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YSSP

Young Scientists Summer Program



Proceedings of the YSSP Late Summer Workshop 2014



International Institute for
Applied Systems Analysis
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IIASA's annual 3-month Young Scientists Summer Program (YSSP) offers research opportunities to talented young researchers whose interests correspond with IIASA's ongoing research on issues of global environmental, economic and social change. From June through August accepted participants work within the Institute's Research Programs under the guidance of IIASA scientific staff.

The Proceedings of the Late Summer Workshop constitute summaries of the research results obtained during Young Scientists Summer Program and presented in a workshop at the International Institute for Applied Systems Analysis, Laxenburg, Austria, 25–26 August, 2014.

The proceedings receive only limited review and are not for publication in the current form. Views or opinions expressed herein do not necessarily represent those of the Institute, its National Member Organizations, or other organizations supporting the work. This compilation contains all the summaries available at the time of finalization of the proceedings.

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Workshop Program

Monday, 25 August 2014						
9:00 – 9:10	Welcome and Introduction by YSSP Dean Joanne Bayer (Wodak Room)					
	WODAK Room			GVISHIANI Room		
Day 1 - Session 1	ENERGY & CLIMATE CHANGE Transportation: Fuels and Emissions Chair: Jens Borken			POVERTY & EQUITY Social Heterogeneity Chair: Joanne Bayer		
09:10 - 09:35	Piera Patrizio	ESM	Enhancing the optimization model BeWhere by including the generation of biogas and its use as a vehicle fuel	Oreane Edelenbosch	ENE	The influence of social heterogeneity on consumer choices in the transport sector
09:35 - 10:00	Guilherme De Paula	TNT	Analysis of historical cost reductions in Brazilian ethanol production	Lukas Figge	ASA	Uncertain cultural consequences of global ecological overshoot: exploring future perspective change and dynamics
10:00 - 10:25	Younha Kim	MAG	Assessment of effectiveness of Seoul metropolitan area air quality management plan (SAQMP) using the GAINS-Korea framework	Farid Karimi	RPV	Carbon capture and storage: a cultural approach to understanding risks perceptions and experts' views in three European countries
	10:25 – 10:45 B R E A K					
Day 1 - Session 2	ENERGY & CLIMATE CHANGE Renewable Resource Modelling Chair: Nicklas Forsell			POVERTY & EQUITY Fertility Choices Chair: Elke Loichinger		
10:45 - 11:10	Pietro Elia Campana	ESM	Potential sustainable locations for photovoltaic (PV) water pumping systems	Sergey Orlov	ASA	Reproductive fitness and differential mortality: the role of social status
11:10 - 11:35	Madeleine McPherson	ENE	Development and application of an improved tool for renewable resource modeling within MESSAGE	Abhishek Kumar	POP	Intergenerational influence on fertility preferences of young women in rural Bihar, India
11:35 - 12:00	Tao Wang	ASA	Analysis of a multi-factor model for resource productivity in China	Zepeng Sun	EEP	Seasonal life histories in changing environments
	12:00 – 13:30 B R E A K					

Monday, 25 August 2014						
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Day 1 - Session 3	ENERGY & CLIMATE CHANGE Financing Renewability Chair: David McCollum			POVERTY & EQUITY Human and Natural Capital Chair: Rastislav Skalsky		
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13:55 - 14:20	Thomas Schinko	RPV	Governance of risks in financing concentrated solar power investments in North Africa	Kun Ma	ESM	Application of EPIC model to explain historical change in soil organic carbon stock of Roige Wetland, China
14:20 - 14:45	Fabian Schipfer	ESM	Biomass deployment strategies for the transition to a bio-based economy			
14:45 - 15:00 B R E A K						
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15:00 - 15:25	Gbenga Abiodun	EEP	Climate change and malaria incidence in South Africa	William Lamb	ENE	Basic needs, development pathways and the global carbon budget: Articulating the links between climate change mitigation and human well-being
15:25 - 15:50	Quiying Ding	WAT	Soybean production in China under climate change: Analysis of the effect of adaptive techniques based on DSSAT and AEZ-China model fusion	Mikko Dufva	ASA	Emergence of shared perceptions of futures in a foresight system
15:50 - 16:15	Etienne Fluet-Chouinard	WAT	Global conservation prioritization of wetland ecosystems: proof of concept of hydrogeomorphic classification	Niharika Tripathi	POP	Preferred life expectancy and its correlates among elderly women in rural Uttar Pradesh, India
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16:55 - 17:20				Adriana Reyes	POP	Could fertility patterns act as a driver of global migration?

Tuesday, 26 August 2014						
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09:35 - 10:00	Hana Nielsen	TNT	The Czechoslovak steel industry in a comparative perspective: From scale to efficiency	Daniel Suarez	RPV	The institutionalization of ecosystem services in transnational policy networks
10:00 - 10:25	Thi Luu	ASA	Dynamics of bank-firm interrelations	Floor Soudijn	EEP	Ecosystem-based fisheries management of cod and sprat in the Baltic Sea
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11:10 - 11:35	Jessica Gephart	EEP	Impact of shocks on the global seafood trade network	Shengfa Li	WAT	An Estimation of the Extent of Cropland Abandonment in Mountainous Regions of China
11:35 - 12:00	Hongmei Zheng	ASA	An urban metabolism and carbon footprint analysis of the Jing-Jin-Ji regional agglomeration	Jon Nordling	ESM	Global agricultural monitoring and mobile data collection
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13:55 - 14:20	Moonil Kim	ESM	Optimal forest management model for climate change	Jie Zhang	ESM	Assess the capabilities of remotely sensed indicators for agricultural drought monitoring
14:20 - 14:45	Olga Turkovska	ESM	Forest management in recursive dynamic global partial equilibrium model	Apolonia Diana Sherly da Costa	RPV	Community Resilience for the 2011 Flood Disaster in Remote Area of Eastern Indonesia
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15:25 - 15:50	Nur Aulia Bt Rosni	ESM	Determining urban sprawl geospatial indices using remote sensing and GIS	Margaret Garcia	RPV	Development of a Socio-hydrological Model of Las Vegas Water Management
15:50 - 16:15	Jun Liu	MAG	How to improve air quality in China: A policy scenario study	Edoardo Borgomeo	RPV	Don't leave me dry: Modelling vulnerability to drought in water supply systems
E N D O F W O R K S H O P R E C E P T I O N I N C O N F E R E N C E A R E A						

Energy & Climate Change

Enhancing the Optimization Model BeWhere by Including the Generation of Biogas and Its Use as a Vehicle Fuel

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Introduction. In December 2013, the Italian Ministry for Economic Development finally started the long-awaited incentive program for biomethane grid injection and biomethane for transportation, which opens up new opportunities for alternative applications of biogas. Because of the complexity of its supply chain and the wider range of feasible options, identifying most suitable alternatives in terms of economic and environmental performances becomes more and more difficult. Biomass feedstock is a scarce resource and the profitability, environmental and social impact of biogas projects are affected by decisions on technology, location and capacity, which are interdependent. My project deals with the development of a biogas supply chain model which accounts for alternative uses of biogas while taking a supply chain oriented, spatially explicit approach. The goal is to identify the optimal location where new biogas plants should be installed, the most ecological and profitable technology and capacity options, thereby determining the optimal feedstock mix to be supplied to the plant and designing the structure of the required direct and reverse supply chains.

Methodology. For this purpose, the optimization model BeWhere has been adapted to the biogas technology, by considering different technological and economic indicators within the supply chain and by creating an extensive database related to feedstock characterizations and availability. Three different final utilizations, such as combined heat and power, biomethane grid injection and biomethane for transportation, have been analyzed, while the application of the model to the North Italian Scenario, allowed to directly connect the biogas production potentials with actual heat, power and fuel demands at a local scale. A reference scenario accounts for the economic and environmental performances of the supply chain considering the existing infrastructures like Districts Heating for heating supplying, natural gas grid and existing refueling stations for biomethane injection and vehicle fuel utilization. In order to account for further development of those technology three scenario have been subsequently developed, in which each option is individually promoted through the introduction of a policy incentives range.

Results and Conclusion. In the reference scenario the CHP technology turns out to be the most selected option, primarily due to the small environmental impact of its supply chain, as no transportation activity is required for the delivery of byproducts. Several upgrading plants are feasible for CNG production and delivery, mostly located in areas where the demand for such fuel is higher, while the injection option is always rejected. Comparing suggested plant locations with potentials, constraint and demand data, it is found that most of the plants are installed in those municipalities where potentials reach highest levels, thus reducing logistics costs and direct emissions. For each of the options analyzed in the remaining scenarios, the sizes and characterization of new plants varies according to economic condition introduced in the model. The optimal solution is thus extremely sensitive to market prices, of which both sales and incentive proceeds are a function, and to economic constraints such as different levels of carbon prices.

Analysis of Historical Cost Reductions in Brazilian Ethanol Production

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Introduction.

Ethanol production in Brazil has increased exponentially in the last decades and there is large potential for continuing growth. The sustainability and expansion of the Brazilian ethanol program depends on continuous improvements in efficiencies and reductions in production costs as ethanol competes directly with gasoline. Recent increases in ethanol production costs have raised questions about the ability of this industry to fulfill its potential without additional government subsidies. The objective of this project is to explain the significant cost reductions in sugarcane ethanol production in Brazil since 1975. This analysis reviews the influential work of Goldemberg and coauthors [1] and Bake and coauthors [2] on Ethanol learning curves.

Methodology.

The analysis of the historical cost reductions is broken down into four steps. The first task was to reconstruct the historical dataset of ethanol costs which involved incorporation of additional data sources and breakdown of cost data into the multiple components of the agricultural and industrial production processes. The second step was a decomposition of historical cost changes into the main drivers of ethanol cost improvements including the development of simple bottom-up model of ethanol cost components. The third step was a sensitive analysis of two main drivers of ethanol production efficiencies, agricultural yields and industrial scaling. The final task was a robust analysis of the learning curve model as an explanatory tool for the evolution of ethanol costs.

Results.

The analysis greatly benefited from the incorporation of five years of ethanol production costs based on producer surveys as well as on thirteen years of historical production costs for the initial stage of the ethanol program in Brazil shared by Rask [3]. As a result we reconstructed the ethanol historical cost data series using consistent data from producer surveys to find that the overall reduction in operational ethanol production costs was approximately 47% for agricultural costs and 57% for industrial costs. Total cost reduction since 1975 was approximately 53%. The compounded annual cost reduction rate was approximately 2% for agricultural process and 2.6% for industrial process. Most of the cost reductions happened in the first phase of the ethanol program and the learning curve model is not a robust tool to explain ethanol cost reductions.

Conclusions.

The previous literature overestimated the historical cost reductions of the Brazilian ethanol program and underestimated the uncertainty in the historical data series. Initial estimates suggested ethanol costs reduced by a factor of three while we can only justify a 50% reduction. The key drivers of ethanol cost variation are factor prices, agricultural yields, and industrial scaling. Agricultural yields is the key determinant of cost improvements and there is a successful technological change story that precedes the start of the Proalcool program in 1975. There is evidence of diminishing returns on the efficiency of the ethanol production process and after 40 years since the introduction of the Proalcool program the highly productive sugarcane ethanol is not competitive with gasoline and remains dependent on government subsidies and gasoline taxes.

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Assessment of Effectiveness of Seoul Metropolitan Area Air Quality Management Plan(SAQMP) using the GAINS-Korea Framework

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Introduction. Air pollution in and near megacities requires special attention because of their high population density and associated impacts. Korea has ambitiously set its 2nd phase (2015-2014) air quality improvement program for the capital and surrounding areas called Seoul metropolitan area Air Quality Management Plan (SAQMP). The air quality improvement targets for 2024 are 30 ug/m³ and 20 ug/m³ for PM₁₀ and pm_{2.5}, respectively. Emissions of PM₁₀, PM_{2.5} are required to be decreased up to 35%, 45%, respectively, from their future baseline level. This research investigated the effectiveness of the SAOMP using the GAINS-Korea framework that is being under development in IIASA MAG program. The analysis includes various special measures, such as cap-and-trade, and EURO standards program, implemented to control emissions over Seoul metropolitan Area.

Methodology. The GAINS-Korea has been developed using IIASA's Greenhouse gas – Air pollution Interactions aNd Synergies (GAINS) modeling framework which is widely used to design and manage smart emission control strategies that can achieve air quality/climate improvements with least costs. To assess the effectiveness of the SAQMP policy measures, four different control scenarios were analyzed as follows;

Sce1, NFC2010 : No further control after year 2010. All controls will be phased-out as their life time reaches

Sce2, CLE2010 : Maintain 2010 level of control until 2025. No more control policies/devices will be introduced

Sce3, SAQMP : Implement all planned control policies and technologies in SAQMP 1st + 2nd until 2025.

Sce4, MFR2025 : Maximum Feasible Reduction by 2025. More stringent controls will be installed and more stringent control policies will be introduced

The GAINS model can assess the impact of emission reductions of sources on air quality in receptor regions based on Source-Receptor(S-R) matrix, derived from a chemical transport model. In order to develop S-R matrix for GAINS-Korea, The CAMx model with PSAT/OSAT tools was applied for January of year 2005 in this study.

Results & Conclusions. The emissions under four scenarios in base year (2010) and future years (2015, 2020 and 2025) were estimated. In 2025, emissions of primary PM_{2.5} will be changed 6(38%), 2(10%), -5(-33%), -8(-50%) ktons/year compared with base year for NFC2010, CLE2010, CLE2025, and MFR2025 scenarios, respectively. The results of emission for the other air pollutants (PM₁₀, NO_x, SO₂ and VOCs) are similar to PM_{2.5}. For SAQMP Scenario was evaluated as to meet the target emission reductions, except for VOCs which indicates fugitive pollutants, such as VOCs, fugitive dust, need additional controls. The MFR2025 scenario showed a significant reduction potential which would reduce NO_x, SO₂, PM₁₀, PM_{2.5}, and NMVOC emissions to 71%, 54%, 44%, 50% and 57% from the baseline projection. The PM_{2.5} air quality from S-R analysis show reasonable range 14.9~36.4ug/m³ with 77% of in-region contribution of SMA. For 2025, air quality can be changed to 38.3 ug/m³ with 80% of SMA contribution in NFC2010, or to 33.4 ug/m³ with 64% of SMA contribution. The not only in-region efforts but international cooperation should be important because out of SMA region contribution of PM_{2.5} is more than 70% in January 2005 case.

Potential sustainable locations for photovoltaic (PV) water pumping systems

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Introduction. In China, the grassland area is nearly 4 million km², accounting for more than 40 % of the national land surface. It plays a key role in achieving sustainable development and enhancing food security of the country since 100 million livestock is grown with forage from those areas [1]. In 2009, the Asian Development Bank (ADB) supported Qinghai Province to develop and demonstrate pasture conservation through the innovative use of photovoltaic water pumping (PVWP) systems for irrigation [2]. The aim of this project is to identify the suitability and optimal location of grassland areas for the implementation of PVWPs across all China.

Methodology. The suitable grassland areas for implementing PVWP technology were evaluated by assessing spatial data on land cover and slope, precipitation, evaporation and water stress. The optimal locations for installing PVWP systems were evaluated on the basis of two different approaches: a) based on the benefit cost ratio (BCR) methodology; b) with the help of IIASA's renewable energy systems optimization model BeWhere [3], an optimization model for localization of bioenergy production facilities.

Results. The suitable grassland areas represent about 25% of China's total grassland area. The estimated suitable grassland locations were compared with previous assessments following an approach by ADB. The comparison shows a significant disagreement in the spatial distribution due to the lacking consideration of the spatial water stress factor in the ADB approach. The analysis of the optimal locations according to the BCR methodology shows that the location profitability is very sensitive to the depth of ground water resources and potential forage production. The BCR is also affected by the optional surplus electricity generation with the PV systems. Results from the BeWhere model indicate that forage produced under irrigation from PVWP systems is presently only competitive at high forage prices, mainly due to high investment and transportation costs. The potential forage production from domestic grassland cannot meet the estimated domestic demand but the imported volumes. Finally, hybrid maps functioning as a basis for optimal planning of PVWP systems were developed to provide a handy tool for policy makers, farmers, investors and consultants interested in solar pumping applications.

Conclusions. PVWP systems can become a crucial part for optimal solutions to support the sustainable development of the agriculture and livestock sector in China. The potentials of PVWP systems in China is large. Nevertheless, the suitable and optimal locations are sensitive to important environmental and economic parameters, such as forage water requirements, ground water depth, grass price and subsidies that need to be carefully taken into account in the planning process.

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Development and Application of an Improved Tool for Renewable Resource Modeling in MESSAGE

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Introduction. Integrated Assessment Models (IAMs) such as MESSAGE provide a global view of energy supply and demand and its associated greenhouse gas emissions for decades into the future. While this model framework enables long term system level scenario analysis, it lacks temporal and spatial resolution to endogenously simulate the variability of renewable energy resources (VRE). Facilitating VRE integration requires various electricity system services and investments for grid balancing, which should be accounted for in high VRE deployment scenarios. This paper aims to account for these additional VRE integration requirements in MESSAGE by parameterizing three generalized variability time scales. Different storage technologies can facilitate VRE integration at each of these time scales; as such a detailed representation of storage technologies techno-economic characteristics is implemented.

Methodology. Distinct VRE variability time scales were incorporated into MESSAGE through three constraints: a short-term constraint to represent primary or regulating reserves, a flexibility constraint to represent secondary and tertiary reserves (load following and ramping), and a long term constraint to represent seasonal variability. Short-term (or operating) reserve requirements are required for inertial response, frequency regulation and control, and fast automatic balancing; flywheel and battery technologies have a fast response time which allow them to balance the short term variability. Pumped hydro and compressed air energy storage facilities typically have a power and energy capacity commensurate with hourly-daily storage, enabling them to provide load following and ramping services. Finally electrolysis combined with hydrogen gas storage can store energy over the course of a season to balance long term renewable resource variability. The impacts of the new variability constraints and storage technology profiles were tested for impacts on VRE deployment, storage deployment, VRE curtailment, and system costs. Finally scenario analysis explore the impact of storage technology techno-economic sensitivities as well as external factors such as demand side management, transport-sector developments, and carbon price.

Results and Conclusions. Preliminary results show less overall storage deployment in mitigation (450ppm) scenarios extending to 2100 as a result of the proposed implementation. This is largely due to disaggregation of low-cost storage technologies with tight potential capacity bounds from high-cost storage technologies which are eventually deployed. Accounting for this cost-capacity relationship results in higher incremental storage costs by the end of the period. Interestingly, this decrease in storage deployment does not limit VRE deployment, indicating that storage technologies are deployed to provide system flexibility rather than mitigate VRE curtailment. Sensitivities on storage techno-economic assumptions have a large influence on both the timing and quantity of storage and VRE deployment. This analysis points to the importance of treating the unique impact of VRE deployment on the electricity system in IAM scenario analysis which forecast large VRE market penetration.

Analysis of a Multi-factor Control Model for Resource Productivity in China

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Introduction. Natural resources function as a material foundation for the world economy and nowadays have become a critical issue for sustainable development. The simplicity of the GDP output per resource input ratio makes resource productivity an appealing and widespread environmental sustainability indicator. The goal of this project is to construct an adequate aggregate model of China's economy for 1980-2010, and then carry out retrospective analysis of sensitivity of resource productivity with respect to variations in investment scenarios based on the model.

Data and Methods. Economy-Wide Material Flow Analysis (EW-MFA) and derived indicators focusing on the whole economy have been established as the most widespread tools useful for monitoring a vast range of issues related to consumption of materials. Data on EW-MFA indicators of Domestic Extraction Used (DEU) and Domestic Material Consumption (DMC) are from worldwide database of SERI and UN Comtrade for 1980-2010. For modelling, multi-factor economic growth model have been used with classical production factors such as capital, labor and technology, incorporating natural resource as an additional production factor. Data on labor, R&D expenditures and GDP are obtained from China Statistical Yearbook. Data on Capital stock are from estimation of literature.

Results and Conclusions. First we construct an adequate aggregate economic growth model of China's economy for 1980-2010, the model's mean error in GDP is 5.5 percent. And we assume that exploitation of natural resources is also related to these classic production factors such as capital stock, labor and R&D stock. The resource extraction model's mean error is 3.4 percent. Second, in order to increase resource productivity by 1 percent on average in 1980-2010 investment in capital goods could have been increased by 1.5 percent or investment in technology by 0.09 percent, that also means in terms of quantity of money, investment in capital goods and technology could have been increased by average 400 and 24 hundred million yuan in constant price 1980 per year during this period of time. Third, we can obviously see resource productivity and resource domestic extraction are both more sensitive to technology investment than capital investment. Besides, we find potential impact of quantity of resource extraction is subject to this sequence: Non-metals> Metals>> Biomass> Energy in improvement of resource productivity. But on the contrary, when importing materials from ROW.

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Quantifying the Impact of R&D Investment on Energy Pathways for Sustainable Development

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Introduction. Chapter 17 of The Global Energy Assessment (GEA) (Riahi et al. 2012) identified three key branching points in the transition to a low carbon energy system: energy efficiency, transportation system electrification, and the composition of the supply side portfolio. While GEA sustainability objectives are easily achieved in a low demand, advanced transport world, there is evidence that society continues to focus on supply side measures despite significantly higher returns to demand side investment (Wilson et al. 2012). This research examines the welfare impact of R&D investment on the supply side across a range of demand, transportation sector, and climate policy scenarios.

Methodology. A Monte Carlo style sample of eight key parameters of five low carbon energy supply technologies is used to create a set of inputs to the MESSAGE model. The results of these “what-if” scenarios are then combined with elicitation-derived probability information (Baker et al. Submitted to Energy Policy, 2014) to calculate the expected value of key performance metrics. A sensitivity analysis performed across demand, climate policy, and transportation electrification assumptions.

Results. Initial results indicate that the relative impact of supply side R&D investment varies widely across technologies. The capital cost of biofuel plants in particular appears to have a significant impact on welfare (Figure 1).

Conclusions. While research is still ongoing, initial results indicate that a carefully designed supply-side R&D investment strategy can improve welfare while working

within the reality of today’s supply-side focus.

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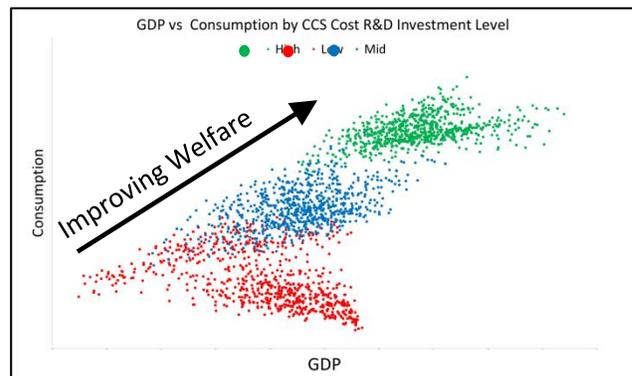


Figure 1: Scatterplot of GDP vs Consumption by R&D investment level shows a connection between R&D funding level and welfare.

Governance of risks in financing concentrated solar power projects in North Africa

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Introduction. A low-carbon energy transition on the basis of renewable energies (RES) is of crucial importance to solve the interlinked global challenges of climate change and energy security. To transform the global energy system, substantial public and private investments will be needed. Yet, especially developing countries are struggling to foster private RES investments. The literature argues that the economic feasibility of a RES investment project hinges on the availability of affordable project financing, which itself depends on perceived risks by investors. Since financing costs are found to be particularly high for capital-intensive RES projects and in developing countries, we investigate the economic impacts of a financial de-risking approach for concentrated solar power (CSP) in four North African countries.

Methodology. First, we investigate the current risk environment and quantify the influence of each risk category as identified by Komendantova et al. (2012) on the overall cost of capital by applying the financing cost waterfall approach (UNDP, 2013). Second, we analyze the direct impact of a de-risking approach on the cost of electricity from CSP in a Levelized Cost of Electricity (LCOE) model. Third, we derive macroeconomic effects of a de-risking strategy by applying a Computable General Equilibrium (CGE) model. Fourth, by carrying out expert interviews, we identify from an investors point of view public and private de-risking measures.

Results. (1) A comprehensive de-risking approach reducing the North African financing costs to European levels leads to a 32% reduction in the average North African LCOE from CSP. (2) The macroeconomic analysis of a 5% CSP target by 2020 in the four North African countries indicates that an ambitious de-risking strategy has the potential to increase GDP on average by up to 0.15% or, in total for the four countries, by up to 1.3 billion USD. (3) By conducting expert interviews with RES investors we learn that investors are aware of concrete investment risks, such as regulatory, political, revenue and market, and technical risks associated with RES projects in North Africa, and of private risk transfer measures to mitigate these risks.

Conclusions. Even though there is a long way to go to achieve a full financial de-risking of RES investments in the North African region, we find a substantial feasible potential for financial de-risking, eventually leading to overall economic benefits for the region. This is a reassuring conclusion, since without de-risking RES investments, the stimulation of the required levels of private investment for a renewables based energy transition to mitigate climate change, increase energy security, and foster economic and human development in developing countries will not be attainable.

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Biomass deployment strategies for the transition to a bio-based economy

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Introduction. The knowledge driven functionalization of biomass can help to diversify our product portfolios for alimentation, material and energy application. Thus it holds the potential to enhance robustness of the systems where applied. In order to outline strategies for the integration and extension of an industry based on renewable resources it is helpful to draw possible relevant developments and to discuss these scenarios with regard to the boundaries of the affected systems.

Methodology. For this work we focus on the substitution of existing fossil based product flows for material applications. This follows the concept of the diversification of the fossil fuel product portfolio with energy deployment from renewables. Substitution pairs for the introduction of biomaterials are determined and investigated with regard to current capacities for their traditional counterparts. These pairs are further disaggregated considering historic trends and future developments described in literature. Consistent storylines are discussed and used to produce scenarios for the EU28 on a member state level for the time frame 2000-2050. In overall the format of the results are chosen to simplify further discussions through enabling the direct integration into the GLOBIOM-model.

Results. Several substitution pairs were identified. Pairs for which information on the historical trend and/or future pathways could be found have been selected for the scenario development. The 2013 reference scenario of the PRIMES-model (Capros et al., 2013) and statistical data from OECD iLibrary (IEA and OECD, 2014) was used to project the fossil based counterpart. Three storylines for the biobased part were discussed finding in one hand the highest theoretical potentials in the substitution of vinyl polymers, polyamides, synthetic rubbers and asphalt and on the other hand the most likely relevance in the substitution of polyester, lubricants and surfactants. Furthermore conversion factors for the production based on eleven feedstocks which can be modeled in the GLOBIOM framework are acquired. Through the application of these factors the major role of wood can be identified. Furthermore palm oil and starch from potatoes can become an important resource for the production of biomaterials as well if production capacities for biomaterials increase.

Conclusions. The used approach and derived scenarios are capable of addressing the main structure, its potential and boundaries of a possible upcoming market, in this case for the diffusion of selected biomaterials. The scenarios can and should be extended with additional existing and/or future biomass applications as well as feedstocks allowing for example also cascaded use to be represented. However since the material application of biomass can be based on the same objectives as bioenergy deployment an integrated knowledge driven discussion for these sectors is recommended not only assisting but also incorporating food and feed deployment. It is to be noted that structural changes in overall demand patterns could not be addressed within this work although they could have similar impacts on the affected systems than the substitution of demanded products.

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Climate change and malaria incidence in South Africa

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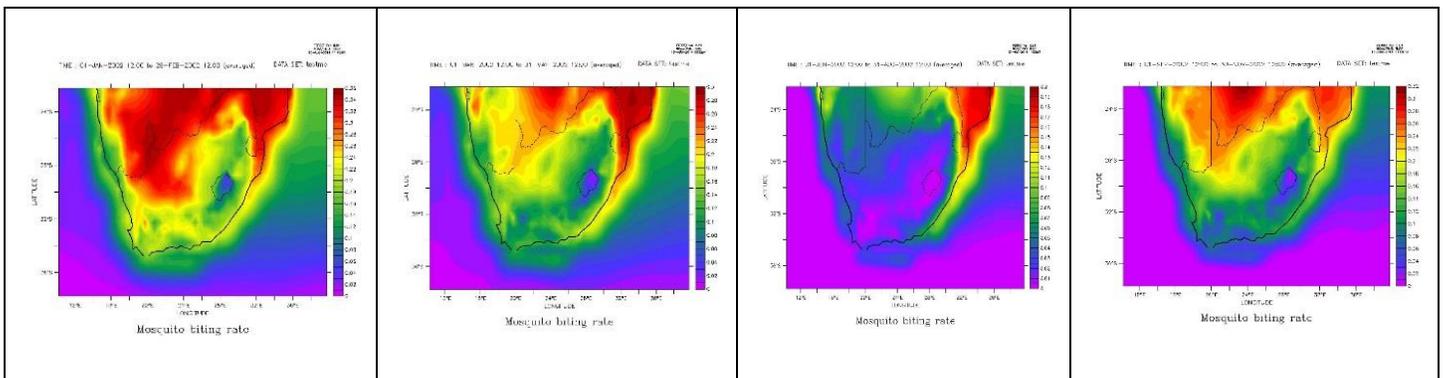
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Introduction. Every year, malaria infects around 200 million and kills over one million people, most of whom are children and almost 90% of whom live in sub-Saharan Africa (Update on Malaria in Southern Africa, 2003). Since mosquitoes thrive better in a warm moist environment, there is a big concern that projected global warming coupled with ecological factors may make malaria parasites spread over more provinces in South Africa or Africa at large, thereby exposing more population to malaria. This study will consider the impacts of temperature and rainfall on malaria incidence.

Methodology. In this study, a mathematical model to study the population dynamics of mosquito is developed. The six compartmental model accounts for impacts of climate (rainfall and temperature) on both aquatic and adult stage of three major Anopheles species responsible for malaria transmission in tropical Africa, which are: *A. gambiae*, *A. arabiensis* and *A. funestus*. Furthermore, the model examines the impact of temperature on gonotrophic and sporogonic cycle, while the mosquito biting rate is also simulated over South Africa for the year 2002.

Results and Conclusion. The population density of each classes show an increase and decrease along with rainfall and temperature in KwaZulu Natal province over 3 years (2002–2005). Also, the simulated mosquito biting rate over South Africa reveals that the biting rate is very high between December–February (summer), moderate between March–May (autumn), very low between June–August (winter) with an increase again between September–November (spring).



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Soybean production in China under climate change: Analysis of the effect of adaptive techniques based on DSSAT and AEZ-China model fusion

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Introduction. Soybean plays an important role in China's food and livestock feeding system. Although this worldwide important crop originates from China, in recent years the demand for soybean products has been increasing much faster than its domestic production. Since the 1990s China began to turn into an importer, and by 2010 some 49 million tons of soybean products were imported, accounting for about 75% of the total domestic consumption. Like most crops, soybean cultivation faces a wide range of production conditions in China and is rather sensitive to climate change, especially temperature and rainfall. Though crop modeling is widely used in China to assess climate change impacts, what we currently lack is the coupling of models across different spatial scales and the multi-scale evaluation of adaptive technologies both locally as well as for different cropping regions and the country.

Methodology. DSSAT (Decision Support System for Agro-technology Transfer) is a site-specific model, which can estimate with the GLUE module (Generalized Likelihood Uncertainty Estimation) crop-specific parameters based on time-series of observed data at selected research stations. AEZ (the Agro-ecological Zones model system) is a widely used tool to simulate suitability and potential production of crops based on specification of so-called Land utilization types (crop species at specified management level) at regional, national or global scale. In this study, we first run DSSAT simulations based on the observations for 22 sites covering the period 1981-2011 to establish the soybean parameters, and upscale site results based on a cropping systems zonation of 2005 using ArcGIS. Using these site observations and DSSAT site simulations, we verify and update the LUT parameterization of the China Agro-ecological zone model (AEZ-China) and produce the spatial simulations for current and future climates.

Results. The R-square between the site observations and simulated results from DSSAT is quite high for both anthesis dates (0.89) and maturity dates (0.95), which are critical parameters for soybean yields. This means the DSSAT site simulations are reliable enough to derive information for updating of the LUT parameters used by AEZ. Though AEZ evaluates all LUTs in each grid cell and usually selects the one with highest yield, this default selection was changed to reflect farmer's choices under multiple cropping, where they prefer to plant short cycle soybean considering the total year-round income from farming rather than only the best possible soybean crop. So we adapt the AEZ optimal crop LUT selection to consider only the short cycle cultivars in areas with intense double and triple cropping system (currently mostly in southern and eastern China). In northern China, in areas with single cropping or limited double cropping, the best performing LUT is chosen to define soybean potential of each grid cell. AEZ simulates multiple cropping conditions based on climate characteristics and this selection rule was applied both for current and future climate simulations. From the spatial results both in DSSAT and AEZ, the climate change will be beneficial to soybean in Northeast China but adverse to the southern part. But DSSAT shows a more markedly decrease in southern part. In both two models, Irrigation helps to slowdown the adverse impact.

Conclusions. In DSSAT model, the same planting date range and fixed cropping zone are used in the future, it should be changed but not considering in this study, so the adverse impact maybe aggravated. AEZ choose the best planting date and the adapted cropping-zone in the future. This need be improved in the future.

Global conservation prioritization of wetland ecosystems: proof of concept of a hydrogeomorphic classification

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Introduction: The rapid loss of biodiversity and limited resources for conservation has made necessary to identify priority locations for conservation. Global prioritization studies have generally focused on terrestrial biodiversity while freshwater assessments have lagged behind (Brooks et al. 2006), despite freshwater biodiversity being degraded at a faster rate than its terrestrial counterpart. Here, I present a classification of wetland ecosystems, which are biodiversity hotspots, over Africa and South America as a first steps toward a global conservation prioritization of inland wetlands.

Method: Habitat classifications are used as surrogates for biodiversity where data is limited, as in the case for wetland biodiversity. Many classification exist for wetland and the most widely used is the one from Ramsar Convention based on ecosystem properties, but global wetland maps do exhibit and equal level of detail. I developed a classification scheme harmonized with the Ramsar Convention's, grouping of classes into hydrogeomorphic superclasses (Semeniuk & Semeniuk (1997). Ramsar Sites of Wetlands of International Importance were used as training sites for decision tree learners based on both geomorphic and hydrologic predictors to classify the entire wetland cover. A rapid assessment of conservation coverage and anthropogenic biodiversity threat (Vörösmarty et al. 2010) across wetland classes is conducted as preliminary steps to a complete global assessment.

Result & Conclusions:: Despite the grouping of wetland classes, the hydrogeomorphic predictors classified wetlands only moderately well. Intermittently inundated classes such as creek and floodplain were particularly poorly represented, which may be due to the uncertain site delimitation, variable quality of reporting, and inadequate predictors. Despite its inaccuracy compared to other global wetland covers (Lehner & Döll, 2004), the classification produced represents a first step toward a global wetland cover consistent with Ramsar's classes. Finally, the cursory assessment showed that wetland types are unevenly protected while differences among threats are more location specific.

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Poverty & Equity

The influence of social heterogeneity and behavior on consumer choices in the transport sector

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Introduction. Energy end-users do not adopt energy-efficient technologies based solely on a cost-effectiveness criterion (Gillingham et al. 2009). This can be explained by engineer or an economist as barriers to optimality and by a psychologist or sociologist as inherent characteristics of real world behavior and decision-making. However, Integrated Assessment Models (IAMs) often represent investment decisions and technology choices as made by a homogeneous and ‘unboundedly rational’ consumer group (Mundaca et al. 2010). This research analyses how behavior of different consumer types, reflected in their vehicle choices, impact the adoption of advanced climate-friendly technologies. Or in other words: How can we represent in our models influences on vehicle choices beyond costs and prices, in order to improve our evaluation of energy efficiency policies?

Methodology. In the IMAGE model, an IAM that simulates the interacting human and natural systems worldwide up to 2100, vehicle choice in the transport sector is represented by a multinomial logit function based on vehicle costs. In this function (depicted on the right) the lambda determines how sensitive the model is to cost differences, and represents heterogeneity.

$$Share_{i,t} = \frac{\exp(\lambda \times Cost_{i,t})}{\sum_i \exp(\lambda \times Cost_{i,t})} [-]$$

i = technology, t = time, λ = lambda

The LDV vehicle choice model is expanded to 27 consumer groups in the United States, which vary in their living environment, attitude towards technology and car usage. For each consumer group non cost factors, representing behavior in decision making, based on the MA3T model (Lin, Green 2011) are added to the vehicle costs. The IMAGE model results are compared to the MESSAGE model in which a similar method has been applied.

Results. Adding non cost factors delays the timing of alternative vehicle technology (e.g. HEV, PHEV, EV, FCV) adoption and their total share in both IMAGE and MESSAGE. Refueling station availability and EV range are embedded in the non costs, forming a hurdle to buy new technologies. In a baseline scenario, all consumer types choose to drive an ICE vehicle. Disaggregating the consumer groups therefore does not lead to more heterogeneity in the vehicle fleet. In a mitigation scenario, where a carbon tax is applied, low GHG emission vehicle technologies are more cost competitive. The consumer groups make different vehicle choices, leading to a more heterogenic vehicle fleet and a longer technology diffusion time. This heterogeneity can be simulated by adjusting the lambda of the multinomial logit in the original model.

Conclusions. Including non cost factors in decision making, that represent disutility’s for different types of consumers, has a large impact on the vehicle choices made in the transport sector. Mitigating GHG emissions becomes more difficult as consumer’s perspective on alternative technologies are an additional barrier to a transition to climate friendly transport technologies.

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Uncertain cultural consequences of global ecological overshoot: how to explore future perspective change and dynamics

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Introduction.

According to Ecological Footprint data we have lived in the state of ecological overshoot since the 1970s. Methodologically the key determinant of overshoot is the carbon footprint that cannot be taken up by natural systems and therefore accumulates in the atmosphere, driving climate change and indirectly other related issues, such as resource degradation, biodiversity loss and soil erosion. Mainstream Global Environmental Assessments and Ecological Footprint scenarios which employ modeling and quantitative scenarios consistently fail to incorporate complex dynamics and feedbacks in integrated human-earth (or cultural-ecological) systems. This poses the following research questions: how to include culture and behavior (social values and norms) in a quantitative climate change model? Cultural Theory has been applied in various modeling approaches, but which specific feedbacks and causal relations in cultural-ecological systems do they include? What are the strengths and weakness of different approaches? And last, what is a promising way forward in this field?

Methodology.

The methodology is a comparative and analytic literature review of existing Cultural Theory based modeling and gaming approaches. General issues of interest are: the spatial and temporal coverage and resolution, the thematic focus and whether processes are top-down or bottom-up. For Cultural Theory it is interesting to look at the conceptualization and operationalization of human agents, cultural biases, negotiation and learning and (climate change) feedbacks.

Results.

The research has shown that broadly speaking there have been two approaches. First there are global models of environmental and climate change that primarily look at how different dominant cultural perspectives produce different scenarios and pathways of climate change. Those models have high levels of aggregation and are only capable of addressing top-down processes. Agent-based approaches on the other hand look at bottom-up processes and therefore allow the analysis of emergent social properties, by including negotiation and learning in response to climate change impacts. The key preliminary result of this research is a conceptual model that integrates both approaches and includes bi-directional relationships and dynamics in a cultural-ecological system.

Conclusions.

All approaches so far exclude the fatalist perspective, which however may account for a significant amount of the general population. If this should be the case, crucial cultural dynamics may be overseen. Current approaches operationalize human agents as global or national policy makers. The way forward is to treat human agents as individuals who make consumption and life-style decisions in a socio-cultural (other agents) and ecological environment which imposes a boundary condition. Different combinations and aggregations of lifestyle choices under different assumption about the boundary condition produce different climate change scenarios, which themselves impact the perceived quality of life, thereby causing cultural changes and dynamics. New approaches should aim for full causal looping.

Carbon capture and storage: a cultural approach to understand experts' views in Finland, Norway and Germany

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Introduction:

The challenge of the transition to a sustainable energy regime is not limited to its engineering aspects and has strong social and political dimensions. In this research, the implementation of Carbon Capture and Storage (CCS) technology is being scrutinized from the perspective of socio-cultural structures and the following questions are addressed:

- What are the experts' concerns about CCS technology projects?
- How do experts from different cultures perceive the risks?
- How do different risk perspectives translate into different approaches to the technology?

By addressing these questions, the authors would like to contribute to the risk governance of CCS by demonstrating *who fears what and why* with respect to CCS.

Methodology:

This research is principally based on the analysis and mapping of the data gathered from: interviews with experts from Germany, Norway, and Finland, and the case study of CCS projects in these countries. The interviews were mapped by applying methods developed by Cultural Theory (1). The experts' perceptions and concerns about CCS are analyzed using Cultural Theory-based discourse analysis (2). Based on this method each "story" "creates a setting (the basic assumptions), villains (the problem(s) and who or what is causing them) and heroes (solution(s) and who or what should be responsible). These narrative components enables researchers to map areas of agreement and disagreement thereby utilized for generating solutions to a wicked problem.

Results and Conclusions:

The CCS discourse in Germany is significantly dominated by hierarchical and, to a lesser extent, egalitarian forms of social solidarity. The discourse in Norway, on the other hand, is mainly dominated by individualistic and, to a lesser extent, hierarchical forms of social solidarity.

By comparing the results of the discourse analysis, an obvious contrast between experts' views in two countries is observed. While the mainstream view in Norway considers CCS as a must, most experts in Germany object the technology by all means. For instance, a scientist who represents the view of a research body in Norway profoundly supports CCS and sees "not doing CCS" as the most significant risk. While, a scientist in Germany, strictly rejects the technology.

According to experts from these case studies, the main issues which should be taken into consideration before the commercialization of the technology are the high cost of the technology and more demonstration projects to identify the risks and the potential mitigation strategies.

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Reproductive Fitness and Differential Mortality: the Role of Social Status

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Introduction. Unlike non-human social animals, social status in humans does not consistently correlate with higher fertility and in some cases appears to suppress fertility. This discrepancy has been used by scholars to argue against the use of evolutionary biology to understand human behavior. However, some researchers have argued that social status and its implications for survival during high-mortality events may indicate that status seeking at a cost to immediate fertility may be an optimal strategy over the long term when such events are frequent (Boone & Kessler 1999). Does the potentially greater survival probability due to status imply a greater number of offspring over the long term under climatic or other disasters with high mortality risk? More generally, how may preferences about the number of children and their social status influence the long-term number of offspring in different environmental situations?

Methodology. We address these questions by developing and investigating a theoretical model of overlapping generations in which each generation makes decisions on their own consumption, the number of children and their education, as well as the bequest to leave to them. We assume that the social status of an individual is defined by her income and education. Each generation faces the dilemma between allocation of resources into rearing more children or into increasing social status of fewer children. The latter solution might be a preferred option in case higher education pays off largely in terms of income. Moreover, higher social status provides better survival opportunities, therefore, in the presence of high-mortality events (such as natural disasters or epidemic), investment in education may pay off even more.

Results. We analyze optimal strategies of dynasties having different preferences towards social status under different economic and social constraints. First, we show that the model yields qualitatively different optimal strategies in case the gap between a minimal and a maximal wages is low and in case it is high. In the former case, the optimal strategy would be to have as many children as dynasty's wealth allows given the rearing costs sacrificing their education. In the latter case though, the opposite is optimal: a dynasty ensures maximal education for children and thus has fewer ones. These optimal strategies remain the same for small-magnitude mortalities as well; however, for more severe conditions it becomes optimal to prioritize allocation in social status independently from economic conditions (the wage gap).

Conclusions. The developed modeling framework helps explain the trade-off between social status and fertility in different economic, environmental and social situations. The analysis reveals robust long-term survival strategies.

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Intergenerational influence on fertility preferences of young women in rural Bihar, India

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Introduction: A wide array of studies, mainly on developed countries has shown intergenerational transmission with respect to reproductive preferences and behaviours. The principle of linked lives (Elder, 1977) states that parental behaviour during the children's life course significantly influences both desires and behaviours of the children also in adulthood. Empirical evidence has confirmed that people learn and incorporate the preferences and behaviours of others. Research on developing countries has shown that living in an extended family is associated with higher fertility (Easterlin, 1978), but so far little is known on intergenerational transmission of fertility preferences in such contexts.

Aim: This paper examines the influence of mother's and mother-in-law's fertility behaviour on young women's fertility preferences in rural Bihar. Since women interviewed in our survey are still in reproductive age, we focus on their fertility preferences.

Methodology: The present study is based on primary data collected during mid 2011 from 450 pairs of mother-in-law (MIL) and daughter-in-law (Index woman – IW) which were co-residing and sharing the same kitchen. The samples were selected from the Saran district of the state of Bihar – a state of the eastern part of India. Desired family size of the IW is dependent variable in the study and it is classified into three categories: low, medium and high. This variable is derived from the most widely investigated measures of desired family size: the Coombs scale, which is found to produce a more accurate indicator of fertility preferences compared to a single-item measure of ideal family size (Jennings *et al.*, 2012; Axinn *et al.*, 1994; Coombs, 1974). Descriptive statistics are used to examine the association between the desired family size of the IW and a set of background characteristics. Ordered logistic regression analysis is used to understand the influence of older generation's fertility and preferences on the desired family size of the IW.

Results: Our findings suggest that both, biological mothers and MIL's fertility as well as MIL's preferred number of grandchildren have an independent and significant positive influence on the desired family size of the IW. However, when other background variables are taken together, only the influence of the MIL's preference remained significant. Among the other predictors, mother's and individual education have an inverse and significant influence on the desired family size of the IW. In the case where index women have much higher education than their mother-in-law, the ideal family size gets smaller.

Conclusions: Two important conclusions could be drawn based on the findings. *First*, social pressure has significant influence on fertility preferences of an individual after accounting for the socioeconomic context. *Second*, index woman with much higher education are more independent in their decision making on childbearing.

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Seasonal life histories in changing environments

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Introduction. Climate change is altering the seasonal dynamics of many species. In this project we examined the evolution of seasonal reproduction schedule of consumer population in stage-structured consumer-resource interactions in changing environments and investigated the eco-evolutionary processes through which individuals with altered seasonal reproduction schedule can invade into resident population.

Methodology. We started our project on a stage-structured consumer-resource biomass model with one consumer population and one resource. The changing environments are modelled by a periodic growth rate of the resource. Adaptive dynamics theory is used to investigate the growth of rare mutant in the environment established by resident population and Floquet theory is the approach to calculate the “invasion fitness”, which is the growth rate of rare mutant.

Results. We consider two evolutionary traits: the starting point and the duration of the reproductive season of consumer population. These two traits divide the year to non-reproductive season, within which the adults are converting all their net-biomass productivity to energy storage, and reproductive season, within which the adults are releasing their energy storage into offspring. On the other hand, it's of disadvantages for adults to reproduce when the resource availability is low for juveniles, otherwise, the juveniles may experience a high starvation mortality rate. On the other hand, the adults can store reproductive energy in their own bodies, which helps the juveniles avoid more severe competition on their resource. Our research shows that if all the individuals are feeding on the same resource, leading to starvation mortality in both stages in winter then the optimal reproductive schedule would be a continuous reproduction all over the year. The reversed case occurs if adults and juveniles are feeding on two separate resources with different seasonal patterns of growth. Under such conditions, there would be significant delays for starvation to occur in two stages (or starvation only occurs in juvenile stage), then evolution results in seasonal reproduction. The latter case is usually altered by climate changes when two resources have different levels of tolerance on climate.

Conclusions. The evolution of the reproduction schedule of consumer population depends on the seasonal patterns of the resources of two consumer stages, which can be driven and affected by climate changes. Our research enables us to assess how populations in seasonal environments will need to adjust their life histories in order to cope with changing seasonal patterns in their environments.

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Research Project: A Projection of Human Capital from Educational and Health Perspectives – A Case Study of Beijing

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Introduction: Education and health are components of human capital. Beijing, as the capital of China, has the best education and high level of population health with the lowest fertility rate (TFR) in China. But great number of population and immigrants, and air pollution hinder Beijing to enhance human capital of both local residents and immigrants. This study wants to project how human capital will change in Beijing to 2050 in different policy scenarios from education and health perspectives.

Questions: How the natural growth, such as fertility and mortality of Beijing could change based on present behavioral and policy trends? How will migration be affected by industrial adjustment for alleviating air pollution? How could air pollution affect human capital, especially the health in the projection model and vice-versa the effects of population change on air pollution in the projection model?

Methodology: The methodology available for projecting change in natural growth is a multi-state population projection model which is developed by IIASA. Based on 6th Census data and Beijing government report and air pollution control plan, scenarios are set up to project the association between migration and industrial adjustment. A model will be used to compute the impact of air pollution on health and mortality.

Results: By changing the “family planning” policy, the number of children increases while in the same condition of migration, the ageing rate will decrease from 32.39% of base scenario to 28.51% and the population will increase from 31.32 million to 35.59 million in 2050. For the mortality, with the strictest air pollution control policy, the life expectancy (LE) extends 3.5 and 4.5 years for male and female respectively. Adjusting industrial structure may make low educated people leave and high educated people move in Beijing. The total migrants during 40 years in medium and low pollution scenarios are 4 million and 7 million less than that in the base scenario. Considering air pollution control, migration administration and birth control policy, the scenario of low pollution and high fertility is regarded as the best one. The projected population in 2050 will be 29.77 million, following the government’s plan. 40.43% of them have a bachelor degree or above. The ageing rate will be 33.57%.

Conclusions: Beijing is far more developed than near cities or provinces. Market cannot coordinate population and air pollution control well so policy plays an important role. With changes in policies of birth control and industrial adjustment for mitigating air pollution, the total fertility rate will get higher and mortality rate becomes lower. There will be less immigrants but with higher education level. Human capital in Beijing will enhance and less population can help improve the air quality.

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Applying EPIC to explain historical changes in soil organic carbon (SOC) stocks in the Roige wetland, China

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Introduction. Wetlands cover 6% of the world's land surface and contain 12% of the global carbon (C) pool. Estimation of C pool is a prerequisite for management and protection of wetland resources and implementation of C sink enhancement plans. The international important Roige wetland is a typical marsh located in the northeast of Qinghai-Tibet Plateau and SOC storage is one of its most important ecosystem services. Since 1970s, management practices such as drainage, peat exploitation and grazing in the Roige wetland may have affected its SOC stock. In order to estimate to which extent SOC stocks were altered since that period, we employ the EPIC model to estimate the change in SOC through time and driving factors of this change. The outcome of this study can be useful for the forthcoming management and restoration of the area.

Methodology. This study consisted of two steps: (1) defining the parameters and input variables for EPIC (30 years), e.g. soil, climate, land cover and land management data, and (2) defining land cover and land management scenarios. The scenarios are as follows: wetland: wetland without drainage and no grazing (WET+NOTDR+NOGRAZ), wetland drained and no grazing (DR+NOGRAZ), wetland drained and in lower grazing intensity (DR+LOWGRAZ), wetland drained and in higher grazing intensity (DR+HIGHGRAZ); grassland: no grazing (NOGRAZ), lower grazing intensity (LOWGRAZ), higher grazing intensity (HIGHGRAZ). Subsequently, we evaluated the main drivers of the changes in SOC stock.

Results and conclusion. Wetland SOC stocks (Fig1.a) are consistently higher than those in grassland (Fig1.b) because wetland soils are subjected to lower aeration and C mineralization. Thereby, in the long term, there is C accumulation in wetland soils which were not drained (WET+NOTDR+NOGRAZ, Fig1.a). Nonetheless, C stock build up is reversed following wetland drainage. In both land cover types, more intense grazing promotes the increase in nutrient input from animal waste, therefore promoting soil fertility and, finally, the increase in SOC stock.

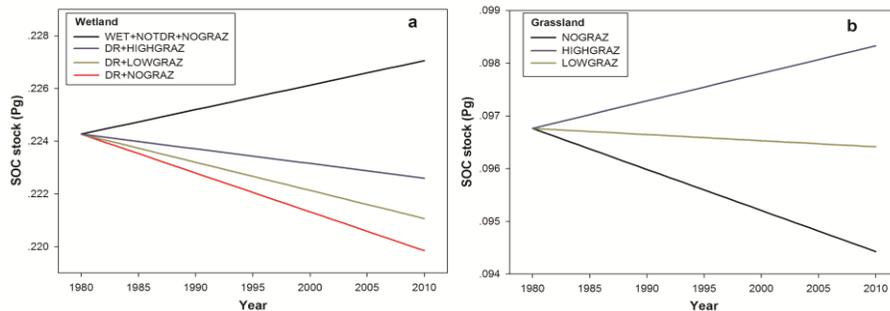


Fig 2. SOC stock change in different scenarios

Drainage is one of the main driving factors for C loss in Roige wetland. And grazing could be benefit to C accumulation. But more researches need to be focused on the boundary of grazing intensity. The outcomes of this study highlight the need for wise land use management to protect wetland, especially the capacity of C accumulation.

A sufficient operating space for development? Reconciling greenhouse gas emissions, life expectancy and access to basic needs.

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Introduction. Human development and climate change mitigation are linked via the consumption of energy services and access to key infrastructures. Where the provision of such services entails an increase in energy consumption and associated carbon emissions, contemporary debates about a “right to develop” take on a central role in informing the plausibility of global climate mitigation regimes. In this project we seek to elaborate on the actual energy and emissions necessary to achieve high development outcomes. The resulting estimates of “development space” are then compared to scenario spaces generated in an integrated assessment modelling framework for achieving climate stabilization at 2°C – in effect revealing the differences between an efficiency-based method of allocating emissions reductions (IAMs) and one which describes only the emissions needed for development.

Methodology. The analysis investigates the bivariate relationship between five overlapping domains of human development (HD) and environmental impact (EC). When defining HD we proceed from the assumption that GDP per capita provides only a very narrow focus on economic activity [1]; thus we also look at life expectancy and calculate a composite indicator for basic needs (comprising access to sanitation, energy, water, education, nourishment and health care). EC is defined as greenhouse gas (GHG) emissions and final energy consumption. We perform multi-year cross-sectional regressions on each pair of HD and EC indicators using functional forms from the literature [2]. The resulting elasticity’s of human development are used to project forward EC for Africa, India/South Asia, China/Central Asia and Latin America. We compare the cumulative EC for each region to a MESSAGE emissions scenario which allocates mitigation effort according to equal GDP-loss.

Results & conclusions. Our results indicate that there is sufficient space in the global carbon budget to accommodate high levels of achievement in human development – but a careful allocation of emissions rights is necessary to avoid regional shortfalls. Of particular note is India/South Asia, where fast growing HD and an insufficiently rapid decoupling rate lead to a significant deficit in the available carbon space required to achieve high outcomes of life expectancy and basic needs access. This analysis calls for further investigation into model parameters that may avoid such a fate, as well as a more detailed elaboration of the links between GHG emissions, energy services and the delivery of human well-being.

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Emergence of shared perception of futures in a foresight system

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Introduction. The understanding of innovation process has shifted from a linear view to a systems approach. As a consequence of this shift, a centralized teleological narrative of societal progress is replaced by the interplay of different competing perceptions of what the futures should be. Even though these perceptions are crucial in shaping the future of the innovation system, the dynamics of how they emerge and change has not gained much attention in the innovation or foresight literature. In order to address this gap, we focused on the following research question: how do shared perceptions about the futures emerge in a foresight system. By foresight system we mean the network of interacting agents set up to catalyze future-oriented insights, decisions and actions.

Methodology. We analyzed the changes in the concepts used during the making of the Finnish government's report on the future. In order to mitigate researcher bias, we used text mining and software generated concept maps to guide the qualitative analysis of material produced during the process. The foresight process was then framed as one sequence of activities in a foresight system. Functions adapted from innovation systems literature were used to analyze the systemic reasons for the identified changes in perceptions as reflected in the concepts used.

Results. The concepts used stayed almost the same during the process. The only notable exception was the introduction of the concept of digital economy from another parallel project in the latter part of the process. Even though the set of concepts stayed the same, their emphasis and framing changed. For example, the discussion around the concept of growth changed from ensuring economic growth while staying in the boundaries set by environment and social equality, to defining sustainable growth, and finally to reframing economic growth as sustainable by decoupling it from material growth. The mode and intensity of interaction between the agents in the system affected these changes, as did the set of agents involved.

Conclusions. The better understanding of what happens in a foresight process and how the foresight system affects this increases the transparency of outcomes. The outcome of a foresight process is not an agreement of what the futures might be, but rather a reflection of the dominant logic used when describing futures. In our conceptual framework, foresight is not just a single process, but a system of agents interacting. This interaction gradually changes the concepts used when discussing the futures. The main contribution of foresight is not in creating new knowledge, but in changing the emphasis and reframing existing ideas by increasing the set of cognitive schemes. This implies that the foresight process should be seen as one part of a continuum of interaction between agents in the system, and a space for bringing new agents and new cognitive schemes into the discussion.

Preferred life expectancy and its correlates among elderly women in rural Uttar Pradesh, India

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Introduction. Life expectancy (LE) is an indicator of individual survival which represents the advancement and gaps in overall population and societal health. Evidence from range of demographic and gerontology works suggests improvement in LE over past few decades across globe owing to progress in medical science, technology, food supply and healthy behaviors. These improvements starkly vary both between and within countries. Increasing life expectancy and declining fertility resulted into population ageing in both developed and developing world. However, there is dearth of scientific evidence regarding that how these advancements in life expectancy relates to personal desire or preference of an individual to live (particularly elderly women) in developing societies. This study intends to examine the association between preferred life expectancy (PLE) - *how long people want to live*- and its selected socioeconomic, demographic, social support and self-rated health status characteristics in low resource setting of rural India.

Data and Methods. Data for the study comes from a field based primary household survey of 300 elderly women (60 years & above) across four villages of Deoria district in the eastern parts of Uttar Pradesh in India. Mixed method approach was used to collect both quantitative and qualitative information to explore the gender dimensions of ageing, particularly preferred life expectancy, financial dependency, perceived health status, economic and social support networks, involvement in community life, etc. Cross tabulations, chi-square test, and nested ordered logistic regression models were used in the analyses.

Results and Conclusion. Data suggest that the mean preferred life expectancy of elderly women was relatively low (5.42 years, CI: 4.96, 5.88). There were significant differences in PLE across demographic and socioeconomic characteristics as elderly women reported lower PLE with increasing age, deprived social caste groups, widowhood, economic dependency, lack of time and support from children, lack of safety in community/society and poor self-rated health. In addition, the adjusted results from ordered logistic model confirms statistically significant and negative influence of age, deprived social caste groups, lack of support and time from children, lack of safety in community/society and poor self-rated health on PLE among elderly women. Findings from this study may address issues related to the on-going debate on to what extent efforts of improving life expectancy per se are really sufficient. It also throws some light on the comparative ad(is)vantages of economic support vis-à-vis social support that influences PLE of elderly women. Results may help to address emerging issues in the field of active and healthy ageing of population, and to understand the circumstances that shaped these notions and expectations of elderly women.

Decomposition of SO₂ and NO_x emissions in the EU: Leakage or technology adoption?

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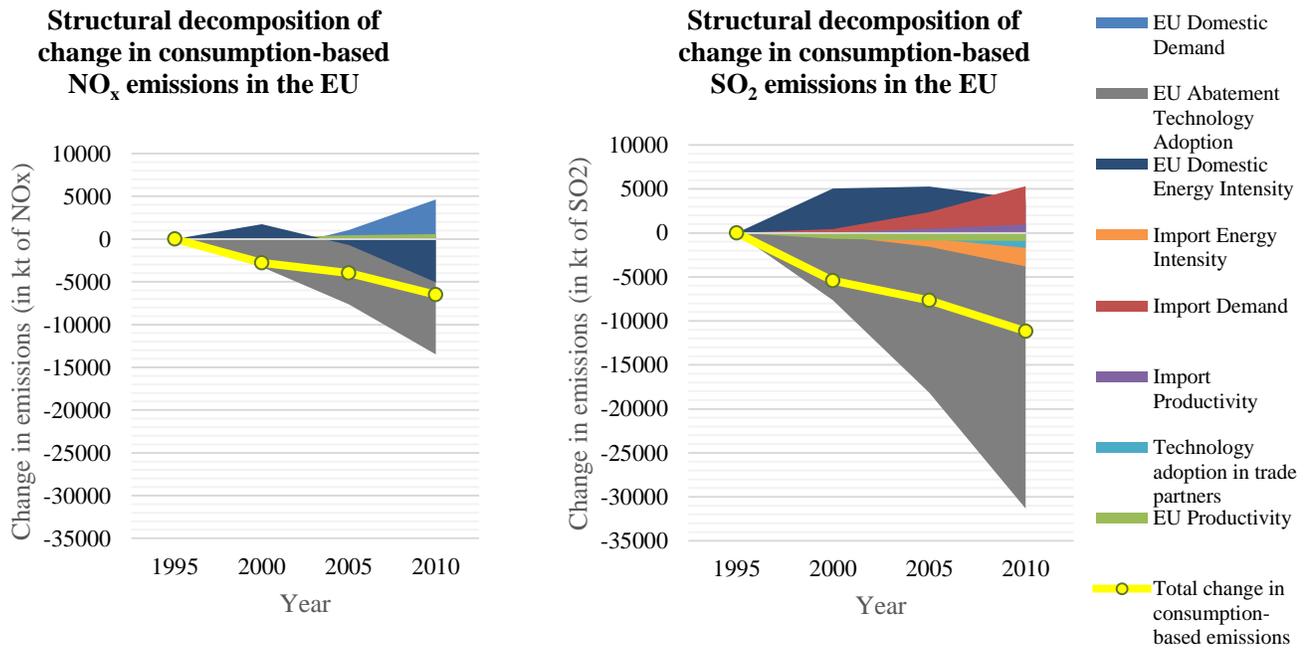
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Introduction. Europe has made remarkable progress in reducing its emissions of SO₂ and NO_x. Using consumption-based emissions in the EU-27 countries over the period of 1995-2010, this research investigates if this reduction has been due to adoption of pollution abatement technology or a relocation of production to other regions.

Methodology. Consumption-based emissions are calculated via integrating emissions data from the GAINS model and input-output table from the World Input-Output Database (Timmer, 2012). Through a structural decomposition analysis, emissions embodied in trade is segregated as those that occur through a change in final demand, an increase in productivity, energy intensity, or adoption of abatement technology.

Results. First, consumption-based emissions in the EU have been decreasing. The structural decomposition analysis finds that a decrease in emissions factor from application of abatement technology within the EU has contributed to most of this decrease as shown in the figure below.



Conclusions

This research finds that a decrease in SO₂ and

NO_x emissions in the EU are primarily due to an implementation of abatement technology. In contrary to existing literature on emissions leakage (Balistreri & Rutherford, 2012), we find that both demand for EU production and EU import increases. An increase in energy intensity in domestic EU production has a positive effect on emissions, while a decrease in energy intensity in imports to the EU contributes to the decrease in emissions.

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Could fertility patterns act as a driver of global migration?

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Introduction. The stock of international migrants has increased to over 230 million immigrants, though the magnitude of migration flows has been relatively stable over the past twenty years¹. These changes in migration patterns are the result of many factors including size, economic production, and demographic composition of countries. Previous research on migration determinants have focused on migration into one or a handful of destinations or used net migration to examine determinants. In this paper, I will use a harmonized global database of international migration flows to investigate the determinants of migration with special focus on the relationship of fertility in sending and receiving countries, which has not previously been studied as a driver of migration.

Methodology. Data on migration flows between countries is merged with macroeconomic, geographic, and other country characteristics. An expanded gravity model is used to examine the determinants of migration flows between origin and destination similar to previous research but with a focus on the role of total fertility rate (TFR)².

Results. Almost half of the migration flows between countries occur from high fertility countries to low fertility countries. When controlling for geographic and macroeconomic factors, high fertility rates in sending countries increase migration, but at very high levels of TFR migration rates begin to decrease. With controls the relationship between TFR and destination is curvilinear, at low levels of TFR the rate of migration is lower but as TFR in destination increases migration rate increases. While the absolute levels of TFR are significantly associated with migration rate, the relative fertility also impacts the migration rate between countries. The migration rate is significantly larger between countries where the flow goes from a high TFR country to a low TFR country than any other direction.

Conclusions. The fertility rate in both sending and destination countries appear to have an independent effect on migration flow. High fertility in sending countries generally increases migration, and high fertility in receiving countries is also associated with increased migration. One factor driving this finding is that although migration flows go to countries with high TFR, migrants are still migrating to countries that have a lower TFR than their origin country. When we look at migration rate by the difference in fertility rates, we see that the migration rate is highest between high fertility sending countries and low fertility destination countries. Migration destinations are more varied than previously, and many emerging economies are attracting immigrants although they have yet to complete the second demographic transition. This indicates some of the impact of fertility on migration may be relative fertility and not just the absolute fertility of origin and destination countries.

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Advanced System Analysis

Signatures of speciation: from theoretical mechanisms to observable patterns

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Introduction. Every living organism contains a unique set of biological information in its genome – genetic patterns resulting from ever ongoing evolutionary processes. These processes are affected by the ecological and biogeographical backdrop experienced by each individual, processes that ultimately might lead to speciation. Although evolution has been studied extensively both from an eco-evolutionary and from a genetic point of view, no theoretical attempt has been made to combine these two factors in a spatially structured system. Here, such a model is proposed with the goal to understand how genetic signals differ between speciation scenarios. These findings are compared with genetic data from a system of endemic finch species in the *Nesospiza* genus on the isolated Tristan de Cunha archipelago. The goal is to disentangle and backtrack the evolutionary history of the finch species from the genetic patterns (Ryan et al. 2007).

Methodology. The individual-based, discrete time model describes the genotypic and phenotypic evolutionary dynamics of sexually reproducing populations in a spatially explicit setting (with two habitats, each habitat containing two resources). Each individual can migrate between the habitats. The phenotype, consisting of one ecological trait and one mating trait, is determined by the individual's genome, allowing for dominance as well as epistatic effects. The ecological trait affects local resource utilization and the mating trait regulates the degree of choosiness when mating. During the speciation process, ecological, spatial and mating differentiation (reproductive isolation) will evolve at different rates and to different degrees depending on factors such as geographic speciation mode and mating preferences (see Dieckmann et al. 2004). To study the genetic patterns, pairwise F_{ST} is used to measure differentiation *between* and π , nucleotide diversity, to measure variation *within* populations. These measures are compared for selected and neutral traits. By varying the ecological settings, comparisons can be made between the eco-evolutionary processes and the emerging genetic patterns.

Results. The main overarching result is that the eco-evolutionary pathways and the genetic patterns are indeed interconnected. Every speciation mode will give rise to a specific genetic “fingerprint”. More specifically, it shows that it should, in principle, be possible to deduce the underlying eco-evolutionary processes between populations with similar ecological endpoints by analyzing the genetic imprint – the genome itself contains information about the path taken. Even if some general patterns can be found in these preliminary results, to fully understand how to deduce process from pattern, extensive statistical analyses have to be done for different settings. In order to test these predictions, the theoretical results can be compared to the *Nesospiza* data set.

Conclusions. Gaining a theoretical understanding of the connections between eco-evolutionary dynamics and the resulting genetic structure is of fundamental importance for interpreting speciation processes. The project will shed light on conditions promoting the formation of biodiversity, and from a conservation biology point of view, the maintenance of evolutionary processes. Understanding the mechanisms underlying the origin of extant species, as well as their recent evolutionary history, may be of paramount importance for their future persistence and the efficiency of species management.

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The Czechoslovak steel industry in a comparative perspective: From scale to efficiency

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Introduction. Globally, the iron and steel industry is responsible for a significant share of final energy consumption (19%) and accounts for about 25% of the CO₂ emissions in the industrial sector, even despite the significant reductions in energy intensity over the last century¹. Yet the current growth in industrial energy use in China and other developing countries and the continuously increasing demand for steel accompanying economic development has overshadowed the past efficiency advancements. Understanding the historical processes associated with steel technology diffusion, capacity growth and energy efficiency change provides valuable information for future scenarios. An in-depth analysis of scaling at both industry and unit level is conducted for Czechoslovakia over a 130-year period, compared to other major steel producing countries and linked to the available data on energy efficiency of the sector. The major aim is to identify whether the regime change (from market to centrally-planned economy) in Czechoslovakia did have an impact on the domestic iron and steel industry, by looking into a number of industry indicators across time and space.

Methodology. To analyze the historical patterns of growth in various steel production technologies, logistic growth functions are fitted for the historical data on industry size and individual furnace size with the help of IIASA's "Logistic Substitution Model 2" software. The adoption path of each steel production technology in the 'core' (the early adopters of new technology) and 'rim' (the followers) countries and Czechoslovakia are then compared. Furthermore, using the logistic fit parameters (saturation level in tons: K, or the 'diffusion time' in which the technology increased from 10% to 90% of K) allowed for further comparisons across regions and other non-steel technologies. For the energy efficiency analysis, Malmquist productivity index was calculated for Czechoslovakia and a panel of 8 countries comparing the countries' energy input and steel output across the past 50 years.

Results. At the industry level, the steel technology diffusion followed a similar pattern as the 'rim' countries with delayed but faster diffusion of steel technology, with the exception of basic-oxygen process (BOF). This is likely due to the technology lock-in in previous dominant technology, the open-hearth (OH). The pervasiveness in the utilization of this 19th century technology (OH) to meet the growing demands of a centrally-planned economy was also seen at the size of the individual furnaces. As other countries were phasing out the OH to adopt modern BOF methods, Czechoslovakia was, in fact, increasing the average capacity of its OH furnaces while continuously improving their efficiency. Consequently, despite the use of this 'outdated' technology, the energy productivity of the Czechoslovak steel sector operated only some 20% below the efficiency frontier and particularly during 1960-1973 Czechoslovakia was able to move closer to the most efficient steel producing countries. The results have not identified any major impact of the changing political regime in the iron and steel industry, although certain technology lag could be, to some extent, linked to the characteristics of central-planning and its extensive growth strategies. Contrary to expectations, the energy efficiency of Czechoslovak steel was comparable to its Western counterparts.

Conclusions. Improving energy efficiency in industry has been identified as one of the "most cost-effective measures to help supply-constrained developing and emerging countries"¹ meet their future material demands. This case study has shown that Czechoslovakia, despite a certain technological lag, managed to operate at relatively high energy efficiency levels, therefore the potential for developing countries to reduce their industrial energy use does not necessarily require immediate adoption of advanced capital-intensive technologies.

¹ IEA, Tracking Industrial Energy Efficiency and CO₂ emissions, 2007

Systemic risk of overlapping portfolios in the Bank-Firm credit market of Spain

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Introduction: Much of the analysis of economic and financial links has focused on the study of one mode network (e.g., interbank network, production network). Here we instead look at a bipartite structure of credit network between two different modes representing two different sectors, banks and non-financial firms with a particular attention to a unique dataset of Spain from 1997 to 2007. In our study, the structure and temporal change of Spanish credit network as well as the systemic risk of overlapping portfolios are empirically analyzed using the tools of method of reflections, network analysis, and eigenvalues analysis.

Methodology: First, we employ method of reflections (Hidalgo and Hausmann, 2009²) to investigate the original bipartite structure of the network. The diversification in lending contracts of banks, the ubiquity of borrowers, and the recursive effects between banking sector and firm sector are focused. The key advantage of this method is that we do not have to take the projection of the original bipartite network. After that, we take the projection matrices of overlapping loans between banks and between firms, and analyze the network structure of those matrices. Although we turn off the internal links within each mode (i.e., we do not consider interbank network and production network in our study), credit relations play as an alternative channel of contagion and indirect links. For instance a defaulting firm may have impact on all co-financing banks. Similarly, a lender having a liquidity problem may in turn have a negative impact on lending to its borrowers. Last but not least, in order to detect the principal components in Spanish credit market, we analyze the leading eigenvalues of bank-bank projection matrices and their corresponding eigenvectors (Kyriakopoulos et al., 2009³). From this, we calculate the eigenvector centrality indices, the main components in eigenvectors, and the corresponding ranks of banks for each year. We also investigate temporal change of the main components over the years in order to detect the evolution of credit market from banks' side.

Main Results: Using the tools of method of reflections and recursive analysis between banks and firms, we found that there is a gradual change in the credit relations between banks and firms from 1997 to 2007. The diversification of banks and ubiquity of firms are equivalent to the degree of banks and degree of firms, respectively. A majority of firms have less than three lenders, and the maximal number of loans receiving from banks is ten. In contrast, the degree distribution of banks is much wider, heavy-tailed, and approximated by power laws. We also observe a positively significant dependence of bank degree and the average degree of other banks who finance a same borrower to bank. In addition, rapid convergence to a huge number of nodes in recursive effects analysis after few rounds of reflections shows the danger of risk of contagion from one mode to the other mode as well as from one node to other nodes in each mode.

The findings from network analysis show that the adjacency matrices of projection matrices are very dense, indicating highly connected between banks and between firms through the original credit bipartite network. We also found the evidence for the existence of clustering and hierarchical structure in projection matrices. Big banks play as the hubs of credit market in both bipartite and projection networks. In addition, breaking down firms into different sectors, we obtain some dominant sectors attracting more credits from banks.

From eigenvalue analysis, we found that there is an increasing trend in Spanish credit market from 1997-2007. In particular, looking at the evolution of eigenvalues of bank-bank projection matrices, we found a significant increase in the largest eigenvalues from 1997 to 2007, especially from 2001 to 2007. In addition, because each element of each bank-bank projection matrix indicates the number of overlapping loans, the increase in the largest eigenvalues illustrates the increase in overlapping portfolios of external assets between banks. This also indicates the increase in the risk of contagion. Moreover, from our analysis of main components of eigenvectors corresponding to the largest eigenvalues, we observe a list of main banks. They are the main lenders in the Spanish credit market but face higher systemic risk of overlapping portfolios.

Conclusions: Our study contributes to gather empirical knowledge and evidence of the structure and temporal change of a specific credit network and to compare with existing findings from other countries. In addition, in our best knowledge, this is the first study detecting systemic risk of overlapping portfolios by using eigenvalue analysis. The empirical knowledge from this research direction is not only important to better understanding the issues of risk of contagion in banking system and in real economy, but also a prerequisite for realistic models of Bank-Firm interrelations in the area.

²Hidalgo and Hausmann (2009), The building blocks of economic complexity, *PNAS*, vol. 106, no. 26

³ Kyriakopoulos, Thurner, Pühr, and Schmitz (2009), Network and eigenvalue analysis of financial transaction networks, *Eur. Phys. J. B*, 71, 523–531

Coupling ecological and social network models to assess ‘transmission’ and ‘contagion’ of an aquatic invasive species

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Introduction. Network analysis has been employed to answer a variety of economic, ecological, social, and epidemiological questions, but novel approaches that combine multiple models are needed to better understand how these varied, complex systems are interconnected and influence one another. Understanding how humans use natural resources is critical for effective resource management, and understanding how an ecosystem responds to disturbances, whether intentional (e.g., stocking fish species) or unintentional (e.g., introduction of a non-native species), allows managers to make proactive, rather than reactive, decisions. The objectives of this project were twofold; first, develop a method for coupling social and ecological network models so that they may be used in tandem, and second, use these models to assess both how humans aid the movement of an aquatic species and what effects this species has on an ecosystem after introduction.

Methodology. The Salt Valley region in Southeastern Nebraska, USA, contains 19 flood-control reservoirs comprising variable fish communities and stocking regimes. The non-native Chinese mystery snail (*Bellamyia chinensis*) was first recorded in the USA in the late 1890s, and is established in 5 of the 19 reservoirs. I adapted the framework of infectious disease models to combine existing social and new ecological network models for this region, enabling us to assess both how angler movement among reservoirs aids in the spread of invasive species, and how the introduction of *B. chinensis* affects energy flows within individual-lake food webs. Directed networks of angler movement among reservoirs informed us how humans are moving around the region (Figure 1). We constructed static mass-balanced ecological networks depicting energy flows within each reservoir using Ecopath and then introduced *B. chinensis* (Figure 2). Using Ecosim, we ran a 25-year simulation to evaluate how its introduction and subsequent population growth affects biomasses of each species or functional group, as well as energy flows.

Results and Conclusions. The simulations showed that mid-trophic level fishes are most susceptible to decreases in biomass after a *B. chinensis* invasion, while higher and lower trophic levels generally increased in biomass. By simulating the timeline of invasion using the concepts of “infected”, “contagious”, and “susceptible” reservoirs, and by coupling the social network to determine “transmission” rates, we identified reservoirs that act as source populations as well as currently uninvaded reservoirs that will cause the most harm if *B. chinensis* is introduced. This case study demonstrates the applicability of combining both social and ecological models to address an interdisciplinary problem within a complex, social-ecological system and can be applied to numerous non-native species.

Figure 1. Directed network of angler network

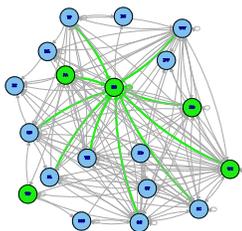
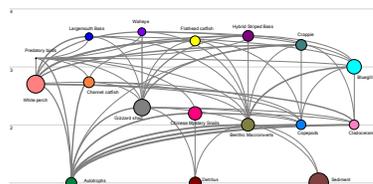


Figure 2. Example of a mass-balanced ecological movement in Salt Valley, Nebraska. A network was created for all 19 reservoirs.



Impact of shocks on the global seafood trade network

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Introduction. Global trade can allow countries to overcome regional shocks to food supply, but reliance on international food trade exposes a country to higher risks of being impacted by external perturbations. Countries which are nutritionally- or economically-dependent on international trade of a commodity may therefore be adversely impacted by such perturbations (D’Odorico et al. 2014). This project investigates how the global seafood trade network responds to environmental and policy perturbations from two angles: first, by studying how negative local impacts such as the collapse of a regional fishery propagate through the trade network, and second, by evaluating how trade flows are redistributed under shock scenarios using an economic model. The implications for food security will be examined by comparing changes in national fish supplies to indices of each country’s economic and nutritional fish dependency.

Methodology. The global seafood trade network was reconstructed from the United Nations Comtrade database (UN Comtrade). A simple model was developed where shocks are propagated through the network as a function of the original trade flows. The propagation of the shocks are assumed to occur on a relatively short time scale so that fishery production is fixed. The degree and location of shocks were varied, and resulting impacts on fish supplies were summarized to evaluate the vulnerability to external shocks within the network. These results were then compared to economic and nutritional dependency on fisheries, computed using data from the Food and Agriculture Organization of the United Nations.

Results. The preliminary results from the simple spread model, which does not include GDP, show the largest percent of the shock ending up in Southern and Western Europe and Central Africa. These same regions tend to also experience the largest per capita decreases in fish supply under the shock scenarios. When individuals in the network attenuate part of the shock at each time step the decreases in fish supply are spread out more among the regions, with the largest importers in the network absorbing a larger share of the shock. With this simple spread model, there were no regions with both a relatively high vulnerability to fishery shocks and a high dependency on fisheries. This does not mean that the impacts in absolute terms do not have adverse impacts. These results may change when GDP is incorporated and when the model is implemented with country-level data.

Conclusions. As the food system becomes increasingly globalized, a better understanding of the food security benefits and risks is needed. This study provides a first step toward quantifying regional vulnerabilities to perturbations within the global seafood trade network.

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An urban metabolism and carbon footprint analysis of the Jing-Jin-Ji regional agglomeration

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Introduction. The Jing-Jin-Ji region (including Beijing, Tianjin, and Hebei province) is the most active and developed area in northern China. Although this region has developed rapidly, it has also encountered problems such as excessive resource allocation accompanied by growing environmental damage. Therefore, it is important to analyze how the three regions interact with each other, and what are their roles in the agglomeration development. The objectives of this research are 1) comparing how the energy consumption and carbon footprint of different sectors in three regions changed from 2002 to 2007, 2) quantifying the metabolic roles of each region in their agglomeration, and 3) identifying energy efficiency options for each sector that reduce a carbon.

Methodology. In this research, we will base on the data from *China Energy Statistical Yearbook* (NBSC, 2000-2002, 2007) and the multi-regional input-output tables in 2002 and 2007. Fig. 1 shows the conceptual model for how to calculate the embodied energy consumption for each sector, some detailed equations can be referred to Zhang et al. (2014). Using the carbon-emission coefficients, we can also account for the sectors' carbon footprint.

Results and Conclusions. The embodied energy consumption for the whole Jing-Jin-Ji was 260.47×10^7 tce, in 2007, it increased to 298.78×10^7 tce (1.15 times the value in 2002). For the regions, the embodied energy consumption of Hebei was the largest in both time periods, followed by Beijing (Fig. 2). Comparing the consumption in two time periods, Hebei increased fastest, its consumption in 2007 was 1.58 times that in 2002, then was the increase of Tianjin (the value in 2007 was 1.10 times that in 2002). The energy consumed in Beijing decreased, the consumption in 2007 was only 56.1% of that in 2002. For sectors, the three industries sectors (sector 2) consumed the most energy in each region, then was other services sectors (sector 5, except that in Hebei in 2002 and in Tianjin in 2007) and construction sectors (sector 3). Therefore, Hebei should pay more attention to energy saving, especially for the industries sector, from 2007.

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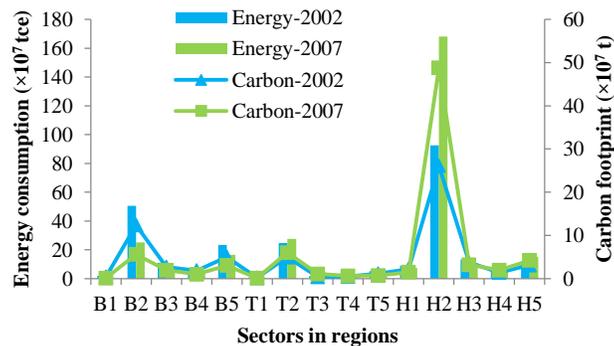
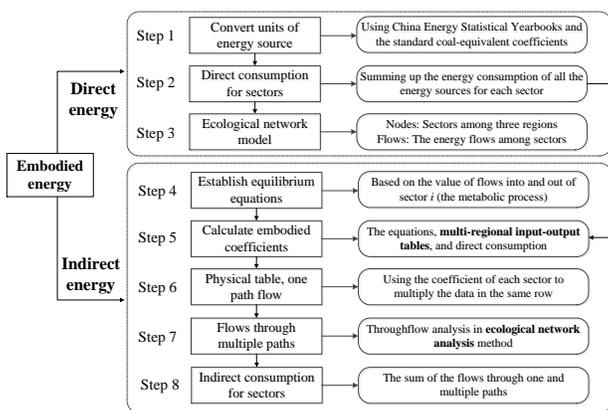


Fig. 1 The conceptual model for embodied energy accounting

Fig. 2 Energy and carbon consumption in 2002 and 2007

A model of size-structured population with asymmetric competition for resource: a case study of forests

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Introduction. One of the ways to study the dynamic of biology species is based on the structured models (L.A. Krumholtz, 1948). In these models, one or more variables of the individuals, like age, size, allow us to show the effect of the physiological state of the individuals on the population dynamics. At the same time, the evolution of the population is determined by so-called vital functions, like mortality, reproduction and growth rates. These functions (growth, mortality and reproduction rates) depend on the functional used to describe the competition among individuals. It determines the adaptation of the model to the real behavior of the species. In many cases, size of individuals has more influence on the evolution of the population than age. The ability of individuals to survive and reproduce depends on it. It gave rise to the consideration of the size-structured mathematical models. Based on the well-known McKendrick (1926) equation for age-structured populations, the dynamics of the size-structured population can be described by the partial differential equation discussed by Metz and Diekmann (1986).

Methodology. The case of forest is the main object of our study analysis of the size-structured population. We assume that a diameter-distributed forest is fully characterized by the total number of trees and the distribution of their diameters, and that each tree is influenced by other trees through competition for light. The competition is affects vital functions and measured by the sum of crown projection area of the trees. It is asymmetric, namely, the higher trees shade shorter ones by depriving them from a part of the light available from the sun. By the competition growth, the growth and birth rates are not increasing while the mortality rate is not decreasing. It is also assumed that the influence of this growth is more affect on smaller size individuals than on bigger one. Growth and mortality rates functions are calibrated using data tables for pine stand, and birth rate is proportional to the projection of the crown area. We show that for any nontrivial initial data the solution converge to a steady state for any given exploitation intensity.

Results. We analyze, from a numerical point of view, some properties in the evolution of a population of size-structured forest. We show numerical algorithm to study the dynamics of a population which use idea of fixed point. With this technique we find the stationary solution of model and study the behavior of the population in order to evaluate the values and deficiencies of the proposed model.

Conclusions. We developed numerical algorithm to find the stationary solution of size-structured model. The algorithm is applied to the pine stand.

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Improvement in Optimal Forest Management Model for Climate Change

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Introduction: More than 63% of South Korea is covered with forest. Recently, most of the forests (69.5%) in South Korea between age of 20 and 40 years have become very dense and competitive for trees (Korea Forest Service 2011). Therefore, we need an optimal forest management plan for solving these problems. To establish a forest management plan, we need a forest growth model considering future climate change and a model to predict changes of the forest done by the forest management plan. I, during my time at YSSP, tried to improve the existing forest growth model and research algorithms of G4M so it can be adapted to South Korea.

Methodology:

A. Improvement of forest growth model for Climate Change

I developed a radial growth model (equation 1) by considering topographic and climatic factors. The model was developed using growth data obtained from 43,532 individual trees at 3,357 National Forest Inventory (NFI) plots

$$\Delta \hat{r}_i = \Delta r_{i-5} \cdot \left(\frac{age_i}{age_{i-5}} \right)^b \cdot \left(\frac{eSG}{meSG} \right) * eSG = \beta_1 \cdot WI^2 + \beta_2 \cdot WI + \beta_3 \cdot PEI^2 + \beta_4 \cdot PEI + \beta_5 \cdot TWI + Int \quad (1)$$

meSG: mean *eSG*, *WI*: warmth index, *PEI*: precipitation effectiveness index, *TWI*: topographic wetness index

B. G4M model study and simulation

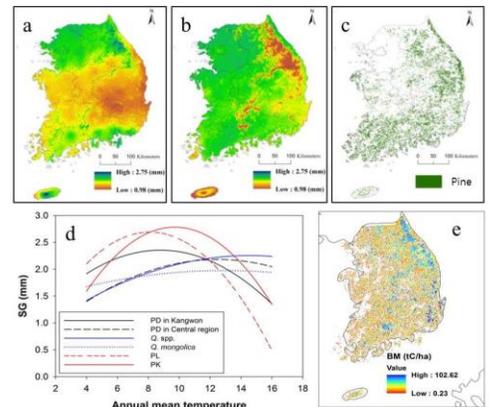
I revised some coefficients of tree growth equations in G4M using yield tables which was made by Korea Forest Service. In addition, I classified the forest area into 2 criteria.

Results.

The growth model developed in this study successfully described the relationship between radial growth patterns of each tree species and climatic factor (d).

The growth model reflects the actual growth distribution of pine trees in high accuracy and even estimated regions with low growth rate of pine tree where there are actually no pine trees (Fig. a, b, c).

G4M model result is reasonable considering the current status of forest area in South Korea (Fig. e).



(a) Current *eSG* of *P. densiflora* from previous growth model (Byun *et al.*, 2013), (b) from our model and (c) actual distribution of *P. densiflora*, (d) The correlation between tree growth and annual mean temperature, (e) estimated stocking stem carbon using G4M more abundant forest than South Korea until 1970s.

Forest management in recursive dynamic global partial equilibrium model

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Introduction. Large-scale partial equilibrium models have a problem of numerical description of forest age class dynamics and representation of forest management in global (partial) equilibrium models (Hertel et al., 2009), (Havlik et.al., 2011). Natural conditions (site productivity) and forest management (species composition, rotation length, thinning intensity) determine age structure of forest and current forest productivity. Having age structure of forest, its growth function and forest management options (e.g., several rotation lengths) we can estimate forest productivity development.

Methodology. We develop forest management model applied linear programming. We use predefined forest management options estimated in G4M (Kindermann et al., 2013)) to choose optimal volume of harvesting for each simulation period. Forest age structure and biomass is updating n according to the chosen forest management option and passed to the next optimization period. In fact these forest management options are modeled in the dynamic global forest model G4M therefore G4M input data and modeling results, in particular, are used for parametrization of the FM module.

Results. We developed a forest management model which includes 16 age cohorts. Each age cohort contains data about forest area, biomass growing stock per ha and sawn logs potential per ha. Wood demand and wood prices are given endogenously. The aim of the model is to maximize forest revenues every simulation period. Simulation period duration is 10 years. Rotation time for forest is endogenous also but final decision in which age cohort wood will be harvested model do by itself. All calculations are done on country level. For some countries we use real age structure distribution if that kind of data is available. If we don't have age distribution within country we assume that we are dealing with normal forest.

Conclusions. Availability of age structure distribution allows to make more accurate estimation of where forest was harvested or where we can harvest it. Also through rotation time we can experiment with different forest management practices and regimes. Very important issue is finding proper data to estimate forest growth correctly which will provide the realistic results of the model.

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Urban energy systems and their increasing importance in global long-term energy strategies

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Introduction. Major news stories about energy and climate change recently have mainly focused on the national or global scale. However, cities are likely to play a growingly significant role to improve energy efficiency and decrease emissions. To identify the influence of urban form on energy, this research set three research questions: 1) What are the key driving forces influencing a shaping urban form? 2) How has the pattern of urbanization and urban density been changing over time in different regions? 3) What is the relationship between urban density, urban residential energy consumption, and income level in select regions?

Methodology. In a first step a literature review was carried out to understand possible urban patterns and identify the relationship between urban forms and energy use, as well as policy options for improving the efficiency of urban energy use. In a second step, trends in urbanization patterns and urban density across regions and over time were analyzed. Finally, quantitative analysis, exploring broad trends and relationships, was undertaken to identify how urban population density relates to urban residential final energy consumption, and to investigate the relationship between those two factors and urban income levels.

Results. The initial literature review identified that most previous studies focused on the relationship between urban form and energy demand in the transport sector. In terms of urban scale and land use, the driving forces for growing energy use explored in the literature include 1) travel time budget, 2) income, 3) technologies. In the second stage of the study, quantitative analysis focused on regional urban population growth patterns and identified that most of population growth will occur in Asian region, specifically in China and India. The urbanization pattern in these regions differs significantly, as much of urban population growth in these regions is in larger cities (more than 10 millions) compared to other regions. In the third stage, further analysis suggests that the higher population density has accompanied higher income growth in these regions. As a result, growing urban population density has occurred alongside decreasing or relatively unchanging urban residential energy consumption per capita in these countries.

Conclusions. Urban populations in Asia, specifically China and India, are rising significantly. The driving force of new urbanization patterns in these regions is a growing focus on more social activities rather than simple economic activities, which was the case in the past. Growing urban population density in China and India has been accompanied by a transition to the use of more efficient energy technologies and infrastructures, which is in part a result of higher income levels. Therefore, the preliminary findings of this work suggest that higher urban density encourages technological transition and tends to lead to a more energy efficient urban residential sector in developing regions.

How to improve air quality in China: a policy scenario study

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Introduction. Recently, Beijing, Tianjin, Hebei and surrounding regions frequently suffered from severe air pollution and regional haze (Zheng et al., 2014). Reduction of coal use and/or its substitution has been recently considered as one of the strategies for air pollution prevention. While historically more efforts were directed at power sector, in this study we explore the potential air pollutants reduction benefits from natural gas substitution strategies in power plants, residential combustion, and industrial boilers sectors in Jing-Jin-Ji Region. And also we carried out sensitivity tests for potential role of ammonia emissions in haze episode. The assessment of the additional supply of natural gas is based on the new-signed Russian gas deal in China. The results should allow for discussion of a rational distribution plan of Russian gas deal in the future, which would consider impact on emissions of air pollutants and concentrations of particulate matter across the region.

Methodology. The integrated assessment model GAINS (Amann et al., 2011) will be used for scenario projection and emission estimates in response to different strategies, and the air quality in different scenarios will be simulated with the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem)(Grell et al., 2005). Emission reduction from replacing coal by natural gas was calculated using equation (1).

$$\Delta E = \Delta A_{Coal} EF_{Coal,m,p} \chi_{Coal,m,p} - (\Delta A_{Coal} eff_{Coal} / eff_{Gas}) EF_{Gas,m,p} \quad (1)$$

where, *Coal*, *Gas*, *m*, *p* represents baseline coal activity, scenario natural gas activity, abatement measure, and pollutant respectively; ΔE stands for the emission reduction; ΔA_{Coal} stands for the reduction in coal activity; $EF_{Coal,m,p}$ and $EF_{Gas,m,p}$ stand for emission factor of pollutant *p* for *Coal* and *Gas* after application of control measure *m*; $\chi_{Coal,m,p}$ and $\chi_{Gas,m,p}$ stand for penetration rate of control measure *m* for pollutant *p* of *Coal* and *Gas*; $eff_{Coal,m,p}$ and $eff_{Gas,m,p}$ stand for the energy efficiency of activity *Coal* and *Gas*.

Results. In 2030, if Jing-Jin-Ji region utilizes 50% of the Russian gas supply, i.e., about 640 PJ, the natural gas can replace as much as 980, 985 and 812 PJ of coal in POWER, RESIDENTIAL (besides coal, also wood) and INDUSTRY scenarios respectively, compared with the baseline scenario. The corresponding total emissions of SO₂ in POWER, RESIDENTIAL and INDUSTRY scenarios will decrease by 57, 332 and 302 kt, emissions of NO_x in POWER, RESIDENTIAL and INDUSTRY scenarios will decrease by 124, 102 and 155 kt, and emissions of PM_{2.5} in POWER, RESIDENTIAL and INDUSTRY scenarios will decrease by 10, 249 and 81 kt.

Conclusions. Application of natural gas substitution strategy in residential sector will achieve the highest SO₂ and PM_{2.5} reducing potentials, and application in industrial sector will achieve the highest NO_x reducing potentials, while application in power sector is the least effective way of reducing air pollutants emissions. Even though power sector consumes large amount of coal, making it a first target for substitution, policies addressing substitution in residential and industrial combustion sectors should be developed and evaluated since they have a potential to achieve larger emission reductions and more significant air quality improvements in this region.

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Food & Water

Modelling of live biomass and Net Primary Production of Northern Eurasia forests

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Introduction. Study of biological productivity of forest is crucial for estimation of terrestrial ecosystems state and dynamics under global change. Models of biological productivity represent dynamics of live biomass and Net Primary Production (NPP) of forest ecosystems. Assessment of dynamics of biological productivity is an important part of the verified Full Carbon Account of the forests. The research will help to reduce the uncertainties of estimation of greenhouse gas emissions in Northern Eurasia, including Ukraine.

Methodology. We used methodology developed at IIASA (*Shvidenko et al., 2007*). The algorithm combines growth models, models of live biomass, and a number of parameters describing the biological production of forest ecosystem. The models have been developed in two steps: (1) development of models for estimation of live biomass dynamics, and (2) modeling of Net Primary Production of forest ecosystems.

Results. We analyzed and updated the existing database of live biomass *in situ* measurements. The database, includes now over 9000 sample plots (part of which is located on the territory of Ukraine). It was used for parametrizing the live biomass and NPP models. The live biomass models consider seven fractions (stem wood over bark, bark, branches, foliage, roots, understory, and green forest floor) of major forest-forming species of Northern Eurasia: Scots Pine (by bio-climatic zones), Black Pine subsp. Crimean, spruce, fir, larch, Siberian Pine, oak, beech, birch, aspen, poplar, Black Alder, Grey Alder, lime, ash, hornbeam. Distribution of live biomass and sequestered carbon in forests of Northern Eurasia was estimated by dominant tree species and biomass fractions. Then we will combine the obtained empirical models with state forest account and forest maps. This will allow to carry out evaluation of amounts of organic carbon fixed in plant tissues and amounts of sequestered carbon.

Conclusions. Within this project, we improved the models needed to estimate carbon stock in live biomass and carbon flux between the atmosphere and vegetation, which is NPP. Tables and models of biological productivity and NPP will contribute to ecologization of forest management and creation of a solid background for sustainable forest management.

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The Institutionalization of Ecosystem Services in Transnational Policy Networks

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Introduction. My dissertation research examines the spread and uptake of ecosystem services approaches in global environmental governance. For my YSSP research, I'm conducting (1) an analysis of the scale and scope of profit-driven finance actually flowing into ostensibly “market-based instruments” in biodiversity conservation; (2a) discourse analysis to develop a typology for understanding the political heterogeneity and evolution of ecosystem services thinking amongst conservationists; and (2b) combining this discourse analysis with social network data mapping ecosystem services' academic research network (or “epistemic community”).

Methodology. (1) The first project analyzes the scale and scope of profit-driven, returns-generating, environmental finance being invested in biodiversity conservation, as distinct from more established pathways of non-profit, state-led, bilateral, multilateral and intergovernmental funding flows. I synthesize recent findings—indicating the scale and scope of global environmental finance which has actually and already been brought being explicitly to generate profits—and place them in political, ethical, cultural, and historical context, connecting them to critical scholarship and ongoing policy debates over the implications of ecosystem services. (2) The second project develops a typology of the different ways in which ecosystem services valuation is being envisioned by conservationists (in terms of arguments pro / con; its appropriate uses / misuses; and the political agendas it can be used to articulate). This project is comprised of two stages. (2a) The first uses primary documents (academic and policy literature on ecosystem services; transcripts from semi-structured key informant interviews; transcripts from event ethnographies conducted at major international environmental meetings) to systematically parse the distinct meanings, purposes, and politics contained in “ecosystem services” discourse. (2b) The second (and ongoing) stage, involves formal content analysis of texts published in the journals with highest output of articles on ecosystem services, specifically, those solicited as opinion (i.e. “opinion,” “commentary,” “editorial,” “policy forum” etc.) to track the relative frequency of occurrences of different meanings, purposes, and politics expressed through ecosystem services over time using the qualitative data analysis software Prospero. Finally, this content analysis will be combined with bibliometric co-publication social network data collected through WebOS to show how these different visions for ecosystem services map onto different groups of ecosystem services researchers.

Results & Conclusions: (1) There is very little profit-driven, returns-generating finance actually flowing into biodiversity conservation. State-driven, bi/multilateral funding streams remain overwhelmingly dominant. This suggests a mismatch between the market rhetoric used to frame biodiversity conservation projects and the actual funding strategies used to finance them. While biodiversity conservation projects are increasingly advertised (and criticized) as becoming a ‘business’, it has not (yet) been hardwired to actually function like one. (2) I developed a typology highlighting different applications (i.e. value recognition, value demonstration, value capture, commodification), and political registers (neoliberal, reformist, radical) of ecosystem services valuation. While the ecosystem services framework is often characterized as engendering ‘market solutions’, its discourse is much more heterogeneous and remains a site of ongoing struggle between different actors vying to direct what ecosystem services means, does, and becomes.

Ecosystem-based fisheries management of cod and sprat in the Baltic Sea

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Introduction. The fishing industry preferably targets large predatory fish, such as cod, as these often are most profitable. These predatory fish depend on smaller fish, such as sprat, for their survival and growth. Typically, these prey fish are also subject fishing. Even though it has become widely recognized that fisheries management should account for trophic interactions and multiple impacts in fishery systems (Walters et al. 2005), fisheries advice still mainly relies on classic, single-species maximum sustainable yield analysis. It is proving difficult to operationalize a multi-species approach as classic fisheries models are missing some essential biological mechanisms and lack the power to handle this kind of complexity (Persson et al. 2014). This hinders the reliability of predictions of the effects of fishing and the establishment of optimal exploitation targets in systems of interrelated stocks. Thus, to account for feedbacks between a predator and its prey, growth and reproduction need to be analyzed as the food-dependent processes that they are. Furthermore, seasonal rhythms, especially in the reproductive output of fish stocks, need to be taken into account, as seasonal variation in prey availability strongly affects the predator, feeding back on the prey. The aim of this project is to examine these two extensions to elucidate how the fishing of cod and sprat affects the Baltic Sea ecosystem.

Methodology. To analyze the effect of fishing on both Baltic cod and sprat, I use an extended version of the stage-structured biomass model for the cod-sprat interaction in the Baltic Sea developed by Van Leeuwen et al. (2008). My model incorporates food-dependent growth and maturation and food-dependent seasonal reproduction. The size-based predatory interactions between cod and sprat and fisheries scenarios were derived from field and fisheries data from the Baltic Sea.

Results. Fishing on the prey fish, sprat, increases the resilience of the predator, cod, to fishing. This happens as through the food-dependent processes in the fish population, competition for food occurs. Fishing on the prey increases the food availability in the prey population, thereby changing the size-distribution of the prey through an increase of reproduction. As a result, fishing on the prey actually increases the food-availability of the predator. In addition, fishing on the prey decreases the potential of collapse of the predator population. These findings are independent of the seasonal pattern of reproduction.

Conclusions. In contrast with the single- and multi-species advice issued by the International Council for the Exploration of the Sea (ICES), my results indicate that increasing the fishing pressure on the prey might benefit, rather than always harm the predator. In addition, a single-species approach predicts different fishing pressures to obtain the maximum sustainable yield (FMSYs) than a multi-species approach, while using ‘classic fisheries models’ a single- and multi-species approach predict similar values for the FMSYs.

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Vulnerability Risk Index of Agricultural Production in the Brazilian Semi-arid.

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Introduction: Weather and environmental conditions in Semi-Arid regions all over the world can seriously affect agricultural production. The Brazilian Semi-Arid region is considered as one of the worlds' most populated semi-arid regions. The rural population is almost 40% of the total population and depends mostly on rainfed agriculture for their subsistence. Its vulnerability is increased by climatic variability, water deficiency, low adaptation capacity and poverty. To understand how to increase the resilience and reducing the vulnerability of communities to agricultural production risk it is necessary to understanding, which are the main components of crop production vulnerability and which regions are and will be most at risk. The purpose of this study is therefore to assess the vulnerability of agricultural production in Semi-Arid of Brazil and indentify sub-regions of Brazilian Semi-Arid, e.g. hotspots, where public policies could be applied to reduce current and future risks.

Methodology: In this work Bean and Maize Crop Yields are looked at. They represent the most cultivated crops in Brazilian Semi-Arid and we asses its vulnerability to Enviromental (Soil, Number of days with a water deficit and Precipitation) conditions. The data was provided by oficial institutions from Brazil such as IBGE, PROCLIMA/INPE. Bivariate and Panel regression statisticals analysis were applied to assess the components which contribute to vulnerabilty and could be used as appropriate indicators to each sub-region. The data time-serie used covers the years from 2005 to 2012.

Results and Conclusions: It was found that the Soil Textural Class and Number of days with a water deficit (NDWD) represented the most satisfactory variables for crop production vulnerability. It was possible to identify at least 24% of all cities as vulnerable in terms of crop production as consequence of the effects of soil and number of dry days. In a further analysis, we considered three different approaches to evaluate these indicators, range of crop production, decrease in crop production, and stress thresholds to crop production. The first one used the difference in NDWD between highest and lowest crop yields. Using this approach we identified 68% of the cities are vulnerable in terms of crop production. In the second approach, we used only the minimum crop yield for each city and the correspondent dry days for that year which happened the minimum crop yield. Considering this approach we found that 54% of the cities are vulnerable. In the third approach, we considered only the cases when the city presented 10 dry days or more. Using this analysis we find that 77% of the cities in Brazilian Semi-Arid are vulnerable according to dry days and Soil Textural Class. Numbers of days with water deficit and the soil textural class are appropriate variable to detect the vulnerability of agricultural production and can be used within an indicator system. All three approaches are showing a different answer to the specific question of crop production vulnerabilty. As the NDWD is essentially a random process, we also determined the risk of each sub-region to fall below given threshold levels of crop production and range.

An Estimation of the Extent of Cropland Abandonment in Mountainous Regions of China

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Introduction. With the wages for migrant workers increasing dramatically in China since 2003, more and more peasants have been seeking employment in urban areas. As a result, in plain areas agricultural machinery is intensively used to substitute for the shrinking farm labor force. However, this 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, which has led to the abandonment of croplands in these regions. Considering that mountainous croplands account for about 25% of total croplands in China, food security in China may be affected in the near future due to the reduction of grain areas as a consequence of the expected massive migration and further decreases of the agricultural labor force. This study aims at estimating the amount of recently abandoned croplands (period 2000-2010) and what changes can be expected in the future in China's mountainous areas. The results can contribute to designing better informed agricultural policies in response to the ongoing processes of rural to urban migration as well as aging in mountainous rural regions of China.

Methodology. We use household data (2003 to 2010) from the Rural Permanent Observation Sites Survey to construct a panel data model for estimating the cultivated area per laborer in mountainous farmland, and then to multiply this value by the reported number of agricultural workers in 2010 in order to obtain the total area of croplands which were actually cultivated in 2010. Subtracting the estimated area of croplands being actually cultivated in 2010 from the total area of croplands reported in 2000, the area of abandoned croplands in mountainous regions of China in 2010 can be obtained. Then, using the PDE model and regression analysis to predict the future rural population and agricultural labor force, we can project the future tendency of cropland abandonment in the mountainous regions of China.

Results and Conclusions. **1)** The total extent of abandoned croplands in mountainous counties for the period 2000 to 2010 is estimated at 16.3 million ha (244 million mu), which means that in total about 35% of croplands in mountainous counties was abandoned. This includes also the croplands converted in the Grain for Green Programme. **2)** The panel data model results revealed that average plot size, agricultural productive fixed assets per household (APFAPH), farm cattle per household, and the multiple crop index have a positive and significant influence on the cultivated area per laborer. **3)** The regression analysis of agricultural labor force showed that the agricultural labor force in all provinces (mountainous regions) would decrease at different rates in the future, except for Xinjiang and Hainan province. **4)** With three scenario assumptions, a sizeable extent of 8.6 to 10.6 million ha (129 to 159 million mu) of croplands may be abandoned during 2010 to 2030. This could exacerbate the future challenges of maintaining China's food security. **5)** As variable APFAPH is probably the main factor that could be changed in the future to increase the cropland area per laborer, an increase of investment in agricultural productive fixed assets could help to mitigate the risk of cropland abandonment to some extent.

Global Agricultural Monitoring and Mobile Data Collection

Jon Nordling

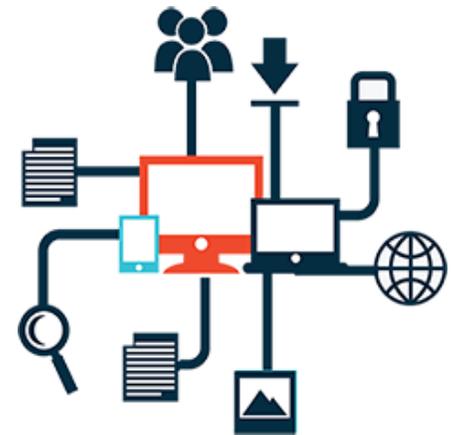
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Introduction. Today's environment is much different from that of about a century ago. A rapidly increasing population and the surge of intensified weather conditions is bringing critical global stresses across a range of systems in the world. Food security is one of the largest of these stresses. Monitoring production of crops at a global scale will increase food security in today's global market, and undoubtedly create a better understanding of our capacity. This paper defines methods and architectures for global agricultural monitoring and explores ways to utilize F-VGI (Facilitated-Volunteered Geographic Information) ground observation information, remote sensing and GIS to gain a monthly understanding of the production crops, globally.

Methodology. The methodology used to synthesis crop conditions combines both earth observation and ground observation information. Coupling remote sensing and crowdsourcing increases the confidence of our understanding of crop conditions monthly. Normalized difference vegetation index (NDVI) anomalies, crop distribution, temperature, and rainfall datasets are used as the earth observation information. The ground observation data provided through using a F-VGI crowdsourcing approach provide another layer of information. This information is facilitated based on the growing season of the crop and then local agriculture experts report on the conditions of the crops. This approach ensures that the information supplied through remote sensing is validated by the ground observation information and vice versa.

Results. To gain a large, frequently collected amount of ground observation information, there was a fundamental need for an accessible geographical data collection platform. The results included the development of GeoODK, which provides a way to collect and store geo-referenced information, along with a suite of tools to visualize, analyze and manipulate ground data for specific needs, in this case agriculture. It enables an understanding of the data for decision-making, research projects and more. As a multi-dimensional application, GeoODK's goal is to provide an open source platform that can be expanded to address current and future needs of data collection. The application is completely open source and aims to combine mobile data collection technologies, remote sensing and GIS as one integrated system.



Conclusions. Agricultural transparency is very important in today's world. Having a real understand of crop conditions is going to help the global market adapt as there are many dynamic challenges ahead. Specifically monitoring the production of crops at a global scale will increase food security to places where lands are not as productive. As we gain better understanding of agricultural conditions, this can trigger important global market trades and influence political decision making. The positive impacts go much deeper than the interface and implementation, but rather they contribute to global needs.

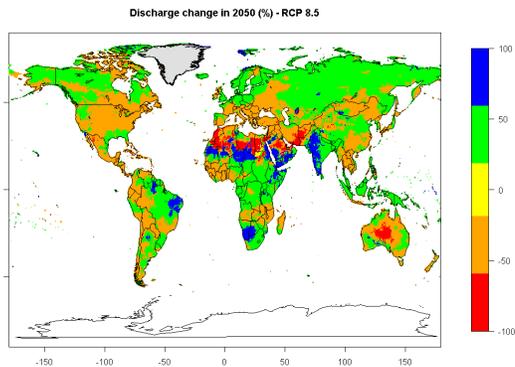
Expanding irrigated land under physical water limitation and socio-economic constraints

Amandine V. Pastor

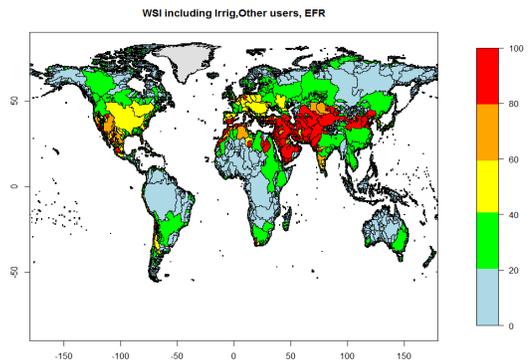
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Introduction. The planetary boundaries of freshwater are likely to be exceeded in the near future [1]. At this time, the vast majority of water is used for food production. The combination of dietary changes, population growth and climate change will have major implications for the food supply and water use in agriculture. In this research, we have created a link between water availability including “environmental flow requirements” or EFRs at monthly time-step with the global biomass optimization model GLOBIOM model [2] to constrain irrigation supply at global scale. Water availability is simulated with the global vegetation model LPJml and EFRs is calculated with the Variable Monthly Flow method [3]. Simulations were run with different conditions of climate change and land use change to predict future food production until 2050. This research aims to compare the spatial allocation of global agricultural lands from scenarios including water availability and EFRs with socio-economic optimization. By combining biophysical and socio-economic constraints, sustainable scenarios of agricultural land allocation and irrigation expansion can be simulated including intra-annual variability.

Methodology. Harmonization of spatial resolution for water availability, EFRs and water withdrawals for irrigation and other users such as household and industry was performed to fit the GLOBIOM model. Data were aggregated to the LUID unit of GLOBIOM (2° by 2° deg). Water availability and EFRs were re-calculated according to the



discharge and EFRs repartition in each watershed [4]. Irrigation coefficient was performed at monthly time-step and at grid cell level to represent the seasonality of irrigation demand from LPJml to adapt the irrigation demand from the GLOBIOM model from annual to monthly time-step. Irrigation supply was constrained as if water demand for irrigation and other user falls below water availability, crop yield will turn from potential to rainfed. To predict water availability and water demand in 2050, we used climate radiative forcing input RCP8.5 to represent the impact of climate change and we use the socio-economic scenario (SSP2) to predict water demand until 2050.



Results and Conclusions. By including environmental flow as an additional water user, we looked at the water stress index (WSI) which is the ratio of water demand on water availability and we can conclude that in 2000, Middle East regions, south-west of Asia and west coast of North America are above the limit of water stress (40%). By 2050, water demand from irrigation and other users is tripled and is likely to be exacerbated by climate change and increase water stress in certain regions such as the Mediterranean basin.

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Assessing the capabilities of remotely sensed indicators for agricultural drought monitoring

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Introduction. Within a changing climate and the frequent occurrences of extreme weather events, the issue of global drought is drawing increasing attention from governments, scientists and the public. Currently, more than half of the land surface is susceptible to drought and the world suffers from a total loss of about 6-8 billion dollars due to drought each year. Agriculture is the major sector to be affected by drought. Although agricultural production has been rising in the past years, agricultural drought constitutes the primary causes of crop loss. Satellite-based earth observation has proven its potential for near real-time drought monitoring and early warning. However, most current remotely sensed drought monitoring methods are generic and not agriculture specific. Compared with other ecosystems, agriculture distinguishes itself due to its relatively shorter & quickly changing phenology and intensive human management. Thus, the performances of these indicators specifically for agricultural drought monitoring, in terms of both responsiveness and effectiveness, are still not clear. The Southern Great Plains (Kansas, Oklahoma and Nebraska) account for almost 40% of US domestic winter wheat production and the recent droughts place a continuous stress on local agricultural production, highlighting the importance of drought monitoring in these wheat producing regions. Focusing on Southern Great Plains, this study intends to examine the sensitivity of different MODIS derived indicators to agricultural drought and investigate the effectiveness of these indicators for agricultural drought monitoring during the growing season.

Methodology. Insufficient moisture limits the available water that vegetation can take up and consequently leads to wilting, which can be detected from satellite observations. Thus, the remotely sensed vegetation status, such as the Normalized Difference Vegetation Index (NDVI), Land surface temperature (LST) as well as evapotranspiration (ET), is extensively used for deriving drought indicators. In this study, these remotely sensed indicators based on vegetation condition, LST and ET were first calculated from time-series MODIS products (2000-2013, MOD09/MOD12/MOD16) at 8-day interval. Next, the indicators for soil moisture stations were extracted for corresponding time periods of in-situ soil moisture measurements. Then, for each station, the lagged correlation between surface soil moisture and remotely sensed indicators was conducted using all available data for the entire year to show the general sensitivities; and also specifically for winter wheat stations, similar work was carried out for each 8-day during the main winter wheat growing season (March-June from green-up to harvest). The highest correlation as well as the time lag with the highest correlation achieved were identified for each station to indicate both the ability and response time of these indicators to agricultural drought and also compared among different stations to show the potential spatial variability.

Results and Conclusions. (1) LST and ET based drought indicators show similar performances for drought monitoring. LST and ET derived indicators are quite sensitive to drought, which shows immediate response after drought; while for NDVI derived indicators, there is no consistent drought response time, generally varying from 1 to 4 weeks. (2) Within each type of drought indicators, the standardized and normalized indicators show similar and slightly better performance than conditioned indicators, and all three types of drought indicators are better correlated with soil moisture for winter wheat and grass as compared to forest. (3) When it goes to winter wheat growing season, LST and ET have more consistent response across space and better performance during the early and late growing season, while the NDVI derived indicators shows more consistent and better performance from the middle growing season. (4) Compared to Kansas and Nebraska, Oklahoma has more consistent spatial patterns of both response time and effectiveness possibly due to the more systematic in-situ measurements and homogeneity within the state, which calls for further work to address this spatial variability in the future.

Assessing spatial and temporal patterns in heat fluxes during wet and dry extreme months using the NOAH land surface model.

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Introduction. Correct calculation of water fluxes requires correct partitioning of net radiation into sensible and latent heat. Latent heat, LE, is the energy spent on evaporating water, whereas sensible heat, H, is the energy spent on rising the air temperature. The energy balance at the land surface is determined by net surface radiation and latent, sensible and ground heat fluxes. The Bowen ratio $B=H/LE$ describes the partitioning into latent and sensible heat fluxes. Bowen ratios are generally lower at agricultural and deciduous forest sites where latent heat dominates over sensible heat, because the evaporation there is high. In this study, we first compare simulated heat fluxes with observations, second establish the variability of heat fluxes across extremely dry and wet months and third compare the resulting trend in heat fluxes with temperature and precipitation trends for the same time period. We are interested in assessing whether high Bowen ratios accompany dry months and if low Bowen ratios accompany wet months. That would point towards possible feedback mechanisms and thus a need to improve the representation of heat fluxes in current land surface models.

Methodology. Model. Land surface models (LSMs) are developed to calculate the energy balance as well as the water balance and are suited to calculate partitioning into sensible and latent heat fluxes. Today, output from such models differ greatly from model to model, partly because of uncertainties in the input data and partly because of their parameterizations (Jimenez et al., 2011). In this study, NOAH was run using the HRLDAS Offline 2D driver code (Chen et al. 2007) for a domain covering Europe. The model is set up with a 9x9 km grid and the model time step is 6 hours. These time steps were averaged to a daily timestep before comparison with observations, and calculating distributions. Calculations of extremes, including trends, were done for a monthly timestep.

Data. Meteorological fields and soil data from Era-Interim (Dee et al. 2011) were used to initialise and force the offline model. Data for the time period 1979-2009 was used to force the model. To compare the results, measurements of latent and sensible heat from the FLUXNET network was used. 17 stations were selected based on the length of the time series in the free fair-use access dataset. Time series, scatterplots and distributions were plotted and the non-parametric Kolmogorov-Smirnov test was used to compare how well the distributions were reproduced. RMSE was calculated to find the spread in simulated minus observed values.

Analyses. Bowen ratios were calculated for each grid cell by dividing monthly means of sensible heat by latent heat fluxes. We were interested in three cases: dry, wet and median months. Extreme months were defined from the temporal distribution, and Bowen ratios for months drier than the 20 percentile, wetter than the 80 percentile and between the 40 and 60 percentile were extracted. To establish the difference between extreme and median months, the difference between the two groups (wet minus median and dry minus median) was calculated for each grid cell.

Results. Preliminary results indicate that higher Bowen ratios accompany dry months.

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Development of a Socio-hydrological Model of Las Vegas Water Management

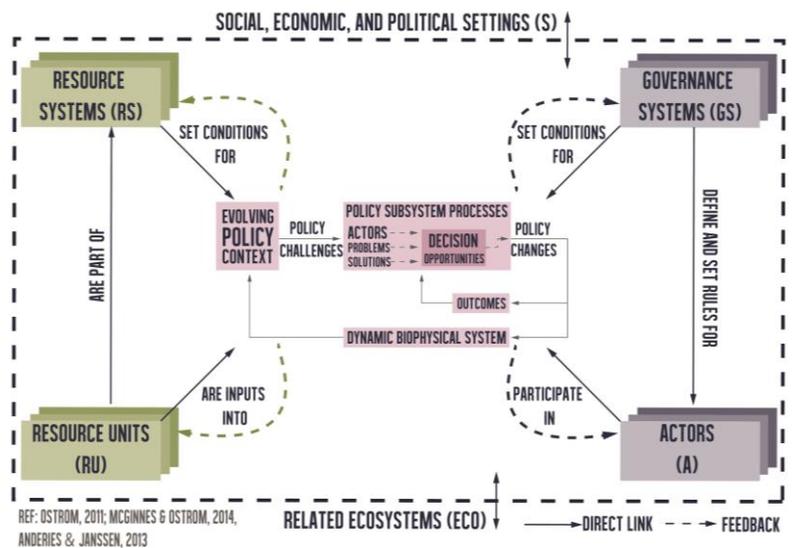
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Introduction. Urbanization and climate change are significant planning challenges for water supply management. Adaptive management and flexible infrastructure have been proposed to address this challenge; however, standard evaluation methods use a narrow set of assumptions of societal response to changing conditions, limiting our ability to assess adaptive or flexible strategies which must be executed over time. To improve evaluation of water supply reliability alternatives, an approach that incorporates the human agency inherent in water management is needed. The first objective of this study is to develop a coupled conceptual model of the system that illuminates the dynamic interactions between the biophysical and institutional systems. The second is to build a partially coupled quantitative model that can be used to test alternative structures of the policy making process. Las Vegas is used as a test case due the water management changes observed in response to population growth and drought.

Methodology. Las Vegas water management responded to three key events during the study period: creation of a regional utility, drought and the financial crisis. The decision making processes initiated by these three events were analyzed using Socio-Ecological Systems framework¹. This analysis, along with data on the biophysical structure, informed the development a conceptual model incorporating the interactions between the biophysical system and the governing institutions. All aspects of the conceptual model, except the policy sub-system, were then quantified in a system dynamics model in Vensim software. After testing the model against historic reference modes, I tested the system's performance under set of scenarios of hydrologic and demand futures. I then tested the performance of policies, identified by the local utility, under these conditions.



Results & Conclusions. The conceptual model developed of Las Vegas water management consists of five coupled sub-modules: water supply, water demand, finances, public perception and policy making process. From this base, I developed a draft quantified model; the policy process sub-system was included to facilitate testing of multiple structures to enhance the robustness of the coupled model. The model performed well under reproducing of observed trends in variables such as reservoir levels, demand and population. The scenario analysis showed that low reliability under plausible future conditions if no action is taken. The policy analysis demonstrates the potential improvements and the sensitivity of system performance to the decision rules used to trigger policy options. Next steps include testing alternative structures of the policy process and fully coupling the model.

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Long and dry: testing London's water supply system vulnerability to drought

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Introduction. Drought is one of the most serious hazards facing water supply systems. Analysis of water system vulnerability to drought is challenging because historical observations are often too short to capture significant drought events. To overcome this challenge, water managers have traditionally studied vulnerability to drought using stochastic stream flow models or, more recently, output from climate models. However, the uncertainties in climate models and their inability to represent long-term persistence mean that limited insight into system response can be obtained. In this paper we present a sensitivity-based approach to test the vulnerability of water resources systems to intense and persistent drought conditions. We develop a stochastic stream flow generation technique to synthesize a large ensemble of stream flow series with different degrees of persistence and drought characteristics, which we use to test the system's vulnerability to drought and compare different water management options on the basis of the robustness to drought conditions.

Methodology. Hydrological droughts result from extended periods of dry conditions, where dry conditions are typically defined as periods where stream flow is below a pre-defined threshold. In this study we define drought using a monthly Q75 threshold (i.e., the flow exceeded 75% of the time). Here we introduce a stochastic framework that synthesizes stream flow time series with different levels of drought duration and deficit. The temporal dependence structure of the time series—controlling drought duration—is represented and perturbed using copulas, and very low flow occurrence—controlling drought deficit—is represented and perturbed using importance sampling. The dependence parameter of the copula function is perturbed to generate stream flow series with longer droughts.

Results and Conclusions. The 100 year long monthly stream flow series with the selected drought duration–deficit properties were used as inflow inputs to the London water supply system model. A stakeholder defined threshold related to the percent of usable capacity in the reservoirs is used to quantify the response of the water system to different drought conditions. Figure 1 provides a way of visualizing the sensitivity of the system to different drought scenarios and it gives insight into the system's workings under drought conditions that are beyond the historical record. The system shows a higher sensitivity to drought deficit than to drought duration, suggesting that short

intense drought events are more likely to bring the system into an unsatisfactory state (i.e. below the stakeholder defined vulnerability threshold).

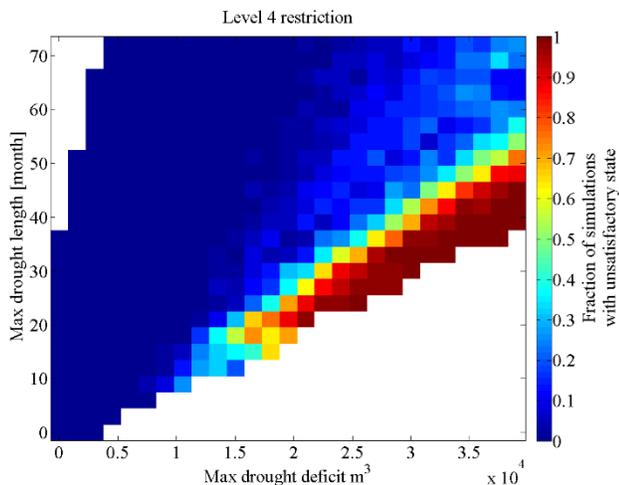


Figure 1. Sensitivity of the London water system to drought duration and deficit.