflicts and human insecurity in the Nigerian savanna

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Abstract

Land and pasture in the vast Nigerian savanna are common pool resources. Poor resource governance and land management framework make exclusion impossible and resource use rivalrous. This has been hypothesized as one of the major causes of perennial violent conflicts between the crop farmers and pastoralist in the savanna. In this study, content analysis of government policy and programme documents on natural resource management and field outreaches were conducted. We interfaced with both the crop famers and pastoralists through household surveys, focus group discussion and key informant interviews across several local governments in the derived savanna. The results suggest the operation of a tragedy of the common where individual users consider only their private costs and not the costs their actions impose on other resource users. Existing resource governance regime has very little impact on ownership and use of common pool resources with no specific rules of engagement between crop farmers and pastoralists. But both the pastoralists and farmers are also worried that resource conflict has become endemic. Although, there are few conflict resolution mechanisms and collective actions often employed by both the farmers and pastoralists to settle transgressions, these have not been effective. A more formidable approach that addresses weak resource governance and negotiation that transcend the pastoral receiving zones to the originating zones with clear and definite policy pronouncement with regards to farmers-pastoralists relations will be required to proffer a lasting solution to the perennial conflicts and human insecurity.

The role of chiefs in customary land consolidation during biofuel land acquisition processes in Ghana: towards a land sale policy?

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Amidst the surge in large-scale land acquisition for biofuels in Ghana, different types of land uses needed to be consolidated to develop large parcels meaningful for large-scale agricultural investments. Along the consolidation and acquisition processes, many actors play different roles along the chain of transaction. Whereas significant research focusing on investors have often branded the processes with all sort of connotations such as land-grabbing or land-seizure, limited research has been done on the role chiefs in these processes. Through interviews with chiefs involved and focus group discussions in communities where such acquisitions took place, this research seeks to share perspective on exact roles that chiefs have played and the motivations that have guided their action. Results suggest that often chiefs go beyond their role as custodians to behave as land sellers, expropriators, negotiators, receivers of compensation, and conflict arbitrators. These roles are emerging because of the weak land administration system in Ghana of which chiefs take undue advantage to bypass both customary and statutory land laws. Chiefs were often motivated by huge economic benefits at the expense of communal interests. Understanding the role of chief as well as their motivations can have ramification regarding policy choices as to whether there is a need to reform land policies in Ghana that go beyond the mere adoption of guideline for large-scale land acquisitions as has happened in the past. For co-production and design to take place, we argue that understanding the hidden roles and motivations of key stakeholders is imperative.

Sustainability Assessment of Soil Improving Management Practices

Farmers' soil fertility management practices in the North China Plain: toward more sustainable in a decade?

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To ensure regional self-sufficiency and adequate rural livelihoods in the North China Plain – an important production base and food bowl of the country, tremendous efforts were made over the last decades by the Chinese government to raise the productivity of crops. Emphasis was placed on high external input use, especially for wheat and maize – two staple food grains, ignoring the particularities and limitations of the natural resource base such as soil, land and groundwater. This study assesses the sustainability of soil fertility management practices over the past decade from 2001 to 2013 on the basis of selected location-specific indicators, and identifies determining factors of the yield and environmental impacts of inputs use. Data used for the analysis were gathered from household surveys which were conducted in 2001 and 2013 respectively by returning-visits of the same households, soil and groundwater tests, and statistical yearbooks, to compare the sustainability of soil management practices after a decade of time. The findings will be useful for the soil management and regional sustainable agricultural development.

Assessment of ecosystem service trade-offs with integrated land use models at landscape levels

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A major purpose of agricultural and forestry land use is the utilization of provisioning services by ecosystems, which usually compete with other ecosystem services valued by society. We present an integrated land use model (ILM) to analyze ecosystem service trade-offs at landscape level for a case study region in Austria. The ILM combines a bio-physical process model with a bottom-up bio-economic land use model. It is applied on scenarios to quantify impacts from climate change and land use policies, i.e. the EU Common Agricultural Policy (CAP), on selected ecosystem services. The latter are represented by direct or surrogate indicators including biomass production, soil sediment load, soil organic carbon, and cultural landscape quality. Climate change adaptation and mitigation are considered to account for farm level land use responses on external triggers. Results show typical patterns along a land use intensity gradient. Favorable climate conditions in a liberal policy environment trigger land use intensification with increasing harvestable biomass output at the cost of soil ecosystem services. In an adaptation policy scenario, conversion of permanent grassland to cropland – if considered possible within the CAP scenario settings – increases biomass output and crop value. However, it leads to losses of soil organic carbon, increases in soil sediment loads and decreasing visual landscape quality. Such results can support the public discourse on preferable land use development.

Soil Moisture Analysis Using Multispectral Data In Central Part of Mongolia

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The objective of this research is to develop model for estimation Soil moisture in Bornuur soum, Tuv province using multispectral satellite data. The study area located (N48⁰14-48⁰43', E105⁰58'-106⁰33') in central part of Mongolia. The soil moisture index derived from Visible Blue and short wave infrared Landsat +ETM7, Land surface temperature (LST), Normalized difference vegetation index (NDVI), slope, DEM were used for regression analysis. Landsat satellite data for 18 September, 2011 and Digital elevation model (DEM) from ASTER-GRTM 30m resolution data were used. We collected ground truth data for soil moisture measurements from different type of soils which are Kastanozemshaplichumic and Gleysolshistic soils. The resulting prediction model for soil moisture was compared to ground truth soil moisture data. The relationship between ground truth soil moisture data and prediction data was 94% in Kastanozemshaplichumic soil while 97% for Gleysolshistic soils. The model can be applied for the other areas which have similar soil types.

Sustainability impact assessment of soil management practices: state of the art and methodological avenues

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The importance of soil system functions and services receives an amplified attention within societal development strategies (UN sustainability goals, European BioEconomy strategies). Likewise, the effects of soil management on soil systems and the corresponding environmental and socio-economic impacts on societal goals require augmented scientific evidence and standards for its assessment. Sustainability impact assessment is a method that identifies effects of human activities on ecosystem functions and services, and their consequences for societal goals such as sustainable development. A large variety of established tools and methods for environmental and social impact assessment are available to do such an assessment (e.g., multi-criteria valuation, cost assessment, life-cycle assessment, and risk assessment). Two questions arise that will be answered: which sustainability impact assessment tools and methods exist particularly for soil management practices, and are established tools and methods one-to-one applicable to sustainability impact assessment of soil management practices? The presentation a) provides an overview of assessment tools and methods applied in impact assessment for soil management including an analysis of strengths and gaps, b) develops a conceptual framework to strategically guide up-coming sustainability assessments of soil management practices, and c) illustrates the conceptual frame with best-practice examples of sustainability assessment of soil management practices.

Impacts of herders sedentarization on land use system in pastoral area— Laqu watershed in North Tibetan Plateau as a example

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Nomad is a traditional production and lifestyle pattern which is suitable for pastoral area, where the relationship between human and environment has harmonized for thousands of years. Since the past several centuries, the prevailing process of transferring from nomad to sedentarization has changed the interaction between human and land system, which may affect ecosystem. Study on the impacts of sedentarization on land use system and grassland ecosystem is helpful to understand ecosystem degradation. Integrating the data of land use, remote sensing image with the GPS tracks, plot survey, and interview to stakeholders in GIS, we studied the impacts of herders sedentarization on land use system in Laqu basin in the North Tibetan Plateau. The conclusions lie in: 1) spatial heterogeneity of the area around settlements increased, and the land use cover tended to diversity after sedentarization. There was a concentric circles structure around the pastoral settlements in the study area, with various functional area such as residential area, pasture area and ecological conservation area distributing from the core to periphery. Land use intensity was improving in generally for the proportion of constructive area and artificial pasture increased markedly. 2) impacts of sedentarization on soil nutrients and ecosystem primary production was characterized by the two opposing procession coexisting in different function areas. One is over-grazing and grassland degraded near to settlements, especially in the residential area and artificial pasture area; the other is less-grazing in grassland idled far away from the settlements. These ecological effects derived from sedentarization should be monitored and coped with effectively in future to harmonize the land and human in pastoral area.

Soil salinity changes after reclamation at the coastal area, mid-eastern China

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Soil salinity is a threat for cultivation in many saline wetlands of the world. Soil salinity in the irrigated arid land and natural coastal wetlands has been concerned. However, in the current studies, little is known about its changes of the coastal wetlands following human reclamation in the mid-latitude region. Our objective was to identify change trends of soil salinity in the mid-latitude coastal wetlands where human agricultural reclamation has maintained over 60 years. We used the “space for time substitution” method to test the effect of reclamation time on soil salinity. Comparing the saline soil in un-reclaimed area and the 1951 reclaimed zone, The E_c decreased from 28.06 to 0.73 ds/m; ESP reduced from 80.07 to 10.32 and pH decreased from 8.7 to 8.4. In the first 30 years, the profile types of E_c of saline soil changed from the “surface accumulation (SA)” type to the “even distribution (ED)” type and the profiles types of ESP of sodic soil were always the “ED” type. After 30 years, the profile type of E_c and ESP both changed into the “BA” type. The evolution threshold of coastal wetland from saline soil to non-saline soil was 30 years in the past 60 years. The soil salinity of coastal wetlands in the mid-latitude region, China could be completely de-salinized but still faced the threat of sodicity following reclamation.

Ecosystem services trade-off under scenarios of paddy land to dry land and in Erhai Lake Basin, China

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As human continue to improve control of natural ecosystems, to meet their needs, the intervention of human on the ecosystem is significantly enhanced. To regulate ecosystem services and maximize the benefits, the case of changing the spatial pattern of land type is increasing, and "Paddy land-to-Dry land" is one of the typical. In this paper, Erhai Lake basin as study area, the feasibility of the implementation of Paddy land-to-Dry land was discussed from the present situation of water resources and the effect of the program. Then, this paper set five kinds of scenarios considering different characteristics of paddy, such as average labor, average pollution, farmers' enthusiasm, average yield, and the distance from Erhai Lake. After that, four ecosystem services——water purification, water supply, soil conservation and food supply, were calculated in InVEST models. Finally, tradeoff was carried out between the ecosystem services under five scenarios. The result showed that "Paddy land-to-Dry land" could significantly improve the quality and quantity of water, although it had certain negative impacts on soil erosion and food supply. Under different scenarios, the difference between water supply and food supply was not obvious, but water purification and soil conservation had relatively large difference. And water supply had positive correlation with water purification and soil conservation. What's more, comparing the comprehensive benefit of five scenarios, the scenarios that change the paddy where the farmers were positive to the program worked best.

Sustainable Agricultural Intensification and Food Security in Developing Countries

Understanding the spatial and temporal changes of Chinese cropping structures from 1980-2010

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Demand for agricultural products has been increasing at unprecedented pace in China due to population growth and more importantly the rapid change in the structure of diet. Food security is still the paramount challenge for Chinese agriculture despite the fact that the agricultural production has increased manifold since the reforms that started in 1978, particularly through shifting to higher-yielding crops, increasing livestock production, and greatly increasing production intensity in the country's main agricultural areas. During this 30-year period, harvested area of maize increased from 20 million ha (Mha) to 36 Mha (80%), while that of rice and wheat decreased by 5 Mha roughly (13% and 17%, respectively). The crop lands changes—area and crops structure change--has great implications to the food security. We use land-use data derived from remote sensing images together with environmental and socioeconomic data at county level to examine spatial patterns and temporal changes of the main crops (wheat, rice, and maize) from 1980 to 2010; we further quantify the determinants for such changes using spatially explicit panel regressions. The results demonstrate how cropping structures increasingly concentrated on cultivation of higher value crops in areas with high biophysical suitability, but threatened by urbanization. Meanwhile, agricultural conversion to grassland and forests stimulated by conservation policies, ironically accompanied by agricultural land expansion in ecological fragile areas, prevail in areas distant from markets and on marginal lands. In sum, changes in land-use patterns resulted in substantially higher value added in agriculture as well as the homogenization of land-use structure.

The El Niño Southern Oscillation, crop production variability, and implications for sustainable intensification

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Global food security requires both an adequate supply of food and that the supply be stable from year to year. When considering regions for sustainable intensification of cropland, it's therefore important to consider both potential yield and the risks posed by climate-induced temperature and precipitation variability. The currently decaying El Niño, for example, has forced widespread drought and food insecurity.

In this analysis we characterize the multi-year evolution of ENSO-induced yield anomalies and demonstrate that current trends in crop intensification may be leading to increased production volatility. We first show that ENSO forces same-sign crop yield anomalies across countries in North and South America despite the differences in cropping seasons. For example, total Pan-American maize production increases on average by 5% during El Niño years, but is reduced by as much or more during the following La Niña years. We next illustrate that ENSO-induced production volatility is important not only for early warning systems, but should also be considered in an analysis of cropping intensification. For example, the recent increase in Brazilian maize production during the safrinha growing season has likely increased the vulnerability of maize to the negative impacts of La Niña.

By intensifying crop production in ENSO-affected regions, we can expect not only an increase in yields, but also an increase in production volatility. For this reason the sustainable intensification framework needs to move beyond the concept of attainable yields to consider also how it may be possible to reduce year-to-year production volatility.

Temporal and Spatial Variations of Health Costs Caused by Chemical Fertilizer Utilization in China from 1990 to 2012

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The health impacts caused by chemical fertilizer utilization have challenged the long-term sustainable development in many countries, particularly developing countries. Based on the method of emergy analysis, we estimate the temporal and spatial variations of the health costs, through atmospheric, water and soil pathways, of chemical fertilizer utilization in China during the period 1990-2012. The costs showed an obvious increasing trend from 1.8 billion Yuan in 1990 to 23.0 billion Yuan in 2012, while the ratio to agriculture output value declined slowly and become stable in recent years. Regional differences were remarkable, which were closely linked to the levels of economic development ($r=0.843$ and $p<0.001$) and sown area in the region ($r=0.588$ and $p<0.001$). Economic developed regions, especially the eastern coastal provinces, had much higher costs than the western regions. Meanwhile, fertilizer consumption shifted spatially from eastern toward the northwest region, same as the health costs. This study provides an advisable method to estimate the health costs comparable between regions and a reference for China's sustainable development.

Map and monitor African urban area: An application of machine learning algorithm to DMSP/OLS nighttime light

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Accurate delineation of the urban/rural area has broader implications to science and policy making. The DMSP/OLS nighttime light have been applied to monitor and analyze human activities and biophysical environment with a top application of urban mapping. With most at city or country level, the research at continental scale is growing. GRUMP (Global Rural and Urban Mapping Project) initiates the efforts to map urban area of 1995 using nightlight at large scale. As urban area continuously growing, updates are needed to understand and monitor the urbanization. The threshold techniques and classification approach are the two categories to quantify urban extent with challenging of defining threshold over heterogeneous surface or applying classification to imbalanced dataset. This paper proposes an approach to apply anomaly detection machine learning algorithm which is designed to data with skewed distribution. Through statistical learning from the urban nightlights pixels in 1995, the model is applied to average nightlights value of 2010-2013 with probability of being anomaly/urban pixels calculated and ranked. To overcome the spatial heterogeneity, the model is running country by country. Pixels with higher probability will be classified as urban with a total urban population calculated with WorldPop. The country total will be summarized and compared with numbers from World Development Indicators from the World Bank. The procedure iterates with incrementally decreasing the threshold of the probability until the optimal is identified for the country. Urban area shows dramatically increases since 1995 with a largely differentiated expansion rate from stable to over 50%.

Can credit programs speed up the adoption of low-carbon agricultural systems in Mato Grosso, Brazil? Results from a bio-economic microsimulation

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In 2010, Brazil established its “ABC Credit Program” in order to finance investments in sustainable agricultural intensification. The program aims to promote the diffusion of low-carbon agricultural practices, including integrated crop-livestock-forest systems (IS) and commercial forest plantations (F). We present a simulation-based empirical assessment of the adoption of these practices in the state of Mato Grosso, Brazil, under different credit conditions. We use the agent-based simulation package MPMAS to capture farm-level heterogeneity and explicitly model farm-level costs and benefits associated with the adoption of low-carbon systems relative to those of double cropping. The model simulates land use change, low-carbon adoption rates and overall costs of credit provision. We find that IS and F have the potential to diffuse, though the impacts and cost-effectiveness of credit vary significantly across the regions due to different opportunity costs of the land. By doubling farmer credit limit, the likelihood of IS adoption would be 7% higher and the costs for the Government would increase by 13%. Increased interest rates lead to low costs for the Government but have a small impact on IS and F adoption. Interestingly, decreased own capital requirements would not contribute to low-carbon agricultural diffusion, as farmers would invest in more profitable activities. Besides economic incentives, the adoption of low-carbon agriculture can be promoted by improving access to markets and information.

The expansion of large-scale agribusiness and its effects on land-system properties in global agricultural frontiers

The role of agricultural scale in cropland changes across South America

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The extent to which agriculture has impacted natural ecosystems worldwide has become clearer in part to advancements in earth observations. However, the drivers, actors, and scale of agricultural production behind this expansion are less apparent. Further, agricultural systems have transformed in some places in spite of lower expansion rates than the past few decades. This agricultural transition is not captured with current datasets that focus only on expansion. Our research asks: what are the patterns of the scale of agricultural production in South America, and which crops are linked to specific scales? In order to examine both extensive and intensive cropland changes, we analyzed links between the scale of agricultural landscapes, agricultural expansion, production, and crop type over a twenty-five year period (1990 to 2015) across South America. A novel method was used to extract individual cropland fields (≥ 0.5 ha) from Landsat imagery across the continent for 5 different time periods over twenty-five years. We then used the extracted field parcels as the proxy measure for agricultural scale, offering a complimentary indicator to farm size, but with a consistent and unbiased approach transcending national borders. To assess the links between scale and crop type, we used national surveys and censuses to compare changes in field size with crop area and production. The results illustrate that the scale of agriculture increased across much of the continent, and overlapping production of specific crops indicates key ties to large-scale farming.

The expansion of large-scale farming in the neotropical dry forests and implications for policies to reduce deforestation

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In this work, using the case of neotropical dry forests, we provide a conceptual analysis of the implication of the rise of large-scale, multi-location agricultural companies as agents of deforestation. Large-scale farms are a common manifestation of a particular type of agribusiness companies. We argue that companies operating large farms gain mobility through the acquisition of know-how, technology, funding access, and markets. Such attributes can be conceptualized as transferable assets that enable a form of “corporate telecoupling”, in which agricultural companies use them to establish production in new places, thereby linking multiple locations within their own structures. While smallholders are constrained in their movements by a lack of access to land, labor and capital, for these companies, the location of production becomes an adjustable variable that is manipulated to optimize business opportunities, by taking advantage of asymmetries in factors such as taxes, land prices, infrastructure and environmental regulations. Companies operating large-scale farms, because of their high mobility and ability to change the location in a relatively easy way, are particularly insensitive to regulations centered on the territory (e.g. REDD+ or conservation corridors and protected areas). We argue that this type of companies are the main agents of leakage and displacement of deforestation, making it necessary to create policies centered in the flows connecting the companies, rather than in territory. We finally suggest priority research topics to better assess the impact of this type of companies in neotropical dry forest in particular and in commodities frontiers in general.

Reconciling agriculture, carbon, and biodiversity in a savanna transformation frontier

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Rapidly rising populations and likely increases in incomes in sub-Saharan Africa make tens of millions of hectares of cropland expansion nearly inevitable, even with large increases in crop yields. Much of that expansion is likely to occur in higher rainfall savannas, with substantial costs to biodiversity and carbon storage. Zambia presents an acute example of this challenge, with an expected tripling of population by 2050, good potential to expand maize and soybean production, and large areas of relatively undisturbed miombo woodland and associated habitat types of high biodiversity value. Here we present a new model designed to explore the potential for targeting agricultural expansion in ways that achieve quantitatively optimal trade-offs between competing economic and environmental objectives: total converted land area (the reciprocal of potential yield); carbon loss, biodiversity loss, and transportation costs. To allow different interests to find potential compromises, users can apply varying weights to examine the effects of their subjective preferences on the spatial allocation of new croplands and its costs. We find that small compromises from the objective to convert the highest yielding areas permit large savings in transportation costs, and the carbon and biodiversity impacts resulting from savanna conversion. For example, transferring just 30% of weight from a yield maximizing objective equally between carbon and biodiversity protection objectives would increase total cropland area by just 2.7%, but result in avoided costs of 27%-47% for carbon, biodiversity, and transportation. Compromise solutions tend to focus agricultural expansion along existing transportation corridors and in already disturbed areas.

Quantifying the impacts of industrial plantation expansion and landcover change in South East Asian peatswamp forest

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Between 1990 and 2012 the area of land cultivated for oil palm in Asia increased from 2.6 million hectares to 10.8million ha, with the vast majority of this expansion occurring in Malaysia and Indonesia. Considering the importance of SE Asia to global biodiversity and the reduced biodiversity of oil palm plantations, the conversion of forest to oil palm, represents a serious threat. Payments for ecosystem services, including REDD+, have been suggested as a tool for funding the conservation of standing forest in the region, however there is no consensus on opportunity costs of such action, hence considerable debate surrounds their cost effectiveness. Recent work however, has suggested there could be synergies between forest conservation and palm oil production with a greater understanding of the spatial heterogeneity of opportunity costs.

We use fine-grain economic, and spatial data from a logging operation and planned conversion of secondary forest to oil palm plantation to model how costs and benefits of conversion vary in space. We then compare the spatial variation of these costs to existing data on biological diversity to explore how the trade-offs between costs and biodiversity vary spatially across several taxa (freshwater fish, birds, amphibians, beetles and mammals). Considering conversion and management costs spatially allows identification of areas with high biodiversity and high conversion costs/low yields, where market based mechanism may be able to fund conservation. Our results can lead to more informed land use planning decisions and ameliorate the impact of oil palm expansion on biodiversity in SE Asia.

Sustainable livelihoods in the global land rush? Archetypes of livelihood vulnerability and sustainability potentials

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Large-scale land acquisitions (LSLAs) have become a major concern for land use sustainability at a global scale. A considerable body of case studies has shown that the livelihood outcomes of LSLAs vary, but the understanding of factors and processes that generate these livelihood outcomes remains controversial and fragmented in terms of cases, contexts, and normative orientations. Therefore, this study presents a meta-analysis of case studies and applies the archetypes approach developed in global change research to analyse the configurations of factors and processes that generate different livelihood outcomes in LSLA situations. The analysis is based on 44 systematically selected studies covering 66 cases in 21 countries in Africa, Latin America, Southeast Asia, and Eastern Europe. The results show that LSLAs affect rural livelihoods through a small set of archetypical configurations. Adverse livelihood outcomes arise most frequently from processes of (1) enclosure of livelihood assets, (2) elite capture, (3) selective marginalisation of people already living in difficult conditions, and (4) polarisation of development discourses, and less frequently from (5) competitive exclusion, (6) agribusiness failure, and (7) transient jobs. The processes are activated in specific configurations of social-ecological factors. Moving beyond diagnosis, the paper identifies archetypical potentials for safeguarding or enhancing sustainable livelihoods in LSLA target regions at multiple levels of decision-making. Finally, we analyse how contextual factors modify these general insights. This paper helps to advance the archetypes methodology for use in global change research that aims at integral analysis of recurrent patterns expressed in local manifestations. The results can be used to better link local case studies with regional and global inventories of the global land rush.

To Scale Up Biofuels? A Critical Look at Expectations, Performance and Governance

To scale up biofuels? Distilling implications of under-performance for process and governance

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This paper distills findings and policy implications from a special issue to be published in Energy Policy entitled, “To Scale Up Biofuels? A Critical Look at Expectations, Performance and Governance.” The special issue consists of a series of review papers querying key assumptions commonly attached to biofuels (carbon neutrality, anticipated social benefits, governability) through a review of the evidence, three papers of which are presented in this session. This synthesis paper takes the findings from these papers as its starting point and asks, “What next?” This is no easy task. Lessons from contributing papers highlight some of the pitfalls that accompany standardized policy proscriptions – namely, that context matters deeply in shaping outcomes, undermining the potential for standardized solutions; that social and natural systems are complex, rendering interventions indeterminate in their effects; and that deriving proscriptions for future action based on evidence of past performance requires leaps of evidence and faith, thus involving moral hazards. We therefore treat our recommendations not as “answers” but as “best bet” approaches which must themselves be tested and refined through an adaptive and evidence-based approach to innovation. The paper begins by summarizing the evidence derived from each of the contributing papers of the session/special issue, and the lessons they suggest. Drawing on these lessons, we posit a set of steps and methodological approaches which in our view represent a more ethical approach to the exploration, planning and implementation of national biofuel programs.

Unbundling the biofuel promise: Querying the ability of biofuels to deliver on expectations beyond climate change mitigation

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While much of the excitement around biofuels initially focused on finding a clean alternative to fossil fuels, many other expectations have also been attached to the “biofuel boom.” Biofuels have not only been expected to mitigate climate change, but also to foster energy security for producer nations; drive rural development; enhance food security; and rehabilitate degraded lands. The pathways through which biofuels have been expected to achieve these goals are equally diverse. This paper reviews evidence on the extent to which these expectations have been met, and where possible, identifies conditions that have either advanced or undermined these aims. The paper begins with a review of expectations of biofuels that have been “bundled” with the promise of cleaner energy by consumer and producer countries, as well as multilateral and civil society organizations active in the biofuel debate. We then review evidence for and against each outcome by using identified expectations as the basis for literature searches. Findings suggest that many of the expectations attached to biofuels have proven elusive, with most positive outcomes having been achieved under a very specific – and often rare – set of circumstances.

How biofuel policies backfire: Misguided goals, inefficient mechanisms, and political-ecological blind spots

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Biofuel/agrofuel production rests largely on strong state interventions in research and development, agro-ecological zoning and (de-)regulations, subsidies for production and processing, the creation of markets through government procurement, fuel-blending mandates, price controls, as well as foreign trade tariffs and quotas. In this article, we use an approach grounded in agrarian political economy and ecology to critically analyze the literature on how agrofuel policies interact with broader production, trade, and agro-ecological processes. We focus on policies involving the most prominent crops in the places where agrofuel production has advanced the most (i.e. USA, Brazil, and the EU), but also extend the analysis to less prominent inputs and the effects of these policies on broader transformations in production relations, markets, and even governance practices around the world. We investigate the political and economic interests driving agrofuel policies, and how these set the terms in which state interventions and policies are conceived and implemented. We then outline multiple blind spots and limitations that render these mechanisms ineffective or even outright counterproductive. Ultimately, we argue that industrial agrofuel policies are driven by corporate and state interests for capital accumulation, rather than for environmental or inclusive pro-poor development purposes and therefore must be critically reexamined so that more effective policies and practices can be conceived and implemented.

Avoiding bioenergy double counting

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Under what conditions can expanding modern bioenergy production in developing countries reduce greenhouse emissions? Bioenergy directly generates greenhouse gases from combustion, but can reduce emissions if these emissions are offset by generating additional plant growth beyond the growth that would otherwise occur, or through use of wastes. Notwithstanding the interest in “marginal lands,” there is little actual evidence of unused, marginal lands that are not already growing plants and absorbing carbon for human use or carbon storage. Given large projected growth in food demand, the opportunity for truly surplus, highly underutilized lands is particularly small. In such contexts, the best opportunities for lowering greenhouse gas emissions through bioenergy involve improving the efficiency of plant growth and increasing the efficiencies of energy conversion to replace traditional, and inefficient use of firewood or charcoal.

Trade-offs and synergies of land-change trajectories in southeast Asia

Practical use of Clumondo for optimum land use option in Lao PDR- A case study of Savannakhet Province

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Rice is staple food for people in the Lao PDR where sticky rice account for more than 75%. The Savanakhet Province is the biggest rice bow in the Lao PDR. The growing area account more than 20% or 190,000 ha of the total rice growing area in the country. This area characterized as the dry with sandy soil and dipterocarpus forest. The rice production is low (1.6 - 1.8 ton per hectare) and having lots of issue of water management. The Government of Lao PDR's (GOL) Policy aims for intensive agriculture area with the secure irrigation water is focusing on the rice and the other area is for other crops. At the same time the GOL also would like to increase the forestland from 40 to 70% cover by 2020. However, the land resource is not change. Furthermore, there was very limited spatial information in the country. Land use/land cover analysis in combination with the field data help to input to Clumondo in Savannakhet Province will serve as a showcase to help the policy maker to be able to normalize the land use by giving alternative options for sustainable land management. This can sustain the food security of the country. Savannakhet Province is the biggest rice bowl of Laos – as food supply side. At the same time, the GOL is also giving land for concession on sugarcane, wood plantation, cassava and so on - as economic development side. Both of information were related to the Clumondo results to see the possible alternative development options as follows: the land for the agriculture to be maintained at 10% and forest cover at 65% for the environment sustainable development.

Projecting land system changes in the Greater Mekong Subregion

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Although land change is a global phenomenon, its manifestations differ from one location to the other. We present a land systems characterization and a land system change projection for the Greater Mekong Subregion. The land systems classification is tailored to this region by including specific agricultural systems and mixed systems, including swidden, permanent agriculture, and large scale land acquisitions. The land systems projections are simulated based on different drivers for land products, including urban areas and food production. Moreover, the different land systems allow changes in land use intensity as well as area, depending on the origin of the demand (local communities or international markets), land availability, and land use management. Simulations will be analyzed in terms of forest cover changes as well as food security.

Modelling of agricultural expansion in Myanmar

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Asia is facing accelerated deforestation especially with an increasing demand for timber and more agricultural land. With rich biodiversity, strong endemism, but poor protection, forest ecosystems in Myanmar are at high risks of irreversible degradation. Traditional conservation plans tend to be static and give insufficient attention to spatial and temporal changes of threats, which may lead to reduced cost-effectiveness. Thus, with limited budgets and time, areas with the highest risk in the future should be identified and prioritized with more resources. This study aims to facilitate forest conservation in Myanmar by analyzing the spatial patterns of land use and predicting areas with the highest risk of deforestation due to agricultural expansion of 13 major crops. Logistic regression and the von Thünen models were used to model conversion of forests to agricultural land for each crop. This land use change was related with agriculture value, transportation cost, elevation, socio-political stability, and protected area status. Probability of forest occurring was predicted under four scenarios: increasing transportation costs, increasing agricultural value, increasing socio-political stability, and a worst case scenario combining the latter two. In addition, deforestation threats to Key Biodiversity Areas were also predicted under the worst case scenario. It was found that spatial patterns of land use in Myanmar may change drastically in the future. Key Biodiversity Areas were predicted to be seriously affected by deforestation, especially freshwater habitats would face the greatest threat. Thus, more measures should be taken to protect these habitats and ensure the integrity of current protected areas.

Assessing livelihoods impact pathways of REDD+ mechanisms in Southeast Asia: ex-ante analysis through participatory simulations.

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Besides mitigating climate change, REDD+ is expected to facilitate the adaptation of forest-dependent populations to climate change. Direct payments to forestland owners for carbon sequestration/stock enhancement or more indirect contributions such as funding of rural development initiatives are supposed to improve or, at least, avoid deterioration of local livelihoods. Concerns have been raised, however, regarding the extent to which REDD+ projects will benefit local populations, especially in terms of ensuring the food security of Southeast Asian shifting cultivators engaged in a process of rapid land use intensification. We assessed the benefits derived from REDD+ by local land users by estimating its potential contribution to their livelihood portfolios. Participatory simulations were used to assess the potential impacts of REDD+ on the land uses and income levels of different household types. Historical land use changes were elicited through participatory mapping with local communities. Research sites in Laos, Vietnam, China and Indonesia were analyzed as successive stages in a broad regional trajectory of land use intensification, starting with extensive, subsistence-based shifting cultivation systems and evolving towards more intensive, market-oriented land use systems. From there, several land change scenarios – including REDD+ scenarios – were defined and explored collectively. Trade-offs between forest conservation and economic growth were investigated, and potential livelihood impacts were examined. This study showed that current land use transitions are probably not compatible with REDD+, so it may be hard for REDD+ to actually contribute to improving livelihoods at all compared to a business as usual scenario.

Drivers, pathways and impacts of agricultural land-use and tree cover change in Myanmar

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This work combines a systematic literature review with insights from grey literature and expert interviews, to synthesize current knowledge and provide an overview of methodological approaches employed towards assessing drivers, pathways and impacts of agricultural land-use and tree-cover change in Myanmar to date. Preliminary results suggest that recent land change research in the Union primarily focused on the drivers and extent of forest and mangrove loss and degradation; agribusiness investments and the introduction and land-use implications of new tenure and investment policies in the agricultural sector; an expansion of inland aquaculture and land changes in relation to protected area management. Knowledge about the causal chain of smallholder land-use decision making and associated land changes in the context of Myanmar's current transition remains scarce. Land-use trajectories as well as social and environmental impacts of tree-cover changes in traditional agricultural landscapes, including agroforestry systems and upland shifting cultivation areas likewise remain under researched. Methodologically, much work relied on remote sensing, GIS analysis, surveys and policy analysis; leaving room for interdisciplinary work that strives to integrate empirical field studies with regional scale assessments to evaluate opportunities and trade-offs associated with transitions from current land-use systems to e.g. forests managed at various levels of intensity, plantations, intensified annual cropping or agroforestry systems. Such insights are a pre-requisite for informed decision making by local communities, policy-makers and other stakeholders about desirable development trajectories for the Union's forest and farming landscapes.

Ethnic perspective on land use for coffee production in southern part of Lao PDR

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After the introduction of new market mechanism and improvement of productivity of cash crop, land used for a non-traditional agricultural export (NTAE) product has been changed. Taking land use for coffee production, as a case, the purpose of this study is to 1) investigate pattern of land use for coffee cultivation among different ethnic group in southern part of Laos, 2) examine consequences on land use for coffee production (reasons to local livelihood improvement and the impact on the household living conditions). Mix approaches were used for data collection and analysis. Qualitative method was applied for data collection including village data, interview, focus group discussion (FGD) and in-depth interview (IDI) in 4 villages in Champasak and Salavan provinces Lao PDR during 2014-2015. A survey of 500 households was carried out during October-November 2015. Data analysis for this paper included thematic analysis, narrative method, and statistical analysis. Findings show, patterns of land use in a non-traditional agricultural export (NTAE) product, case of coffee production in southern part of Laos is varied based on different ethnic groups, geographical location, climatic condition and personal characteristics of respondent. Decision for land use changing for new coffee plant is however justified by economic incentive rather than social and ecological conditions. Different pattern of land use contributes to various forms of livelihood improvement for different ethnic groups. Some recommendations are to secure land tenure for better accessibility to investment capital, contract coffee price, and improvement of productivity for sustainable use of long term production.

Young Scientist Forum on Mapping Land Use and Land Cover Change using Remote Sensing Techniques

Remote Sensing for Land-System Education – An Example with Interactive Teaching Units based on Earth Observation Data from Satellites and the ISS

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Images showing our Earth from a bird's-eye view fascinate people of every age. While methods and techniques of remote sensing and digital image processing are intensively used in our society, a profound background knowledge is not widespread. Accordingly, the application of remote sensing products in everyday school lessons is rare and narrowed to a visual supplement. Hence, the talk presents an approach dealing with the multi-media preparation of Earth Observation data related to land-use change phenomena such as land degradation monitoring, mapping of urbanization, or the quantification of vegetation. It will be explained how remote sensing can be integrated in a digital environment and harmonized with the school curricular in order to foster geospatial and methodological competences. Examples of easy-to-use image processing tools of land-use change detection and land-use classification will be given. Furthermore, we introduce interactive teaching units dealing with the "Our Forest as a Climate Saver!?", "Cities of the World", "Oases – Explored from Near and Far" and "Traces of Fire - Rapid Forest Cover Change in Greece". The presentation provides insights in how teachers can be taught to apply the learning tools in their everyday school lessons. Finally, it will be concluded how remote sensing data can be edited in order to perceive them in virtual reality. The tangible dimensions of pens & papers are virtually lifted into the fascinating environment of space and improve everyday teaching reality.

Assessing in-season crop pattern from multi-temporal GF-1/WFV with selected machine learning algorithms

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Crop pattern is a fundamental description of agri-land cover/use and is related to a number of ecological factors and the regulation of agricultural management. With the recent launch of new satellites and the development of image analysis approaches, we are entering a new era of high spatial-temporal resolution earth observation system. While most crop pattern mapping were focused on cultural landscape, less attention has been paid to exploring the updating and the complete crop growing stage. In this work we assessed different machine learning algorithm combined with object-based imagery analysis to explore the potential and valuable application of GF-1/WFV spectral-textural features and multi-season classification strategy. In our experimental analysis, in-season classification strategy is optimized in way of importing multi-temporal spectral and textural properties in the form of month by month so that the number of crop types is gradually increase and the overall accuracy is over 90% in four temporal combination. Variable importance derived from near-infrared was greater than that of other variables in crop growing stage. An accuracy assessment was performed and it is found that both SVM and RF algorithms produced similar classification accuracies. However, SVM based model achieved higher classification accuracies than those produced by RF when the volume of feature space is small. But RF performed better than classifications produced using SVM in high dimensional feature space. Experimental results for a test area in Beian Country assess the effectiveness of the proposed approach and demonstrate that a multi-season analysis of GF-1/WFV data can provide spatially detailed and thematically accurate geo-information on crop types and distribution by machine learning.

The spatial-temporal pattern and intensity change of China's cropland utilization from 2000 to 2010

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As a big country with large population and advanced agricultural, the spatial-temporal pattern change of China's cropland utilization was widely paid attention. In this study, the GlobeLand30 was used to analyze the change characteristics of China's cropland utilization from 2000 to 2010. The change of cropland quantity, classes transfer and cropland utilization intensity were included in the analysis. Results show that (1) during the 10 years, the cropland area of China decreased 0.53%; 2/3 of the provinces and 3/4 of the main grain producing areas presented reducing conditions in cropland area; generally, the change characteristics of China's cropland area was "increased in the west and decreased in the east". (2) Influenced by the national policies primarily, there were 5% of the cropland transferred to other classes, the artificial surface had the highest percentage; and there were also 5% of the cropland transferred from other classes, the forest and grassland had the highest percentage. (3) The cultivation index of China's cropland decreased slightly in ten years; North-east China Plain, North China Plain and Yangtze Plain had higher cultivation index than other regions, the cropland utilization intensity of them were higher than others. (4) The multiple cropping index of China was "high in the south and low in the north" and increased in ten years, the growth rate in North-east and North-west region were higher than south region. The intensive level of eastern region decreased, and the intensive level of the central and western regions increased.

The lake Telmen (Mongolia) changes and their relations with socio-economical variables

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Remote Sensing and GIS were used to monitor interactions and relationships between lake area change and socio economics drivers in the regional ecology area Telmen lake basin of Zavkhan province of Mongolia. Study area is Telmen lake basin (48°50'N, 97°20'E, 1789 m,) the lake lies near the boundary between the forest-steppe and steppe ecosystems. Automatic extraction of shorelines from Landsat methodology was applied for determining lake area change over years 1986-2014. A decrease of lake area occurred over years 1986-2014. The change evolution outputs of the lake compared with the ground truth measurements with the GIS extraction. The Moderated Soil Adjusted Vegetation Index (MSAVI) from SPOT/VEGETATION was used to monitor vegetation condition for the period 2000 to 2013. Climate drivers (precipitation, air temperature) vegetation condition data and socio-economic drivers (livestock numbers, population, and agriculture activity) were analyzed in order to evaluate the impacts of main socio-economic activities on Lake Telmen and its basin. Findings show that there is a strong relationship ($r=0.82$; $p=0.0002$) between the livestock and lake area changes. Irrigated croplands and the increase of number of sheep and goats have impacts on the lake basin. These activities have caused the deterioration of Telmen lake area along with its values at the average rate of 4.3 ha \cdot y $^{-1}$ which was observed for 1986 to 2013.

Near-real time monitoring of deforestation in the Amazon region by fusion of Landsat and MODIS Data

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Accurate and timely monitoring of deforestation in the Amazon forest would significantly help International programs such as UN-REDD+ and local law enforcement agencies to eliminate illegal logging in protected areas. Remote sensing data has been widely used for studying land cover changes over large areas. However, most currently available global and regional land cover products are updated annually or semi-annually due to the limitations of individual sensor systems (e.g. MODIS Land Cover, Terra-i, DETER). Landsat simply does not collect data frequent enough for near-real time monitoring. The view angle effect of MODIS (Tan et al., 2006) makes it very difficult to compare daily observations. What is missing is a new way of monitoring land cover change and disturbance that combines the strengths of both Landsat and MODIS. Xin et al. (2013) used a Landsat based model (Zhu et al., 2012) to predict future MODIS swath observation. The work presented here is an advancement of Xin's Fusion model. We built a near-real time change detection model based on the time series of the difference between the predicted and observed MODIS swath observations. We tested our new Fusion model in three selected Landsat scenes in the Amazon region for 2013-2015. Our results indicate that the new Fusion model is able to capture most deforestation events accurately within weeks after the change happened. Our on-going comparison study will comprehensively assess the spatial and temporal accuracies of some near-real time change detection products such as Terra-I, DETER, etc.

Separability Index-based Spectral and Temporal Features Selection for Large-scale Crop Mapping Using time-series MODIS data

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The accurate and timely information of crop cultivated area is essential for studies of food security and environmental problems. Traditional image stacking approach may mask some subtle but possibly important phenological events and spectral differences, therefore hard to determine which phenological characteristics play the key role in identifying given crops. In this study, we attempt to present an approach of extracting the crop cultivated area over a large scale by carefully selecting temporal and spectral features. Five vegetation indexes derived from different spectrum channels of MOD09A1 scenes and acquired at the key growing season from the 65th day to the 305th were taken as the main data to fully capture the phenological difference between crop and other classes. Separability Index (SI) was used to evaluate the separability of each spectro-temporal feature for separating crop and then extended to a global measure to guide the selection of optimal feature subsets. The selected optimal spectro-temporal features were conducted soft and hard classification based on support vector machine to generate consistent and discrete crop maps. The accuracy regarding crop spatial distribution in discrete maps were assessed using field samples, while the accuracy regarding crop area estimated from its consistent maps were compared with agricultural statistical data. These resultant crop maps in Heilongjiang province using selected spectro-temporal features can achieve producers' accuracy of more than 85% and users' accuracy of more than 80%. MODIS-derived crop area had good agreements with the agricultural census data.

High remote sensing image based land use and land cover mapping with landform factors support

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High resolution remote sensing images have made greater progresses on feature recognition field than other remote sensing images have. For example, in urban area, 30-100 meters low and middle resolution images can only achieve identification scale of main streets and city blocks, no finer architectural structure could be recognized. High resolution remote sensing achieve a much finer structure of ground features and richer environment information by improving the spatial resolution of remote sensing images to less than 1-2 meters. These new inputs makes it passable to create land use/cover maps in a finer accuracy. Therefore, on the basis of meter scale remote sensing image, the land cover/use classification should be built through combing the surface survey and relevant landform factors. This study use GF-1 high resolution remote sensing images as basic data, DEM , Slope data, historical land use/cover map are chosen as reference. First, this research focused how to defined outlines of the smallest land units by remote sensing image. Then, with help of landform and topographic factors, the land use/cover types of the land units will be specified.

Novel land governance systems to manage natural resources - POSTER SESSION

The Sustainability in the sugarcane sector in Brazil: The Green Ethanol Protocol

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The ethanol production from sugarcane in Brazil has raised a number of questions regarding their consequences and sustainability. In particular, air pollution from the burning of sugarcane as a result of the traditional process of sugarcane harvesting that is manually performed using the practice of pre-harvest burning. The Environmental Protocol aims at rewarding good practices in the sugarcane sector to anticipate the phasing out of cane burning. Upon formalizing this agreement, the companies receive the Green Ethanol Certificate. However, the cane burning elimination is contested by the high investment costs in the implementation of mechanical harvesting and for the negative impact in the reduction of employment. The aim of this paper is to examine the companies' responses and discourses about the Green Ethanol Protocol. The study was based on a review of the literature, the Brazilian Legislation and quantitative content analysis that was applied to a selected media public communication. The result shows progress in reducing burning, in 2010 it was possible to obtain 70% of the crude harvest in mechanized areas and in 2014 was approximately 85%. In 2014 it was awarded 177 green ethanol certificates to agribusiness units, belonging to 69 companies. The Environmental Protocol is the Brazilian examples of new way of implementation and development public policies based on the private, public and civil society partnership that can be replicated to other sectors.

The forest ecosystem services and its decoupling research of compensation in Yanqing county, Beijing city, China

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Assessment for forest ecosystem service can quantify the impact of forest ecosystem services to humans and is the main basis to formulate the standard of compensation. Because of each type of service and the relationships among these services are difficult to be identified accurately, existing methods cannot measure these services accurately, while repetitive computation for direct sum of forest ecosystem service should not be ignored. Low compensation standard and the lack of a dynamic coordination mechanism are the main problems existing in compensation implementation. These problems make the value of forest ecosystem services excessively large and cannot meet the coupling relationship with the low compensation standard. Based on these problems, the research systematic evaluate the total volume of forest ecosystem services. The coupling relationship between forest ecosystem service and compensation standard is analyzed by entropy weight and extension matter-element model and growth curve model. A simulation and verification for the coupling relationship is studied. This research provides reference methods and theoretical basis for the standardization of forest ecosystem service evaluation and the formulation of forest compensation standard.

Emergy analysis to evaluate the environmental sustainability of agro-ecosystem in Huang-Huai-Hai Plain (HHH) of China

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This study is aim to determine the effects of agricultural factors input in Huang-Huai-Hai Plain of China on agricultural production, and analysis the environmental sustainability of agro-ecosystem. An integrated environmental accounting is presented in this study based on emergy analysis methods for the period from 2004 to 2013. Detailed structure of the emergy input (environmental resources emergy, applied fossil emergy and other renewable emergy), emergy yield (main crops, stockbreeding, forestry and fishery production) and a series of emergy system indicators to evaluated the environment resources basis and production a historical perspective for the contemporary the regional agriculture in the latest ten years. Temporal variation of indices such as increasing environmental load ratio (ELR), decreasing emergy yield ratio (EYR) illustrate a weakening sustainability of the HHH Plain's agro-ecosystem characteristic of profound transition from traditional to a modern industry based on nonrenewable resource consumption. This study has recommended the effect of regional agro-ecosystem and its environmental sustainability recommendation.

Red line for forest conservation- A case study in a remote city in western China, Guyuan

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Forest is one of the most important natural resources for the sustainable development in most of the ecological fragile region in China, providing various ecosystem functions and services. And the central government attempts to make a red line for forest conservation for the forest management and make it as one significant indicator to evaluate the performance of local governments. Thus the red line research is essential for the local well-being and government management. Taking Guyuan, an ecological fragile, remote city in western China, as a case study, we made the red line for forest conservation, basing on its capacity in providing important ecosystem services; the sensibility to the natural and manmade factors; the adaptation of forest and the need of forestry product. In this paper, the ecosystem services refer to water conservation, soil conservation and carbon sink function; the sensibility includes the environmental factors such as soil properties, geographic characters and climate change, and the disturbing factors includes human disturbance and natural disturbance; the adaptation of forest is presented by the minimum ecological water demand; the providing ability of forest, such as forest productions; and the original location of forest. Through it, we identified which area should be under protection and confirmed its area and location - red line for forest conservation. The result of this red line for forest conservation may help the local government manage the forest reasonably, support the recovery of forest as well as meet the demand of relevant ecosystem services.

Long-term socio-ecological research in the Austrian Eisenwurzen region: success criteria in a heterogeneous research field

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Long-term socio-ecological research (LTSER) aims at understanding socio-ecological change over long time periods and at contributing to sustainable regional development. The Eisenwurzen LTSER platform was established in 2004 and fosters LTSER in the Austrian Eisenwurzen region through three formal elements: (1) infrastructure, i.e. ecological monitoring sites; (2) research, i.e. research projects; and (3) regional stakeholder networks. The platform thus attracts LTSER researchers studying this region with different research foci and from various disciplinary backgrounds, and with differing degrees of stakeholder involvement. The amount and quality of inter- and transdisciplinary cooperation has been internationally acknowledged by reviewers of the Austrian “LTER White Paper” in winter 2015.

In an exchange process among researchers and between researchers and regional stakeholders, success criteria of LTSER developed in the Eisenwurzen platform were discussed. The status quo of LTSER in the Eisenwurzen platform was depicted and three research strands were clustered: long-term ecological research, socio-ecological basic research, and transdisciplinary cooperation. While cooperation between all three strands exists, the wide scope of approaches is an important resource of LTSER in the region. Major success criteria for LTSER were elaborated: (1) stable networks are important both between stakeholders and researchers, but also among researchers from different backgrounds; (2) availability of and access to data and information are indispensable, and vary considerably between the strands; (3) continuous funding has been key to the evolution of LTSER in the Eisenwurzen region and may be threatened if Austrian national tenders, currently funding many LTSER projects, cease to provide.

Modeling Brazil's future LUCF greenhouse gas emissions

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In the COP-21 Brazil has pledged to cut its greenhouse gas (GHG) emissions by 37% below 2005 levels by 2025 and to reach a 43% reduction by 2030. In 2005, land use, land use change and forestry activities accounted for two-thirds of Brazil's GHG emissions. One of the principal tools Brazil has at its disposal to help meet emissions reduction goals is the revised Forest Code that restricts deforestation of private lands and requires forest restoration in illegally deforested areas, among other provisions. Here we present the projected impacts of Brazil's new Forest Code in terms of land use change and forestry (LUCF) emissions using simulations based on a consistent land cover map for Brazil and a bottom-up global economic partial equilibrium model of the agriculture, forestry and bioenergy sectors. Emissions are computed by spatially projecting land use changes for the whole country through 2050, taking into account both internal policies and external trade. Overall, our projections show that a thorough implementation of the Forest Code should enable Brazil to attain zero net LUCF emissions as early as 2030. The accumulated deforestation emissions per decade decline from 11.58 GtCO₂e in 2010 to 1.21 GtCO₂e in 2030 and 0.38 GtCO₂e in 2050. In addition, carbon uptake from forest regrowth is estimated to remove 1.41 GtCO₂e in 2030 and 1.03 GtCO₂e in 2040 and 0.51 GtCO₂e in 2050. These results show that the implementation of the new Forest Code is essential for Brazil to meet its international commitments.

Changing Land Tenure in Tribal Areas of Jharkhand

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The issue of land tenure is found very significant in the socioeconomic studies due to nature of property relationship and complexities of social processes associated with land. FAO defines land tenure or tenure holder is the relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. (For convenience, “land” is used here to include other natural resources such as water and trees.) Land tenure is an institution, i.e., rules invented by societies to regulate behaviour. Rules of tenure define how property rights to land are to be allocated within societies. Jharkhand abodes many tribal communities and primitive tribal communities and its population accounts 26 percent (Census 2001) of the state population. Tribal believed to be forest based community with deeper relation with their lands and where customary laws are survival ingredients of their society. This Paper emphasizes on political process and change in power structure as well as land ownership in tribal society. This paper also analyses various forms of customary practices and their nature of transformation. Also, there is focus on statutory land laws and practices that evolved over the period. Moreover, the attempts are to review of existing policies and Acts pertaining to tribal land in the context of Jharkhand. The CNT Act, SPT Act and CBA Act among other regional Acts and legislation are the part of the discussion in this paper. The author discusses how some of the Acts and legislation are the result of historical peasant/ Tribal’s struggle in Jharkhand that rooted through colonial process. The author counter the argument that statutory process without taking into account the significance of customary norms and practices have resulted both violence and instability in the social system. Therefore, there is need for understanding normative values attached with customary practice in land management. Changing land tenure in Jharkhand further provides avenue for discussion on socioeconomic development and sustainable development in the state.

Governance and the social participation in Clean Development Mechanism Afforestation Reforestation projects in Latin America

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Some initiatives in the forest sector are establishing multi-level governance structures that involve communities from developing countries in global mitigation efforts. In particular, the Clean Development Mechanism (CDM) of the Kyoto Protocol has allowed the participation of plurality of actors. The “Stakeholders’ comments” is one of the basic requirements of the CDM project design documents, therefore the project developer have to describe how comments by local stakeholders have been invited and compiled. Then, using quantitative content analysis and political ecology approach that have long been interested in the dialectical relationship interactions between State, markets, nature and society, this papers aims to examine the social participation in CDM projects in the Afforestation Reforestation sector in four Latin America countries: Brazil, Colombia, Peru and Nicaragua. The results showed that the four countries have very different policies regarding stimulate the social participation. There is no clear definitions of stakeholders in local consultations as consequence unsorted actors are include, destabilizing the distribution of participation opportunities. The analysis concludes that although that the opportunity for local stakeholders to express their concerns and to participate in decision-making is seen as an important factor for achieving sustainable development, this interaction is not seen as being particularly evident in practice.

REDD+ in Brasil: Possibilities and Challenges

The Possible Effects of Indirect Land Use Change and Leakage in REDD+ in Brazil

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Reducing carbon emissions from deforestation and forest degradation now constitutes an important strategy for mitigating climate change, particularly in developing countries with large forests. Zero deforestation is now a central piece of Brazil's national climate change plan and research suggests that anti-deforestation policies together with market based mechanisms successfully reduced deforestation in Amazonia. Here we discuss potential indirect land use changes and leakages to the Brazilian cerrado that might result from higher environmental enforcement in Amazonia. We discuss differences in legislation and theoretical rent-based mechanisms that make the cerrado more attractive to agricultural expansion. We provide preliminary field based evidence on whether environmental enforcement is relevant in determining investment location choice in the MATOPIBA region of Brazil. We conclude the presentation by discussing the challenges for REDD+ implementation in Brazil and elsewhere.

Pasture intensification, land sparing and REDD+ in Brazil

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Achieving food security for a growing population, safeguarding the life support systems provided by natural ecosystems and avoiding dangerous climate change are three interlinked global challenges of the 21st century. Sustainable intensification of lands already converted to agriculture has been suggested as a key part of the solution to conciliate these three challenges. Here we explore how these three goals are connected in the Brazilian context. We show that current pasture productivity is only 32% of its sustainable carrying capacity and, as these areas occupy 75% of Brazilian agricultural lands, there is substantial potential for land sparing. This potential would be enough to free up space for the largest agricultural expansion globally, avoidance of deforestation and space for large scale restoration. We also discuss the challenges to achieve this more sustainable land-use scenario, including the risks of a rebound effect.

REDD+ in the context of Brazil's INDC

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In its INDC, Brazil pledged to cut its greenhouse gas emissions by 37% below 2005 levels by 2025 and to reach a 43% reduction by 2030. To achieve these ambitious goals, Brazil aims to reduce emissions from deforestation and land use. Model simulations developed by our team in the REDD-PAC project, using the GLOBIOM-Brazil model, show that Brazil can fulfill the emission targets of the LULUCF sector that are part of Brazil's INDC, if it succeeds in enforcing the provisions of the new Forest Code, approved in 2012.

The 2012 Forest Code mandates farmers with large properties that have deforested more than their legal limit (20% for Amazonia biome) to restore native vegetation. The code also gave an amnesty from restoration to small farmers. A further provision are the “environmental reserve quotas”, preserved areas in private properties that can be traded to offset required restoration areas. These three provisions set up a basis for REDD+ markets in Brazil.

This presentation will use the results of the GLOBIOM-Brazil model to explore the possible outcomes of REDD+ policies that focus in one of the three components: (a) funding forest restoration; (b) incentives for small farmers; (c) buying quotas to preserve native forests. We will compare the trade-offs in increased restoration and loss of native forests in each case and point out the possible consequences of different REDD+ incentives for Brazil.

Lessons from conservation policy impact evaluation for REDD+ in Brazil

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Impact evaluation is a standard procedure, for example, in medical sciences and development economics. A relatively large literature with an evaluation focus also exists in conservation management, i.e. the statistical measurement of impacts of alternative land management practices. In the forestry sector, however, environmental and conservation policy instruments, including for REDD+, have only recently become the focus of counterfactual based impact evaluation. Apart from studies of protected area effectiveness, relatively little is known about the ability of forest conservation policy instruments, such as law enforcement, integrated conservation and development projects (IDCP), or payments for environmental services (PES). This presentation reviews recent developments in conservation policy impact evaluation, among others, based on a forthcoming PLOS ONE Collection titled “Measuring forest conservation effectiveness”. Given Brazil’s national efforts to reduce forest loss in the Amazon region, a large number of evaluation studies using a wide range of innovative empirical approaches were reviewed. Lessons for the design of tropical forest conservation strategies are discussed including against the backdrop of REDD+ as a potential international instrument for conservation finance.

Beyond participation: How do we integrate different types of knowledge and experiences in land governance systems?

Integrating land tenure in planning for regional governance of climate-induced relocation in the Pacific Region.

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Retreating from affected coastal areas through migration as an adaptative strategy to changes in environmental patterns has always been part of the Pacific Islands' communities culture and practices. Methods to cope with the adverse effects of natural disasters in the region is integrated in their traditions for millenaries. Local relocation in the Pacific can be either within or beyond the land tenure boundaries of the affected communities, planning for relocation within the customary land allows a preservation of social cohesion crucial for the Pacific Island communities survival.

The diversity of customary land rights in the Pacific Island region makes relocation a particularly complex process that needs to include negotiation at early stages of the process, including Governments, local leaders and both relocatees and hosting communities. Understanding this dimension is crucial and without deep comprehension of ancestral adaptation strategies and planning around land management, the relocation process is likely to be unsustainable as it will lack the important local specificities and the essential link between Islanders and their land, which is considered an extension of one's own self.

Including this local dimension in the design of global approaches is crucial to produce scenarios in the particular case of future slow-onset environmentally-induced relocation in the Pacific region. The paper suggests therefore a Slow-Onset Climate Change Relocation Preparedness Checklist with a particular focus on customary land tenure in the Pacific Region adressed at the regional level of governance. This "checklist" transfers theoretical findings of the paper into a

practical tool providing a “memory trigger” for regional governance that highlights aspects to consider when planning for Sustainable Relocation in the Region. This tool provides support to efforts aiming at integrating climate change mitigation and adaptation policies into regional strategies, linking crucial local specificities and climate change adaptation strategies.

Gender-specific appreciation of landscape multi-functionality

Gender specific land-use decisions and its implications for ecosystem services and resilience in Central Sumatra

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Gender specificity in response to land-use options and agents offering new investment opportunities has received little attention to date. It may influence ecosystem services delivery especially to areas under conservation agreements (such as reduced emissions from deforestation and degradation). We combined an agent-based modeling and experimental games to compare female and male land-use preferences and decisions, with implications for ecosystem services and resilience in a rubber agroforest landscape in Sumatra, Indonesia. Rice fields (mostly owned and inherited by females) provide part of local staple food needs, rubber agroforests provide income plus forest resources for local use, rubber and oil palm monocultures are fully geared to market-based income. In both model and games, males prefer the *status quo* rice plus agroforest combination, but females prefer transforming agroforest to more profitable monocultures, leading to increased carbon emissions. Although both genders exhibited similar preference for provisioning services, regulating services (i.e., climate and water regulations) differ. Thus, ecosystem services tradeoffs are potentially greater in female-dominated landscapes.

Exploring gender perspective on land access and food production

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Gender equality in ownership and/or access to land resources is crucial to increasing agricultural and food security. However, there is little information on gender equity in land access and food production in the Upper East region of Ghana, which is one of the poorest regions in the country. The objective of this study was to assess gender-based access to land and its effect on food production in the Veve catchment, Ghana, which affects the multi-functionality of landscapes. A total of 300 semi-structured questionnaire were administered equally to male and female headed households. Results showed that both male and female headed households have access to land; however, males have about 41% more land than females due to the patrilineal system of inheritance and succession in the study area. Males generally cultivated larger land holdings than their female counter part, which translates into a higher farm output and gross income. On the other hand, female-headed households allocated higher percentage of their land (32.5 %, and 35.3%) to the cultivation of traditional cereals and traditional cereal legume than their male counter parts. Males tend to cultivate cash crops such as peanuts whereas females cultivate crops for home consumption. Groundnut and traditional cereal based farmers were the two main household agents identified from the Principal Component and K-Mean cluster analysis for both gender groups. Policy interventions should be geared towards strengthening female's right to land through joint access before vital incentives are provided to increase food security.

Tree-cover transition in Northern Vietnam from a gender-specific land-use preferences perspective

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Vietnam is one of the countries where a shift from net deforestation to net reforestation is taking place. This study examines the pattern of tree-cover transition and gender-specific land-use decision making in northern Vietnam. We employed a multiple-method approach that combined a land-use transition analysis, gender-disaggregated surveys and role-playing games to assess relationships between tree-cover transition and gender. The first two methods revealed continuous conversion of protection forest to tree plantations and upland crops (dominated by swidden rice). Factors affecting conversion identified by a regression analysis were elevation and labor availability. The land-use role-playing game results explicitly highlighted gender-specific preferences for annual crops and tree-based agroforestry systems and underlying motivations. The overall pattern of tree-cover transition in northern Vietnam falls under the smallholder agricultural intensification path. Nevertheless, agroforestry systems potentially balance the specific land-use preferences of men and women to achieve their specific land-use related livelihood objectives.

Gender perspectives, roles and land use preferences - implications to land restoration and multifunctionality

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This presentation highlights the roles that women play in agricultural production, their land use choices, and the implications of those choices on landscape multifunctionality. Based on case studies from six countries (Cameroon, Indonesia, Malawi, the Philippines, Vietnam and Uganda), we argue that the pathway to land restoration is influenced by the way land is appreciated by direct stakeholders. Women, due to their increasing productive roles, could become agents of either land degradation or restoration, so ignoring their specific needs may lead to unsuccessful implementation of land restoration programs. We recommend understanding gender-specific differences over land use and land management practices as the entry-point, followed by nuanced design and implementation of gender-responsive and gender-focused land restoration approaches and investments.

The Governance of Ecosystem Services – lessons learned and way forward

Understanding stakeholder-ecosystem service associations to improve governance and avoid environmental conflicts

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Ecosystem services (ESS) analysis and valuation can be key means of improving land governance systems, beyond standard spatial planning and market mechanisms. However, humans value different ESS differently, not only as individuals, but also as collectives sharing similar value systems and patterns. We have analysed such patterns by (i) conducting a systematic stakeholder analysis in the field of agricultural land use in different countries in Europe and South East Asia, (ii) conducting qualitative interviews to identify the values they emphasise, and (iii) classifying the values found based on the schemes available from the literature. The result is a matrix showing which group of stakeholders tends to emphasise which types of value. Of course, these matrices are context dependent – indigenous groups with specific cultures and religions have different ones than urban dwellers.

Nonetheless the matrices are helpful for land management planning and ESS governance in that they highlight which groups have to be addressed, and which themes have to be addressed when communicating with them. This may help avoiding extended disagreements over land use decisions which might otherwise hinder sustainable land management implementation and cause environmental conflicts.

Our research is a rare example of not first defining ESS categories and then looking for them in reality, but asking stakeholders about what they value in plain language, and later classifying the answers in desktop research. In this method, the ESS concept is used as a meta-language to make results comparable, in line with the bridge concept character.

Can PES meet the trade-offs between ecosystem conservation and poverty alleviation: insight from Sloping Land Conservation Program in Southwest China

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Sloping Land Conservation Program (SLCP) is a world largest payment for environmental service program implemented in China. The initial goal of this program is aimed to provide compensation to upland farmer for converting the marginal cropland into forest. The SLCP has driven a dramatic change in rural landscape in term of land use and livelihood transformation. However, there is few study taking an integrated approach assessment its effects in both biophysical and socioeconomic terms. Particularly, issues of effectiveness, efficiency and social fairness are rarely addressed in existing literature. Taking an interdisciplinary approach, this research reveals the gap between the policy's objectives and the actual results of implementation by presenting extensive field evidence of effects of SLCP. We argue that it required explicitly local participation and pro-poor considerations to meet the trade-offs in PES program.

Multi-level ecosystem services governance in the european union: conceptual challenges and empirical observations at eu and regional level

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Mainstreaming the ecosystem services (ES) concept in EU policy-making comes along with great expectations from practitioners, policy-makers, and scientists to improve environmental policy and halt the loss of biodiversity. This paper, first, addresses three major conceptual challenges for such a mainstreaming: the need for (1) vertical and (2) horizontal policy integration, and (3) the question of stakeholder involvement in policy-making. Second, this paper investigates empirically the way in which – and the extent to which – selected EU policies, covering policy fields ranging from biodiversity and water policies to climate policies and policies for rural and urban areas as well as a mobility and infrastructure-related policy, enable or impede the mainstreaming process. Here, the design of those policies at EU level as well as their implementation in the EU Member States and at regional level is looked at. This article assesses how existing EU policies address ES explicitly or implicitly. Further, it investigates the extent to which the different policies at the level of definitions, objectives, and implementation (including policy type, mode of steering, reporting, monitoring, evaluation, and financing mechanisms) are able and ready to incorporate the ES concept to ‘produce’ a meaningful and integrated policy. Here, the paper draws empirically on a review of legal, policy, and scientific documents, on a focus group with policy-makers from several EU Directorate Generals, and three regional case studies. The results may help to estimate the impact of EU policies on local and regional land management and to improve a place-based ecosystem management.

Governing Moisture Recycling Ecosystem Services

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Although ecosystem services related to surface water have been thoroughly described, the relationship between atmospheric water and ecosystem services has been mostly neglected, and perhaps misunderstood. Recent advances in land-atmosphere modeling have revealed the importance of terrestrial ecosystems for moisture recycling. In our work, we analyze the extent to which vegetation sustains the supply of atmospheric moisture and precipitation for downwind beneficiaries, globally. We define vegetation-regulated moisture recycling as the difference in moisture recycling between current vegetation and a hypothetical desert world. Our results show that nearly a fifth of annual average precipitation falling on land is from vegetation-regulated moisture recycling, but the global variability is large, with many places receiving nearly half their precipitation from this ecosystem service. Despite this advance in ecosystem services theory and quantification, effectively and equitably governing this ecosystem service will likely pose significant challenges for both national and international governments. Using preliminary results based on our ecosystem services analysis, and other recent work, we discuss the scientific, management, and legal challenges that may arise from attempts to govern moisture recycling ecosystem services.

Determining Potential Best Management Regimes on Plantations at Stand-level: A Case Study of Moshao Forest Farm in Southern China

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A number of problems concerning even-aged forest structure and dwindling ecosystem services existed for plantations in southern China under the traditional forest management. The objective of this study is to determine best management regimes (BMR) aiming at sustainable forest management, with a case study at Moshao forest farm. We propose a framework of BMR modeling, which is characterized by high scheduled timber production (STP), low fluctuations in periodic scheduled timber harvest levels (FPS), and age class structure (ACS) at the end of planning horizon, and a simply paired analysis is conducted among the three indicators to identify a suitable management planning for long-term timber production. Our results suggest that STP, FPS and ACS are correlated to each other, it is possible to control these forest performance indicators in a planning horizon by setting various harvesting intensities. Management regimes with cutting area percentages of 20%-40%, cutting period of 10 years combined with small area clear cutting (≤ 5 ha) may be BMRs for Moshao forest farm in Southern China, and management regime with cutting area percentage of 35% is probably the best one. These findings suggest that applicable management regime could be designed by identifying the best harvesting intensity. The local current harvesting intensity can be increased properly under a balance between timber production and ecological impacts on the plantations.

Modelling trade-offs among forest structure, biomass, and timber production under long-term forest management alternatives for plantations in South China

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Forests are facing serious problems such as degradation on structure and function at global to local scales. Focusing on plantation ecosystems, it's useful to know how to achieve the most appropriate comprehensive benefits through a sustainable forest management approach. Setting the forest management scenarios under human influence, including forest protection, forest regeneration, timber production and sustainable forest management, the effect of different strategies will be investigated, to propose a more suitable management strategy for plantations. LANDIS-II model was adopted to simulate the dynamics of structure, biomass and timber production under four strategies that meet actual conditions. Then a standardized difference method was used to investigate trade-offs on different ecological functions. As harvest intensity increases, timber production increases at the same pace, while forest areas and aboveground biomass decrease. Harvest strategies will improve forest age composition. A sustainable approach can achieve the optimization of overall ecological benefits through trade-offs on timber production and biomass. To achieve sustainable forest management in the long-term, a strategy that is based on forest type classification showed an indispensable advantage. It can fulfil the requirement of timber production without damaging other ecological functions, especially on plantations in South China.

The Impact of Large-Scale Land Transactions on Smallholder Livelihoods and Agroecological Systems

The Global Rush for Land: A Socio-Environmental Synthesis

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In the global South a ‘rush’ of large-scale land acquisitions (LSLAs) is occurring of intensified pace and scale by governments and transnational investors seeking to secure access to land in developing countries to produce food, bio-fuels, and non-agricultural commodities. A globally integrated view of the scope, context, impacts, and feedbacks between LSLA social process and land outcomes provided through this research effort will provide key inputs for the formulation of appropriate policies for global land governance and sustainability. This project employs several synthesis approaches recently identified in the land change science (LCS) literature, to integrate geospatial intelligence, in particular satellite-based remote sensing (RS) data of *verified* LSLA sites; variable- and case-oriented meta-analysis of localized LSLA case studies; geospatial and international trade data describing globally-relevant (i.e., coarse-resolution, large-scale patterns of) social, environmental, political, and economic contexts, in a global synthesis of LSLAs in order to understand the causes and consequences of LSLA changes to land systems globally. By combining ‘interpretive’ synthesis of causal factors derived from the social science case study literature with ‘integrative’ synthesis of land change outcomes of LSLAs observed from remote sensing and correlated with context variables, we will develop several ‘stand alone’ synthesis products that will be used to develop two explanatory models that will be cross validated to predict average land change outcomes, as well as predict possible ‘no change cases.’

Spatial Patterns of Large-Scale Land Transactions: Number, Size, Context and Outcome in Cambodia, Ethiopia, Liberia and Peru

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The scale and pace of large-scale land transactions, often framed as ‘land grabbing’, are historically unprecedented, with millions of hectares changed hands over the past decade. However, the rapidly growing body of research on land transactions provides few rigorous assessments on their spatial patterns and outcomes. In this paper, we present a fine-scale investigation of land transactions in Cambodia, Ethiopia, Liberia and Peru based on land transaction boundaries and their social, economic, and environmental covariates. Our results showed divergent patterns regarding land transaction size, number and context. Although land transactions can cause forest loss, deforestation rate is not always accelerated when comparing to the buffer areas and national average. Results from the multi-level mixed-effects model indicate that pixel-level predictors such as forest cover, night light, and population density are more significant in determining deforestation than transaction-level predictor such as transaction size. Our findings suggest that different pathways can occur from land transactions, resulting in distinct ecological outcomes. Thus, we suggest not assuming outcomes *a priori* in the study of land transactions, and call for more rigorous assessments of on-the-ground implementation and the full array of impacts on the social-ecological systems.

The governance of land systems

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Commercial farms in Zambia and the relationship with smallholder farms

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In light of the surge of foreign large-scale Agricultural Investments (LSAIs) in developing countries, concerns have been raised that smallholder livelihoods may be negatively affected by large-scale agricultural projects. There is, however, very little evidence beyond case studies that supports these claims. Drawing on a combination of nationally representative household datasets from 2003 and 2014 as well as an inventory of foreign LSAIs from Zambia, this study investigates commercial farms and their relationship with smallholders in Zambia. In a first step, we take a detailed look at the investment projects in Zambia and study the particularities of the regions that host commercial farms compared to those that do not host any. In a second step, we use the Generalized Propensity Score to estimate a dose-response at different levels of treatment (exposure of smallholders to commercial farms). Thereby we take account of the fact that the effects of commercial farms vary over magnitude and time. In light of the surge of foreign large-scale

Towards ‘Integrated’ GEC research practice: Learning from examples of co-design and co-production in land systems science

Co-designing Future Earth: the Nexus Knowledge-Action Network example

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Future Earth is a 10-year international initiative that aims to provide knowledge to accelerate our transformations to a sustainable world. In 2016, Knowledge-Action Networks were launched to provide collaborative frameworks that facilitate integrative research in support of addressing major societal challenges to sustainability. As a first step Knowledge-Action Networks are conducting agenda-setting exercises with the goal to define their research agenda. These processes must be in line with Future Earth principles that emphasise greater interaction among disciplines and between scientists and societal actors as key approaches to improve the contribution of science on the solution of societal issues. The presentation will focus on one specific example, the Knowledge-Action Network on the Water, Energy, Food Nexus, and how its research agenda is being co-designed. A highly interdisciplinary research is needed to better understand and manage interactions between water, food and energy systems. Relevant science fields go well beyond the traditional global environmental change communities. Engaging energy experts for instance has proven to be challenging. More importantly, while Knowledge-Action Networks are global initiatives, most of the challenges and solutions related to the nexus occur at sub-global levels. Co-designing a global research agenda with stakeholders at all scales is certainly one of the main challenges faced by Future Earth. We will highlight how we have been trying to cope with these challenges through the building of an open network of scientists and stakeholders concerned by nexus issues, who are asked to enrich the reflection of a working group through various means of interaction.

Young Scientist Forum on Farmer's Land Use Decision-making

Contemporary Tools and Models of Farmer Decision-Making and Food System Assessments

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Stakeholder engagement is a key element in research on farmer decision-making and food system assessments. System dynamics, bayesian networks, fuzzy cognitive mapping and agent-based modeling are mature analytical tools to use, and accordingly software packages are developed. A reflection on these tools and models would contribute to the methodological development of land use and land cover change research, especially to multidisciplinary projects. Different combination of tools can have different function in contribution to knowledge and solution to local nature-society system. The combination of discourse analysis, game theory and agent-based modeling is an example to be examined to enlighten the principles to cook up a portfolio of tools and models to optimize research framework.

Using farmer decisions as drivers for crop land use change to develop future scenarios

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The drivers of agricultural land use are mostly assumed to be financial in nature. To verify how much influence financial factors have in determining crop land use, four independent groups of farmers in two agricultural areas located in mid-latitudes (Altmühl River, Bavaria (Germany) and the Pike River, Québec (Canada)) were asked to rank decision-making factors that they consider for choosing which crops to grow each year, or for changing the crop types grown on their farm. Responses showed that the drivers of land use (as well as land use change) were composed of a suite of factors. The directly-related financial factors made up approximately half of the factors. For some questions, the indirectly-related financial factors (i.e. access to farm equipment, the farm experience, and climate) ranked higher, or just as high, as the financial factors. The ranked drivers as well as the categorization of drivers were helpful for the development of a farmer-driven scenario storyline to 2040 in both regions. A comparison scenario storyline for each region was derived based on agricultural subsidies, income support, crop insurance, and policies. This proved to have more crop diversification and less cash crops than the farmer-driven scenario which had large increases in maize areas. Questioning farmers on their driving factors led to changes that may otherwise not have been captured in the scenarios, specifically related to planting new crops. The quantification of the driving factors aided to build scenario storylines for future application to determine further changes in the watershed.

Using decision trees to analyze household's land-use decisions in Sichuan province, China

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China's rapid economic development was accompanied by massive rural-urban migration and strict birth-control policies slowed population growth. Combined, this led to a sharp decrease of the agricultural labor force, which in turn has caused declining agricultural intensity and land abandonment. However, unclear land tenure and dysfunctional land markets impeded the transition towards larger farm structures that may help responding to the reduced labor availability. In recent years, the Chinese government started experimenting with land rights reforms to stimulate land market activity. To understand the reaction of farmers to the changing boundary conditions, we investigate the determinants of land-use decisions, such as changes in area and intensity of land use, including land transfers. We collected survey data of 410 households in four counties of Sichuan province. The counties are characterized by diverse topography, natural endowments, and distance to the market centers. We use the household data to calibrate decision trees (DT) that allow quantifying the determinants of household-level land-use change. The non-parametric DT allow for filtering multiple variables and the graphic interface permits easy and transparent interpretation of the results. Our findings suggest that households with more off-farm work, higher income, and better market access are more likely to abandon or rent out land. We anticipate that more efficient farms will emerge around markets centers while land-use intensity will further decline in the remote areas. These insights contribute to a better understanding of the potential effects of land market liberalizations and their impact on land-system properties in rural China.

Understanding farmers' valuation of ecosystem services in Calakmul Biosphere Reserve, Mexico

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Farmers are increasingly targets of policy interventions that ignore their relationship with their environment and assume that in order to conserve we must pay farmers. Yet farmers are heavily dependent on goods and services provided by forests. Research is needed to understand the extent to which farmers themselves care about ecosystem services. In order to fill this gap I investigate factors explaining farmers' valuation. The paper draws on interviews with 280 farmers from twenty-eight communities in the Calakmul Biosphere Reserve in Mexico. Farmers in this area currently receive payments for ecosystem services. I show that farmers who receive payments are more likely to value ecosystem services. Payments provide people much needed economic resources, as well as information about the value of the forest. Farmers who are more involved in community level decision-making and who have a network of contacts working in the government are also more likely to value ecosystem services. In these cases information also plays a very important role by enhancing farmers' understanding of the importance of the forest and the benefits of conservation. Measures of household wealth and vulnerability are not associated with valuing ecosystem services. The findings of this paper show that by narrowly defining farmers as recipients of payments, conservation policies reduce farmers' agency and limit their role in forest conservation. In addition to payments, involving people in decision making and bringing the government closer to the people help raise farmers' appreciation for the services the forest provides them.

eFarm: crowdsourcing farmer's decisions for improving agricultural land use

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Agricultural landscapes frequently change due to human activities. Timely and detailed data in both biophysical and socioeconomic aspects within a full extent of agricultural area are much needed for capturing such dynamics and thus for a better management. Previous data availability on agricultural land use – either separately based on remote sensing images or statistics or household surveys – often limits the integrated explanations on landscape dynamics and human-environment interactions. In particular, despite agent-based models (ABM) aimed to analyze human-environment interactions from a bottom-up perspective, the micro-level information is wretchedly inadequate to reflect individuals' decision-making, which results the current ABM are merely robust in empirical application.

A crowdsourcing tool called eFarm has been developed, aiming at: 1) make the timely, land parcel-based, and large amount of human decision-making information available through a global access to smart phone networks and internet; 2) bring together various datasets – images, sensors cadasters, statistics, census and surveys – into a land parcel-based “big data” system that integrates human-environment information.

The presentation outlines the components that comprise eFarm and how they are integrated in the architectural design. An overview of its main functionality is then provided along with case applications. eFarm shows strong ability in data collection and integration. It could be of great help in less developed and smallholder agriculture regions, where cadasters, statistics, and census are inadequate. Moreover, the development of big data system would support new approaches such as deep learning for innovating understandings on human-environment interactions and for improving better agricultural land use.