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YSSP

Young Scientists Summer Program



# Proceedings of the YSSP Late Summer Workshop 2013



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# Proceedings

of the Late Summer Workshop

**Young Scientists Summer Program 2013**

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**26 – 27 August, 2013**

Edited by Tiina Häyhä

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 of Applied Systems Analysis, Laxenburg, Austria, 26–27 August, 2013. The proceedings receive only limited review and are not for publication in the current form.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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14:20 - 14:45	Martin Bruckner	WAT	Global biomass flows and associated environmental footprints	Mathias Kirchner	ESM	Modeling the impacts of climate change and market integration on agricultural production and land use management in Austria

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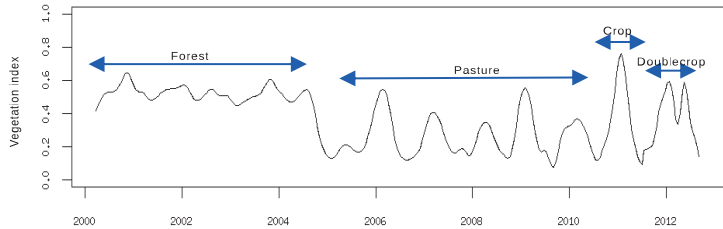
## Satellite time series analysis for land use/cover change detection

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**Introduction:** Brazilian land use data currently comes from their national agricultural census and land cover data comes from global data sets with sparse temporal coverage. This no longer meets the needs of the Earth system modeling community. Long-term satellite image datasets with high temporal frequency yield a sequence of data points in a time series that reflect vegetation phenological cycles (Fig. 1) and can be used to detect land use and land cover changes. The goal of this research is to develop a methodology to improve information about land use and land cover trajectories in Brazil.



**Figure 1.** Phenological vegetation cycles reflected in vegetation index time series.

**Methodology:** In this work a 2-band Enhanced Vegetation Index (EVI2) provided by LAF/INPE [1] was used. These data are based on the MODIS MOD13 Q1 product, 16-day composite images with 250 m spatial resolution. The classical data mining method of Dynamic Time Warping (DTW) [2] was used to match typical vegetation patterns in long-term EVI2 time series. A test area with 8.325 ha, located in Mato Grosso Brazil, was compared to official TerraClass maps [3] from 2008 and 2010 for the following classes: forest, pasture, and crop.

**Results:** In preliminary tests the DTW classification shows satisfactory agreement with official TerraClass maps from 2008 and 2010 with global accuracy of 78.2% and 85.0%, and Kappa coefficients of 0.62 and 0.72, respectively for each year. The main classification errors occur in boundaries between different land covers (Fig. 2), where MODIS pixels contain a mixture of surface reflectance. Furthermore, the maps yielded by DTW show impossible land use/cover transitions, such as the following three years sequence: *forest*→*clear cut*→*forest*.



**Figure 2.** DTW classification (a) and TerraClass classification (b) from 2010.

**Conclusions:** Exploratory DTW results show significant potential to detect land use and cover changes, which is useful not only to provide land use and cover maps but also to understand land cover changes. To improve the results of the DTW classifications, it is essential to include post-processing steps with rules for land use and cover transitions and spatial filtering.

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## Spatial and Temporal Changes of Vegetable Production in China

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**Introduction.** The new economic geography theory has raised concerns that economic integration at the regional and international level may increase the regional concentration of industries and the industrial specialization of regions. Coming with China's economic reforms and rapid growth over the past three decades, many economists have begun to study the problem of industrial geographic distribution and regional specialization of agricultural production in China. This paper is going to measure the geographic concentration and regional localization of vegetable production in China with newly developed indicators.

**Methodology.** Coefficients ( $FLQ^*$  and  $l_i$ ) incorporating the effect of regional industrial scale, developed by Lu et al. (2011), are used to measure the localization of the vegetable sector in each region and the overall geographic concentration of the vegetable production. As supplementary indicators, Global Moran's I and Local Moran's I are used to examine the spatial autocorrelation of vegetable production in China. Moreover, cross-entropy based downscaling approach is utilized to attempt to generate plausible allocations of vegetable production at the scale of individual pixels.

**Results.** At provincial level, according to the values of  $FLQ^*$  and  $l_i$ , the overall level of geographic concentration of vegetable production in China has slightly increased during the past three decades, with a southward shift. This pattern is confirmed with the Global Moran's I. The Global Moran's I reached 0.29 with a z-score of 3.02 by 2010 from 0.02 with a z-score of 0.5 in 1981, indicating that vegetable production was distributed randomly across regions in 1981, but revealed positive spatial autocorrelation by 2010. And the LISA cluster map suggests that vegetable production was concentrated in the HHH & BS Region, with Shandong and Henan provinces as the cluster center.

For the HHH & BS Region (at prefectural level), the  $FLQ^*$  values suggest that the localization level of vegetable production in the top twenty prefectures has decreased within the 1994-2010 period, especially for the top ten prefectures. As the same situation with that at provincial level, the overall level of geographical concentration of vegetable production in the HHH & BS Region is not very high. Nevertheless, the Global Moran's I for vegetable production in 1994 and 2010 suggests that there exists a positive spatial autocorrelation in vegetable production both in 1994 and 2010. The LISA maps of 1994 and 2010 indicate that vegetable production was mainly concentrated in the center, south and southwest of Shandong province and the east and south of Henan province.

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## Spatial modelling of global agricultural field burning emissions

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**Introduction.** Burning of agricultural crop residue is practiced globally to remove excess residue, control pests, and produce ash fertilization. It is an important local air pollution source. The emissions from crop residue burning are included in several models. However, the results from the models differ, especially when specific areas are taken under investigation. Furthermore, it is suspected that the emissions are underestimated. Therefore, this study is answering the following questions: (1) Why are the results from different models so different, and (2) How can the modelling be improved?

**Methodology.** Three different modelling approaches were studied: FINNv1 (Wiedinmyer et al. 2011), GFEDv4 (Giglio & Randerson), and Jessica McCarty's work on agricultural fires (McCarty et al. 2012). The approaches use different fire activity data to assess the occurrence of fires. The fire activity data examined in this study were the MODIS Thermal Anomalies Product, and the MODIS Burned Area (MCD45A1) product. The fire activity data is coupled with land cover data to identify cropland fires and to achieve estimates for the area of burned land. The land cover data that the models use is MODIS MCD12Q1 with IGBP classification (UMD classification in GFED). Emission factors were from FINNv1 and McCarty's collection from literature. To assess the effect of land use data to the results, the emissions were also calculated with the IIASA hybrid cropland product. The results were calculated for and compared in Eastern Europe in order to avoid differences being averaged out, which could happen on global scale. The emissions modelled were CO, black carbon and PM<sub>2.5</sub>.

**Results and Conclusions.** The fire data used were found to have the largest effect on the modelled emissions. Difference between the emissions from the highest and the lowest burned area estimate was 5-fold. The Burned Area product produced higher emissions, but they were also less spread out. Land cover data had smaller impact on the emissions, and the differences were not systematic. In the future, more work is needed to identify the best possible fire data for the emission modelling. Measured fire radiative power, which was not included in this study, should be included in future assessments. The best land use data may depend on the fire data used, as the different fire data represent different quantities (e.g. fire detections, fire intensity or area burned), and they should be assessed together. Local assessment for the emissions should be done in areas where measurement or other type of observations of the burnings exists. Crop specific emission factors that would account for local differences in burning practices and their timing would systematically improve the emission estimates.

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## A comparison of downscaled modeled land use scenarios and their methodologies

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**Introduction.** Land use and land change models are growing in abundance and complexity due to technological advances and the mating of methodologies from distinct disciplines. A common thread between these models is the need to downscale global, continental, or regional land requirements to more local, spatially explicit, and visually satisfying outputs. This need stems from the necessity to communicate and inform policy and decision makers of the consequences of different development pathways<sup>1</sup>. This research aims to compare the spatial allocation of global agricultural lands from scenarios modeled by the CLUMondo<sup>2</sup>, GCAM<sup>3</sup>, and GLOBIOM<sup>4</sup> models, and then explain the differences in agricultural land allocation by comparing their downscaling methods.

**Methodology.** Harmonization of spatial resolution and land use classes for GCAM's RCP4.5, GLOBIOM, and CLUMondo outputs is performed to enhance the comparability of the scenarios across the models. An initial spatial pattern cluster analysis is performed using the Global Moran's I index to determine the degree of clustering in each dataset. The global clustering values for each time step for each model output are plotted to evaluate the temporal differences agricultural clustering trends. Next, regional clustering of high and low concentrations of agricultural land is evaluated using the Local Moran's I index as well as the Getis-Ord  $G_i^*$  statistical measures. A directed evaluation of the downscaling procedures is performed at locations where prominent discrepancies between models exist.

**Results and Conclusions.** High levels of clustering of agricultural lands are found in all three modeled outputs. The regional clustering analysis reveals that consistently high concentrations of agricultural land are located in Southeast China, Central North America, Central Africa and India, for example. Discrepancies between the different datasets exist, and are mostly located along the fringes of clusters of high and low concentrations of agricultural land. It is concluded that discrepancies can be explained by differences in the downscaling procedures. Also, while discrepancies between datasets exist, a discussion of them serves to elucidate potential methodological improvements and enhance confidence and the utility of their results.

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## **The transition to integrated agricultural systems and its impact on greenhouse gases emissions in Mato Grosso, Brazil**

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**Introduction.** Integrated systems (IS) are an interesting strategy to promote sustainable agricultural intensification and optimize land use in already deforested areas. In the Brazilian state of Mato Grosso (MT), the transition to IS would be particularly important to halt the expansion of the agricultural frontier in Southern Amazonia. However, despite such benefits, IS still represent a very small share of MT's area. The present study is an effort to investigate the drivers and barriers of land use transitions under different scenarios, as well as the impact these may have on MT's overall GHG emissions.

**Methodology.** A land use optimization model for MT was built and written in GAMS, based on data gathered for all of its 141 municipalities. Information on the evolution of domestic and international demand for crops, livestock and timber were extracted from Globiom simulations. Based on previous field research in MT, five agricultural production systems were characterized in the model: two IS and three conventional systems. Conventional and GMO technologies for crops were also considered. Four policy scenarios representing new domestic policies and different international market conditions were tested for: (A) credit provision through the ABC Plan; (B) increasing grain prices; (C) increasing beef prices; and (D) increasing fertilizer prices. The period of analysis goes from 2006 to 2020.

**Results.** Under current conditions, IS may be comparatively less profitable in the short run due to their higher implementation costs. However, as the marginal productivity of conventional systems tends to decrease over time, IS become economically attractive already after their second year of implementation, especially on degraded pastures. Land allocation for crops and IS is highly influenced by commodity prices in the international market. IS currently represent less than 5% of MT agro-pastoral area, but their adoption would be stimulated by the further implementation of the ABC Plan, higher beef prices and higher fertilizer prices (whereas higher grain prices would have the opposite effect). However, due to differences in farmers' capitalization requirements and in the composition of the farms' production costs, integrated livestock-forestry systems and integrated crop-livestock system with off-season cattle only take off under the credit provision scenario.

**Conclusions.** The adoption of IS in MT is likely to contribute to the rehabilitation of degraded pastures, but their broader dissemination strongly depends on market prices volatility. Credit provision can stimulate the adoption of IS to a certain extent, especially in a context of increasing production costs, but it is not as influential when analyzed by itself. The calculation of GHG emissions is still in progress.

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## Impact of the changing winter wheat sown area on agriculture water footprint in the North China Plain

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**Introduction.** The North China Plain (NCP) is the major winter wheat producing area in China, accounting for more than 60% of China's total winter wheat sown area. However, the NCP is among the world regions with severe water shortage problems where water resources are regarded as being over-exploited. Agriculture is the largest water consumer in the NCP, accounting for 60-70% of total water consumptions. Groundwater has been the lifeblood to agriculture, especially during winter wheat sowing period, since surface water is very scarce in the NCP. Here, we take into consideration of the winter wheat sown area changes of the NCP since the late 1990s, which can be confirmed according to the official statistics and the result of our field survey. The main objectives of this study are as follows: 1) analyze the spatial distribution of water footprint in the NCP; 2) estimate how the green and blue water consumption changes with the changes of sown areas of winter wheat in the NCP; 3) predict future changes of green and blue water consumption of winter wheat in the NCP driven by different land use change scenarios and climate change scenarios. Our purpose is to contribute science-based evidence that will enable policies affecting agro-land use change to alleviate water stress problems in the NCP.

**Methodology.** China-AEZ model was used in my research to calculate the green and blue water footprint during winter wheat sown period. Climate indicators in base period 1981-2010 as well as future period 2011-2100 under A2, A1B and B2 carbon emission scenarios predicted by PRECIS model were mainly input of China-AEZ model. Groundwater intensity index (GI) was used to subdivide blue water consumption (BWC) into blue water from groundwater sources (BWCg) and from surface water sources (BWCs).

**Results and Conclusions.** 1) Across the NCP, the blue water footprint dominates in the northern NCP; the green water footprint is dominant in the southern part of the NCP. It is more water intensive and blue water intensive to sow winter wheat in northern NCP. 2) With the shifting of winter wheat sown area to southern part of the NCP during 1998-2011, GWC and BWCs increased  $1188.17 \times 10^6 \text{t}$  and  $370.17 \times 10^6 \text{t}$  respectively in the whole NCP, while BWCg decreased  $100.92 \times 10^6 \text{t}$ . 3) There are irrigation water conservations in northern NCP, especially in the Hebei Plain, include CSZ 61, 62 and 63; while in the southern NCP and along the Yellow River basin, especially in CSZ 64, 67 and 81, there are more irrigation water consumed in 2011 than that in 1998.

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## Integrating biophysical and economic evaluations of ecosystem services

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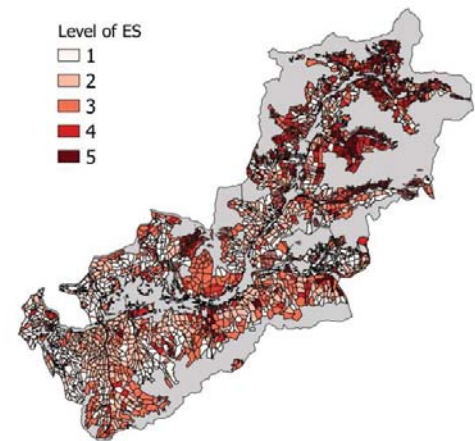
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**Introduction.** Forests provide a wide range of ecosystem services (ES), from timber and non-wood products (provisioning services) to carbon sequestration, hydrogeological protection (regulating services), and recreation and aesthetic experiences (cultural services). Non-marketed forest ecosystem services tend to be undervalued due to the lack of a market price and a clear understanding of their vital support to socio-economic systems. Ecosystem services are interlinked, and therefore the optimization of one typology of services can affect negatively other services. Consequently, forest management choices include trade-offs. This study focused on the supply and spatial distribution of ES in a forest area in the Italian Alps. The supply of ES under alternate management regimes was analyzed to assess the possible trade-offs or synergies among different ecosystem services.

**Methodology.** ES were evaluated both in biophysical and economic units. Spatial data on land cover and forest biomass growth and harvest rates together with data from field interviews were used. GIS was used to spatially analyze and visualize the distribution and provisioning of ecosystem services. Scenario analysis based on three different forest management schemes was used to estimate the impact of different forestry practises on ES.

**Results.** The total supply (Fig. 1) and economic value of the ES was calculated and mapped. Provisioning services accounted for one third of the total economic value while regulating services resulted in almost 60% of the total (Table 1). The scenario analysis showed that there is a trade-off between increased exploitation of timber and bioenergy versus non-wood forest products, regulating, and cultural services.

**Conclusions.** The outcomes of this study highlight the need for integrating biophysical and economic evaluation, especially to assess and value regulating ecosystem services to better recognize their importance. Mapping ES can serve as an important tool to identify priority areas and to better communicate and visualize information on ecosystem services.



**Fig. 1.** Map of the supply of a bundle of forest ecosystem services, Fiemme and Fassa Valleys, North Italy.

**Table 1.** Investigated ES and their biophysical and economic values.

Ecosystem service	Biophysical value	Unit	Shadow price/unit	Economic value per ha (€/ha/yr)	Economic value (€/yr)
Timber	89,500	m <sup>3</sup>	97	218	8,693,135
Firewood	15,176	m <sup>3</sup>	24	9	364,234
Wood chips	7,326	m <sup>3</sup>	15	4	153,855
Game	1,429	head	148	5	211,660
Mushrooms	39,645	kg	14	14	557,233
Berries	14,197	kg	6	2	83,156
Fresh water	2,511,394	m <sup>3</sup>	1	75	2,999,615
Carbon sequestration	201,350	t CO <sub>2</sub>	15	76	3,020,246
Hydrogeological protection	6,946	ha	1,888	328	13,116,047
Recreation: tourists	1,094,866	person	3	77	3,090,281
Recreation: hunting	498	person	774	10	385,425
Recreation: mushrooming	-	permit	-	6	227,423
Total					32,902,310

## Sustainability assessment of forest bioenergy options in multiple-use landscapes

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**Introduction.** Forests provide essential ecosystem services (ES) that are of direct benefit to human beings such as timber for housing, air we breathing, area for recreation. They also provide bioenergy and help with lower global warming. Simultaneously, they are home and living resources for wild species. Multi-uses of forest are not always complement with each other, in many cases there are conflicts. Declining of biodiversity is an example of over biomass extraction.

**Objective.** The project aim to connect the existing models which are used for calculating timber, pulp and bioenergy production, with new methods for biodiversity, carbon stock and recreation evaluation, to make trade-offs and synergies analysis.

**Methodology.** The analysis was made in two management scenarios: business as usually (BAU) and continuous cover forestry (CCF), with a case study of a county in southern Sweden. Six forest ecosystem services were selected in the trade-off analysis: bioenergy, timber, pulp, biodiversity, carbon stock and recreation. LandSim was used for projecting forest growth in 100 years. Timber, pulp and bioenergy production was calculated by Heureka. Ecological profile was the approach to simulate structure changes of habitat. Models for carbon stock and recreation were made based on literature review and previous studies.

**Result and Conclusion.** In BAU scenario, forest resource is dominated by timber, pulp and bioenergy production. Biodiversity will be seriously threatened (figure 1). If 30% of the forest is left for CCF, timber, pulp and bioenergy may not get the same amount of production as in BAU, but all the six ES keep growth in a positive way. Especially for biodiversity, the synergy gained would be 365% increase compare with base year 2010 (figure 2).

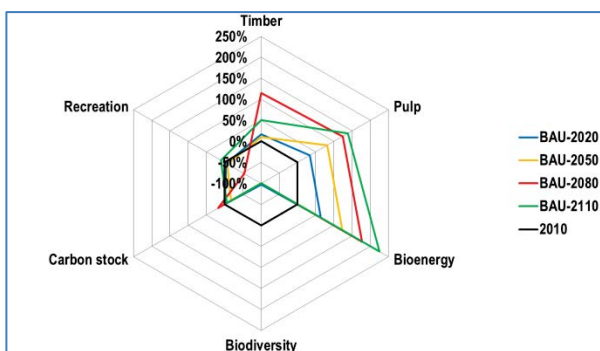


Figure 1: Trade-offs in BAU scenario

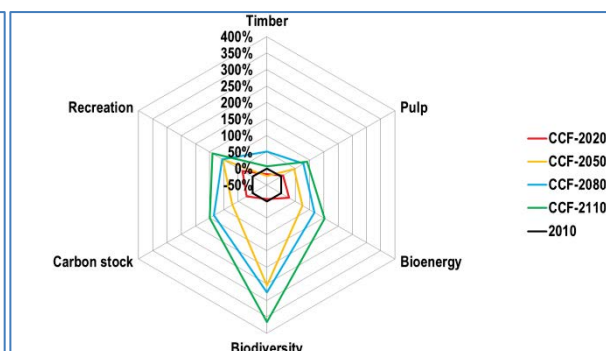


Figure 2: Trade-offs in CCF scenario



## Global biomass flows and associated environmental footprints

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**Introduction.** Various approaches exist for quantifying environmental footprints of biomass consumption by estimating the virtual natural resources (e.g. land and water) embodied in international trade flows. These can be classified into a) *final demand approaches*, applying environmentally extended input-output analysis, and b) *apparent consumption approaches*, using a physical accounting framework. The results of recent studies vary widely, thus hampering their application in policy making.

**Methodology.** In order to study the disparities a literature review was performed and differences in the applied methodologies and base data were identified. Furthermore, a multi-regional input-output model based on the GTAP database (GTAP-MRIO) was set up and used to calculate global virtual land flows and footprints. The results were then compared to that from IIASA's LANDFLOW model, a comprehensive physical accounting model following the apparent consumption approach. The land use data were harmonized in order to exclude this as a source of divergence.

**Results.** The literature review has shown that the two approaches have evolved strictly separated during the past decade within their research communities. The differences in the results, base data and methodologies are tremendous. The greatest share of the variance results from differences in the coverage of crops, processed products and supply chains. The use of different data sources and weighting procedures for the land use data in some cases may also result in differences up to an order of magnitude. Technical specifics such as the application of monetary versus physical accounting or differences in the handling of re-exports still cause differences of often more than 100%. The table shows some results on the cropland footprint (LF) and the virtual cropland import and export flows (IM, EX) for the EU-27, Germany and China published in the literature and derived during the YSSP.

Unit: 10 square meters per capita				EU-27			Germany			China		
Source	Year	Method	Comment	LF	IM	EX	LF	IM	EX	LF	IM	EX
van der Sleen 2009	2005	physical acc.	limited coverage		35	9						
von Witzke & Noleppa 2010	2007	physical acc.	limited coverage		99	28						
Lugschitz et al. 2011	2004	GTAP-MRIO		474	306	84	464	366	48	93	22	29
Yu et al. 2013	2007	GTAP-MRIO		305	193	69	260	192	47	113	20	32
Steen-Olsen et al. 2012	2004	GTAP-MRIO	weighted areas	1280			1410			400		
LANDFLOW	2007	physical acc.	IIASA's model	307	141	77						
GTAP-MRIO	2007	GTAP-MRIO	own calculations	371	108	63	305	119	46	90	3	16

**Conclusions.** A hybrid model combining the advantages of both approaches could provide a framework for the robust and transparent assessment of environmental footprints of global biomass flows. Such an accounting framework should be based on (corrected) statistical data reporting land use, crop production and bilateral trade in physical units, supplemented by monetary data for the sectors and supply chains not covered elsewhere. The mathematical system of input-output analysis (a simple matrix structure) is well suited for the integration of physical and monetary information in varying levels of detail and to deal with indirect effects and re-exports.

## **Index-Based Insurance against Weather Extremes in Mongolia**

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**Introduction.** Weather extremes are often highly detrimental for households' well-being, in particular in developing countries with a high dependency on agriculture. A novel way to prepare for weather disasters are index-based insurance schemes which pool the risk among a large group of households and distribute payouts depending on the regional occurrence of extreme weather.<sup>1</sup> As one case in point, herding households in Mongolia recently got the opportunity to insure their livestock through Index-Based Livestock Insurance (IBLI) against the risk of very harsh winters, so-called dzud disasters. In case of a dzud, households receive insurance payouts depending on the regional livestock losses.<sup>2</sup> The dzud in 2009/2010 led to the death of one fourth of Mongolia's livestock and it was the first dzud winter when a part of herders was insured.<sup>3</sup> This study explores how the livestock insurance helped herding households to recover from dzud losses and to prevent from dropping-out of herding. Furthermore, I show the determinants of insurance uptake before the dzud in 2009/2010 and investigate how and why insurance behavior changed in the aftermath of the disaster.

**Methodology.** On the basis of a recent household-level survey of the German Institute for Economic Research (DIW) on the impacts of the 2009/2010 dzud, I estimate the impact of insurance on herding households' livestock recovery. By using propensity score analysis, I further estimate the effect of insurance enrollment on the households' likelihood of dropping out of herding. Finally, I estimate insurance uptake before and after the dzud under consideration of livestock losses and recovery.

**Results.** There is no evidence that insurance enrollment helped the households to better recover, but it prevented them from dropping out of herding. Insurance uptake depends mostly on the herd size of a household, which is a comprehensive measure of their wealth. Furthermore, I find that households experiencing significantly higher percentage losses are more likely to change their insurance decision after a dzud event.

**Conclusions.** The results on the initial uptake of insurance shows that the implementation of the IBLI has not yet reached out to poorer households and urges for a more comprehensive targeting of insurance dissemination. Furthermore, the study illustrates that insurance is only able to help to a certain extent in preventing the worst case scenario of dropping out of herding and stresses the necessity for herders to use additional risk management strategies to better recover from dzud disasters.

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## Assessing Health and Environmental Impacts of Measures that Supplant Kerosene Use in Developing Country Households: Lighting

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**Introduction.** Reduction of emissions from household fuel combustion in developing countries have been proposed as important actions to decrease short-lived climate forcers and global disease burden. An estimated 1.3 billion people are without access to electricity and an even greater number have unreliable access. To fill gaps in lighting demand, households frequently rely on simple kerosene-fueled lamps that are inefficient in terms of combustion and providing light services. Growing evidence is revealing that kerosene emissions may be more harmful to health and climate than previously understood. Despite the potential benefits of reduced kerosene use and viable alternatives for replacement, few efforts have evaluated kerosene demand for lighting in-depth, how it might be affected by fuel policies, and the role of currently available alternatives.

**Methodology.** A nationally representative survey for India was used to evaluate household kerosene lighting demand trends across subpopulations and electricity access groups. Results were then used to develop a household lighting demand model, accounting for kerosene and electricity, differences across sub-populations, and population and income growth over time. The demand model was linked to an energy system model (MESSAGE) to evaluate how various policy actions would affect kerosene demand. Finally, using demand scenario results, we use the GAINS model to evaluate changes in black carbon emissions, ambient particulate matter concentrations, and selected health outcomes.

**Results.** Survey results indicate that kerosene lighting accounts for approximately 65% (5000-6000 Gg/year) of residential kerosene consumption in India. The share of kerosene consumption by electrified homes with unreliable electricity is approximately equivalent to the households relying on kerosene as primary lighting fuel. Demand curves across electricity access groups indicate that the service cost of kerosene lighting is consistently higher than electricity by a factor of 1.5-3. The relationship between access group demand curves, however, changes depending on the service metric assumed to drive household demand.

**Conclusions.** Preliminary findings highlight the importance of considering populations with unreliable electricity when evaluating residential lighting in developing countries. Most efforts to evaluate the impacts of kerosene lighting have previously considered only non-electrified populations; however, this may be significantly underestimating activity demand. Demand curves for kerosene and electricity for light provide population-derived break-even points for which to compare decentralized electricity and small-scale solar for lighting. Finally, when considering replacement technologies to meet light demand in kerosene-using homes, service metrics used in industrialized countries (e.g. lumen-hr) may not necessarily capture household perceptions of service.

## **Earthquake Risk Modeling for the Evaluation of Different Mitigation Measures to Reduce Losses to Property Owners in the Metropolitan Area of Shiraz**

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**Introduction.** Iran is in a highly seismically active region and structures must be designed and constructed to withstand earthquakes based on the real earthquake risk. Following on the lessons learned from past earthquakes, mitigation are key elements to reduce structural and human losses. Loss estimation plays vital rule in risk management studies because property values change, as do the costs of repair and replacement, building materials, design and practice change along with building codes.

**Methodology.** Current study describes economic and human losses related to the seismic hazard by two approaches: Earthquake Risk Modeling and Probabilistic Benefit-Cost Analysis approaches. Earthquake risk modeling has been designed and implemented in GIS based on four main modules: Hazard, Exposure, Vulnerability and loss. Hazard module characterizes the risk of earthquake hazard by its epicenter location and moment magnitude, along with other relevant parameters. Exposure module characterizes the inventory or portfolio of properties at risk as accurately as possible. In Vulnerability module, the model quantifies the physical impact of the earthquake hazard on the property at risk. Loss module includes the cost to repair and/or replace a structure. Probabilistic Benefit-Cost Analysis (BCA) has been conducted with two concentrations: economic and human losses.

**Results.** According to the obtained results of benefit-cost analysis in 53 different types of buildings, the benefit-cost ratios which are more than one are related to the pre-codes buildings in all types of structures (steel, concrete and masonry). Benefit-cost ratios for the steel, concrete and masonry moderate-code buildings are less than one. Structural vulnerability is highly dependent on the buildings codes rather than hazard. By considering of human losses results shown the significant increase in cost-benefit ratios.

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## **Closing the yield gaps: how sustainable can we be?**

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**Introduction.** Globally, food consumption patterns are changing towards affluent diets. Food production usually requires inputs and induces environmental stress. Presently about a billion people mostly from developing countries is living under malnutrition and hunger. However, crop production could be increased by more than 50% by closing the yield gaps. Due to dietary changes and expected global population of around 9 billion, food production needs to be almost doubled by 2050. This certainly requires more external inputs and exacerbates environmental stress raising an important sustainability question: how to achieve food self-sufficiency (FSS) on global, regional and local scale while addressing the need to minimize agriculture induced environmental stresses?

**Methodology.** We tried to deal with the issue raised above by dividing our investigation into two parts. At first we identified regions where achievement of potential crop calorie production would meet present and/or future FSS. We defined crop calorie production gap as a ratio between potential and observed crop calorie production, and a region as crop calorie deficit if its total crop calorie consumption is greater than its total crop calorie production. The second part comprises the identification of management packages needed to achieve potential crop calorie production. We used data from Global Agro-ecological Zones (GAEZ) model to identify management and input options that would overcome biophysical and socioeconomic factors causing the gaps between traditional low input farming yields and advanced farm management high input yields. We defined eight clusters of countries based on their achieved potential crop calories, management and input levels around the year circa 2000.

**Results.** Most of the countries could obtain FSS or at least upgrade FSS status when achieving potential crop calorie production levels for present and future food consumption levels. Closing the yield gap might not be enough to achieve FSS in many of the countries in Sub-Saharan Africa by 2050 due to population increases and changes in dietary patterns. Closing the yield gap requires a multiple of management and input options additional to fertilizer application, e.g., pest, climatic risk, soil and market management that varies across regions. Results show for example that Sub-Saharan Africa requires a complex package of soil and market management improvements to increase their yield, whereas regions in India require mostly improved soil management and Russia requires climatic risk management. Moreover, the Sub-Saharan African soil management mostly consists of improving nutrition retention capacity of the soil while in India soil management mostly consists of improving workability of soil via mechanization. A map of management packages as required in different part of the world to achieve the high input potential yields is presented.

**Conclusions.** The magnitude of environmental stress hangs largely on ways management packages are implemented to close the yield gap. Therefore, we need to explore synergies between closing the yield gap to enhance FSS and minimizing the agriculture induced environmental stresses.

## Risks for socio-economic development in Egypt: Does investment into renewable energy provide an opportunity?

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**Introduction.** Development has always been the great challenge developing countries face throughout the different eras, however the approaches towards achieving this precious goal varies from country to the other and from age to age. For instances, some countries got rich using its natural resources such as oil in case of Arab countries while others used its human capital; mainly China. Others believed much in the capability of technology in achieving the required growth and development such as Japan and South Korea. This paper is trying to investigate the impact of using an approach that combines both the abundant natural resources and the technology on development. As main source of wind and solar energy, Mediterranean economies should learn lessons from oil experience to efficiently use the abundant natural resources they have. Not only they need to accumulate more value added, but they should also benefit from creating jobs associated with industries that supply intermediate goods for building retrofits or wind turbines. In this regard, expanding economies generally and deepening industrial sector specifically can help developing countries to create solid technological base and sustain higher real GDP growth and per capita income; hence, economic convergence among those nations and developed ones can be maintained.

**Methodology.** The model used in this research is calibrated on the Social Accounting Matrix (SAM) of Egypt for the fiscal year 2006/07. The SAM represents flows of all economic transactions that take place within an economy. It is a statistical representation of the economic and social structure of a country, which refers to a single year and provides static picture of the economy. SAMs are square such that column sums equal row sums in the sense that all institutional agents (firms, households, government and the foreign sector) are both buyers and sellers. Columns represent buyers (expenditures) and rows represent sellers (receipts). Then, the economic multipliers are calculated using this formula  $X = [I-A]^{-1} Y$  where X the output of commodity I and Y represents the final industry demand while  $[I-A]^{-1}$  refers to the matrix of multipliers. Multipliers of three scenarios were calculated in order to test their effects on the Egyptian economy; current investment, implementing DESERTEC plan and securing 100% of the local demand from CSP.

### Results:

#### Summary of Multipliers from one unit injection into CSP

Type of Multiplier	Multiplier of base scenario (current level of investment)	Multipliers of 1 <sup>st</sup> scenario (DESERTEC plan)	Multipliers of 2 <sup>nd</sup> scenario (secure local demand of electricity from CSP)
GDP multiplier	1.62	2.12	1.67
Income multiplier	2.15	2.19	2.04
Output Multiplier	4.04	4.32	4.46

The results show that the DESERTEC plan is the most efficient scenario measured by the GDP as well as the income multipliers. This scenario can achieve the highest possible growth for the Egyptian economy. Thus, the Egyptian government should cooperate with DESERTEC and pave the way for the investments in the CSP.

## **Integrating Vehicle Consumer Choice into the MESSAGE Integrated Assessment Model: Implications for Energy Efficiency and Advanced Technology**

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**Introduction.** Integrated Assessment Models (IAMs) have been widely used as key instruments to develop long-term energy and emission scenarios and to identify cost-effective patterns of resource use and technology deployment over time, particularly in the context of climate change mitigation. Yet, one of the major deficiencies of most current models is their limited representation of heterogeneity on the demand-side. More specifically, systems-engineering optimization models are often very rich in representing supply-side technological details but, in general, represent behavioral parameters much more simplistically. Consumer behavior cannot be ignored, however, when it comes to system-wide modeling, as it is a critical aspect of policy and decision-making. Outside of the IAM community, consumer choice has typically been modeled using non-linear simulation approaches. The objective of this project is to develop a bridging approach to bring in consumer behavioral parameters – specifically for the transport sector – to a linear-programming IAM framework and to test this approach through scenario analysis.

**Methodology.** Our particular focus has been on further enriching the end-use side of the IIASA Energy Program’s prototype MESSAGE-Transport model by incorporating utility-based consumer choice decisions in the light-duty sector. The framework of the MESSAGE-Transport model consists of the vehicle price, fuel cost, and other O&M costs to make the optimal vehicle technology decisions for the system. Market penetration constraints are provided for each technology, and this partially shapes the pattern in which a new technology is adopted in the system. In the new approach we have implemented, a nested multinomial-logit consumer choice model developed by Oak Ridge National Laboratory, MA<sup>3</sup>T (Market Allocation of Advanced Automotive Technologies) (*Liu & Greene, 2010*) is used to obtain consumer behavioral parameters, which can then be transferred to the MESSAGE-Consumer model for utilization with a linear-programming framework. As the first step, the energy service demand is disaggregated into twenty-seven consumer groups, based on the location, risk attitude towards technology, and driving behavior profiles. On the vehicle technology side, in addition to vehicle and fuel costs, a ‘disutility cost’ is included that is specific to the each consumer group and each vehicle technology. This cost, which comes from MA<sup>3</sup>T, captures the inconvenience costs (or non-monetary barrier costs) for the technology adoption. For each consumer group, an optimal least-cost technology decision is made, based on the vehicle cost, fuel cost and the disutility cost parameters. These optimal results are then aggregated for the system across consumer groups. This methodology can technically be applied to any IAM that has the linear optimization framework to improve their demand-side heterogeneity, particularly in terms of behavior

## Developing a Strategic Stochastic Optimization Model, Robust Solutions, and a Decision Support System for Energy-efficient Buildings

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**Introduction.** Energy Systems Optimization is increasing its importance due to deregulations of the energy sector and the setting of targets such as the 20/20/20. This raises new types of dynamic stochastic energy models incorporating both strategic and operational decisions (short-term decisions have to be made from long-term perspectives) involving both technological and market-oriented financial options. Thus, public buildings managers are challenged by decision making processes to achieve robust optimum portfolio. Moreover, those decisions must be made under inherently uncertain conditions.

**Methodology.** Advanced Stochastic Optimization (STO) methods under quantile-based security constraints for optimal and robust strategic decisions have been used. The model procures robust solutions considering all the plausible scenarios. A framework for Decision Support System (DSS) is proposed, see Figure 1. Such a DSS facilitates *stakeholders dialog* under a reproducible research approach, with data analysis capabilities, human- and machine-readable model representation, and interaction with optimizers. The framework relies on R [1] through the development of the `optimr` package.

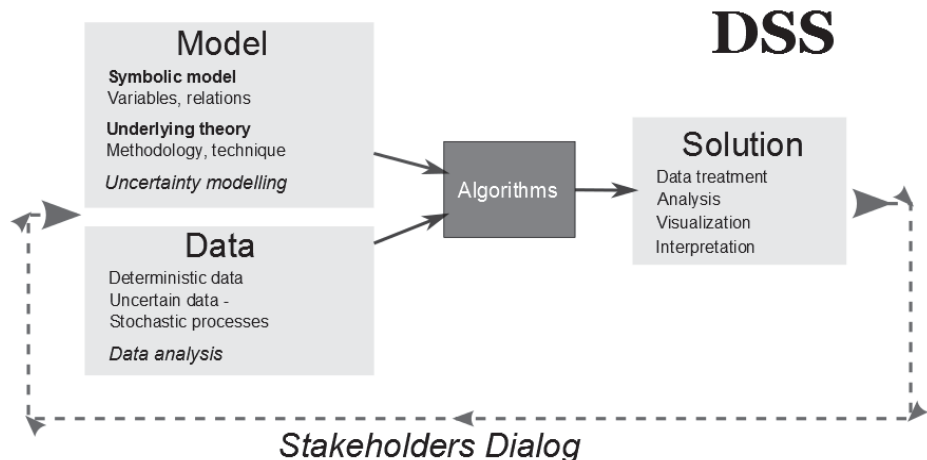


Figure 1: Decision Support System Framework

**Results.** The model has been tested using real data from the EnRiMa project [2], where the framework has been used within a more specific DSS. Results demonstrate the usefulness of using STO improving the outcomes of deterministic models and hedging against risks.

**Conclusions.** Decision making is not a static action, but rather an iterative process that requires stakeholders dialog. Moreover, strategic decisions under uncertainty require the application of advanced models that provide robust solutions against all the possible scenarios and satisfy security requirements. The framework proposed deal with those requisites in a flexible and extensible way.

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## Creating a web-based gaming simulation for green electricity consumption

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**Introduction.** In this research, in order to better understand people's decisions related to energy consumption, a web-based gaming simulation was developed. The gaming simulation itself has different definitions and roles; one of them is to provide a virtual world for people, and then monitor how they react towards new or complicated scenarios [1][2]. We developed a web-based gaming simulation tool with respect to a liberalization of the electricity market leading to free choice on the residential demand side, i.e. consumers with preferences for renewable energy can also switch to energy contracts including a higher portion of green power. The gaming simulation is designed to detect behavioral patterns in the context of new concepts or regulations in society i.e. liberalization of electricity serves as an example here. Participants would experience living in a country where liberalization is introduced. After developing the gaming simulation, which is called Green Energy Consumption "GEC", we conducted experiments via the Internet using a web browser.

**Methodology.** This research applies the gaming simulation method for collecting peoples' decision-making process data. The participants enter a world where the liberalization of electricity markets is introduced which means that they can select one electricity provider from multiple providers who have different portfolios. In this game, they have the role to decide for an electricity provider; also they represent a family of four, living in a detached house in a country with 4 seasons. The main distinguishing features of the different portfolios are their cost and their emission profile. In this game, the participants can select 4 providers which generate electricity by a) hydro energy, b) biomass energy, c) solar and wind power, d) fossil fuel and nuclear energy. To acquire information about the participants, GEC has a questionnaire before and after the gaming simulation to collect the participants' background data.

**Results and Conclusions.** Firstly the data collected via GEC is analyzed. The data sets have 1) personal information, i.e. education level, monthly income and electricity usage, 2) decision-making process data, i.e. which providers they choose. We received to date about 20 participants (note that this is work in progress and that there will be ultimately be 100 people in sample). Preliminary results show that the participants who are living in the country where liberalization was already introduced tend to prefer realistic and complicated simulation results because they have knowledge about liberalization in their daily life. On the other hand, participants who are living in countries where the liberalization is not introduced prefer simpler scenarios. The results display differences determined by the participants' backgrounds. As a next step, we should consider deciding on specific filters, i.e. people have education and knowledge or not, to better analyze people's decision-making process data.

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## Projection of Chinese Vehicle Growth, Energy Demand and Emissions Through 2035

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**Introduction.** Transportation sector plays an important role on urban and regional air quality in China. Projecting its future energy use and emissions have become a hot topic in the community. Previous studies usually projected emissions at national level. This paper aims to make a finer projection at provincial level, taking account of different growth patterns of vehicles between provinces. Then oil demand and emissions are calculated on the basis of vehicle activity at provincial level.

**Methodology.** Vehicle fuel demand and emissions are calculated using equation (1).

$$\begin{aligned} \text{Fuel\_Demand} &= \sum_i V_i \times \text{VKT}_i \times \text{FE}_i \\ \text{Emission} &= \sum_i V_i \times \text{VKT}_i \times \text{EF}_i \end{aligned} \quad (1)$$

where  $i$  represents vehicle categories;  $V$  is the total number of vehicles; VKT is vehicle kilometers traveled each year; FE is the fuel consumption rate per 100 km; EF is emission factor. Gompertz function that links per-capita GDP and vehicle ownership is used in this study to project vehicles for each province. VKT and FE value come from our survey data and projected for future (Huo et al., 2011; Huo et al., 2012). EF value is calculated by IVE model and adjusted according to on-road measurement for the vehicle models we have measured.

**Results.** In 2035, the number of total vehicles will reach 520 million, including 73% urban private cars, 10% rural private cars, 9% commercial LDVs (light duty vehicles), 1% buses and 7% trucks. The total oil demand will reach 465 Mtoe. The emissions of CO, HC, NO<sub>x</sub> and PM<sub>2.5</sub> will reach 5829, 853, 7892 and 171 Gg respectively.

**Conclusions.** Vehicle ownership is increasing fast in China and will reach 7 times as much as that of 2010 in 2035. Although the central and western provinces have fewer vehicles than the eastern ones, they have much faster growth rate that should be noted. The large oil demand and pollutant emissions caused by the tremendous growth need to be controlled through various measures, such as implementing new emission standard, restricting vehicle sales and use.

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## Spatial inventory of greenhouse gas emissions in the industry sector

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**Introduction.** Manufacturing Industries and Construction sector is one of major sources of greenhouse gas (GHG) emission and the one of the most considerable sectors for GHG emissions reduction. To estimate the effectiveness of GHG emission reduction measures one must have information on GHG sources at the level of individual regions, not only at the national (country) level.

**Methodology.** Using available statistical data: amount of fossil fuel consumed, gross value added, coefficient of industrial development, number and distribution of inhabitants and other essential parameters, the universal mathematical models and algorithms for spatial inventory of GHG emission in the industrial sector are created and improved. The algorithms which downloads the total amount of fuel used at the level of the country to specified objects of smaller size are developed. The GHG emissions are calculated according to IPCC guidelines. For presenting the results of numerical experiments, the geo-referenced databases and digital maps of GHG emissions in Poland (as a country - EU member) and Ukraine (a non-EU member ) were created.

**Results. Ukraine.** According to the results of the assessment, the largest GHG emission caused by the industry sector is in Dnipropetrovsk, Donetsk and Luhansk regions, because large metallurgical factories are located here. Coal and natural gas are the main fuel in Ukrainian industry.

**Poland.** The largest source of GHG emission over the country is Southern Poland – the most industrially developed part of Poland. According to the obtained results, the biggest amount of GHG emission from burning fuel are observed in Slaskie, Opolske and Malopolske voivodeships.

**Conclusions.** Results of the developed approach and GIS-based software on spatially explicit GHG inventory from industrial sources allow to identify the most intensively emitted areas and examine the structure of emissions. This will help the power structures in creating new strategies (changing fuels, use of advanced energy saving technologies, introduce renewable energy sources etc.), which in turn will reduce emissions in these categories of industry.

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## Regional assessment of short-lived climate pollutant mitigation measures

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**Introduction.** Methane, carbonaceous and sulfate aerosols, and tropospheric ozone are short-lived air pollutants that influence the Earth's climate and variously damage human and ecosystem health. These air pollutants, collectively known as short-lived climate pollutants (SLCPs), and their precursors share many of the same anthropogenic emission sources. The near-term climate impact of SLCPs is species dependent – some pollutants warm the climate, while others have a cooling impact. In a 2011 report [1], UNEP & WMO identified a set of priority measures aimed at SLCP reductions at the global scale that would simultaneously achieve benefits for both air quality and climate. This project assesses the regional importance of SLCP mitigation measures in China using updated emission projections. An emission reduction scenario incorporating the most-promising SLCP emission reduction measures in China will be used in planned global chemistry-climate model runs.

**Methodology.** An updated emission scenario for China was built from components existing in the GAINS database, including an energy pathway based on regional-level data. All technological measures available in the GAINS database were screened for their potential to simultaneously mitigate near-term warming and provide human health and crop co-benefits through reducing emissions of the short-lived climate pollutants. East Asia-specific emission metrics were used to calculate CO<sub>2</sub>-equivalent emission reductions in 2030 for each co-emitted pollutant for all available pollution control measures. The potential climate impacts from all co-emitted pollutants were summed for each technology, and the emission reduction measures were ranked according to their overall potential climate impact. Potential benefits from air quality improvements were calculated using the GAINS model.

**Results.** The screening process identified over 100 measures in the GAINS database that would result in co-benefits for air quality and near-term climate protection if implemented by 2030. Of the total CO<sub>2</sub>-equivalent emission reductions possible in 2030 from implementation of all of the identified measures, roughly 45% of the reductions can be attained by control of methane emissions from coal mining. Introduction of new, cleaner-burning residential cooking stoves has high potential for both reducing warming emissions and limiting damage to human and crop health.

**Conclusions.** Like the global study, the regional study identified both methane and black carbon abatement measures as being of high priority for limiting near-term warming. In China, methane-reduction measures were found to have the highest potential for mitigating warming. Implementation of the SLCP-reduction measures with the highest potential climate impact can provide co-benefits in the form of avoided damage to human and crop health.

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## **Analysis of possible climate change impacts on agriculture and food security in Ukraine using GLOBIOM model**

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**Introduction.** Climate changes add another challenge to the world food system – a system that is supposed to feed everybody while ensuring the sustainable management of natural resources. Is mankind adequately prepared to face this challenge? Climate change impacts on agricultural systems will vary between countries and regions. Likely, that increased heat waves and lower precipitation level, as predicted by climate change modelers, may shock production of major world grain producers. Many scientists consider that impacts on Ukrainian agriculture may not be as ruinous as in other countries. Agriculture is one of the strategically important sectors, accounting for 9.6% of the GDP and 15.6% of total goods exports in 2011. It absorbs approximately 16.77% of the total employment. Ukraine’s ‘black soil’ is rightly famous, a rich soil that is well known for its fertile qualities. In Soviet times, Ukraine was known as the breadbasket of Europe, the land that fed the world and provided one-fourth of the Soviet Union’s agricultural output. Ukraine’s rich, black soil is one of the country’s greatest resources. It is becoming increasingly important to the rest of the world. My studies address the following questions: what is the range of possible climate change impacts on Ukrainian agriculture; what role may Ukraine play in maintaining world agricultural production and food security under climate changes; what are potentials of Ukraine to increase its agricultural exports?

**Methodology.** We use the GLOBIOM model of IIASA for the analysis of climate change impacts on agriculture and the dynamic recursive procedure for downscaling and harmonization of data. With the help of GLOBIOM-group we consider a range of climate scenarios generated by 5 GSMs and 4 RCPs to analyze their spatio-temporal impacts on crop yields generated by EPIC model. Under alternative productivity scenarios, we use GLOBIOM model for investigating opportunities of Ukrainian agricultural sector to increase its markets share and enhance world food security.

**Results.** The index of gross agricultural production in 2011 has increase by 82.6 per cent compared to the level of 1990. It means that gross agricultural production hasn’t restored the level of 1990 yet. But tendency of growing is positive phenomenon. Half of all arable land in Ukraine is dedicated to wheat, barley, maize and sunflower seed. These are the four main crops grown in Ukraine. Foreign trade value of agricultural products has been increasing for last 10 years. Food products have the biggest part in the structure of Ukrainian agricultural imports, while Ukraine mainly exports products of low and medium level of processing.

**Conclusions.** Studies show that possible positive climate change effects on agriculture and food security in Ukraine have dual character. Current main concerns are increasing cash crop production. To diversify the crops’ basket, it is necessary to introduce regulations as to what crops and where to produce. Possible positive climate change effects on Ukrainian agriculture may be realized if Ukrainian government develops proper policy recommendations accounting for international trade, ecological, as well as socio-economic constraints.

## Water use impacts of future transport fuels: The role of California's climate policy & National biofuel policies

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**Introduction.** In the coming decades, growing demand for energy and water and the need to address climate change will create huge challenges for energy policy and natural resource management. Synergistic strategies must be developed to conserve and use both resources more efficiently. California (CA) is a prime example of a region where policy has begun to incorporate policies to wisely use scarce water resources in energy infrastructure development, even while adopting GHG mitigation targets.

**Methodology.** We analyze lifecycle (LCA) water use of CA's current and future transport fuel consumption to evaluate impacts & formulate mitigation strategies for at the watershed scale. Four "bounding cases" for CA's future transportation demand are projected to year 2030: two scenarios that only meet the 2020 climate target (business-as-usual, BAU) with high/low water use intensity (WUI), and two that meet long-term climate targets with high/low WUI. We assess the main transport energy supply chains: (a) liquids from conventional / unconventional oil & gas, (b) thermoelectric & renewable generation technologies, and (c) biofuels.

For biofuels we extend our scope to the entire US as most of the biofuels consumed in California are and will be produced from outside of the state. We analyze policy impacts that capture both direct & indirect land use effects across scenarios, thus addressing the major shortcomings of existing studies, which ignore spatial heterogeneity as well as economic effects of crop displacement and the effects of crop intensification and extensification. We use the agronomic-hydrologic model EPIC to capture both green water (GW) and blue water (BW) use at a 10 km resolution among three scenarios: (1) a counterfactual with no national biofuel policy, (2) current Renewable Fuels Standard (RFS) mandates, and (3) a proposed national Low Carbon Fuel Standard (LCFS) plus the RFS scenario. Inputs are spatially explicit: (a) cropping areas & yields, projected by a partial equilibrium economic model, (b) daily weather data, (c) soil properties (d) N fertilizer application, & (e) irrigation sources & volumes, by crop.

We assess the differences among biofuel scenarios from 2007-2035 along the following metrics: (1) crop area expansion on prime & marginal lands, (2) Crop-specific & overall annual/seasonal water balances including (2a) water inflows (irrigation & precipitation), (2b) crop-atmosphere interactions: (evaporation & transpiration) and (2c) soil-water flows (runoff & soil infiltration), in  $\text{mm}^3$  /acre.

**Results.** We develop plausible siting scenarios that bound possible water sources, impacts, and dispositions to provide insights on infrastructure siting & limit water impacts of supplying energy. We identify opportunities to improve water use efficiency and highlight salient policy relevant lessons.

**Conclusions.** We find differential water use impacts among biofuel scenarios are a primarily a function of (1) land use conversion, in particular use of formerly uncropped land, (2) irrigation, (3) feedstock water use efficiency, and (4) the longer growing season and predominance of rainfed cultivation of dedicated biofuel feedstocks.

## Modeling the Impacts of Climate Change and Market Integration on Agricultural Production and Land Use Management in Austria

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**Introduction.** Climate change can affect agricultural production both directly (higher temperatures, CO<sub>2</sub> concentration levels, precipitation patterns, extreme weather events) as well as indirectly (via its impact on global agricultural production patterns and thus global markets). We thus want to investigate how both impacts affect agricultural production, land use and the bio-physical environment in Austria.

**Methodology.** The direct effects of climate change are assessed by an integrated modeling framework that builds highly stratified climate change impact chains of Austrian land use systems at a spatial resolution of 1 km by sequentially linking a climate model (ACLiReM), a crop rotation model (CropRota), a bio-physical process model (EPIC) and a price exogenous bottom-up land use model (PASMA<sub>[pixel]</sub>). Moreover, the Global Biosphere Management Model (GLOBIOM) seeks a global partial equilibrium in allocating land-based activities by maximizing the sum of consumer and producer surpluses subject to resource endowments and several balance equations. Synergizing the strengths of PASMA<sub>[pixel]</sub> (i.e. detailed resolution) and GLOBIOM (i.e. global partial equilibrium) allows detailed and consistent analysis of direct and indirect climate change impacts. Thus, we have developed miniGalaxy to combine the strengths of both models. MiniGalaxy is a global PE model with the demand structure of GLOBIOM, but a simplified supply module. The supply module consists of a set of alternative production vectors produced by PASMA<sub>[pixel]</sub> and GLOBIOM through harmonized scenario analysis. The productions vectors contain coded information on commodity outputs, production and adaptation costs, GHG emissions, resource requirements, etc. at aggregate level that is compatible with the demand module. MiniGalaxy seeks a global equilibrium by maximizing the sum of producer and consumer surplus and building a convex combination of the coded production vectors.

**Results.** The direct impacts of regional climate change scenarios until 2040 have already been assessed in PASMA<sub>[pixel]</sub>. We find that crop yields increase in most scenarios (especially when precipitation increases). Higher yields lead to more intensive agricultural production, notably on arable land, and thus to increased mineral fertilizer usage and emissions. Further, the amount of irrigated land is highly sensitive to changes in precipitation patterns. The economic impact is small but positive. If the direct impacts are enhanced or mitigated by considering a global trade regime remains to be investigated.

**Conclusions.** Direct climate change impacts until 2040 seem to positively affect agricultural producer surplus in Austria but can increase pressure on some environmental indicators. Previous sensitivity analyses show that activity choices in PASMA<sub>[pixel]</sub> (e.g. fertilization) react very sensitive to changes in commodity prices. Hence, indirect climate change effects via the global market have the potential to enhance, mitigate or even converse the above impacts. Further analyses will thus consider this aspect.

## Evaluation and Comparison of CO<sub>2</sub> Mitigation Possibilities of the Complete Bioenergy Chain from Two Model Frameworks

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**Introduction.** With increasing pressure to reduce greenhouse gasses for the combustion of fossil fuels, there has recently been significant interest in the use of biomass as a primary source of energy (bio-energy). However, a number of open questions remain: *What are the main primary sources of biomass (crops, forests, residues)? What bioenergy technologies can help with emission mitigation? What is the total emission mitigation contribution? Does increased use of biomass limit land-based mitigation?*

A number of integrated assessment models (IAMs) have attempted to answer these questions. However different IAMs have different representations of land and energy systems, leading to varying results. This project attempts to understand (i) the contribution bioenergy may have as an emission mitigation measure including land and energy system emissions (ii) compare the results of two IAMs in order to see how system representation affect the results.

**Methodology.** The two IAMs included in this study are GLOBIOM-MESSAGE and IMAGE. First a qualitative assessment of the models has been conducted in order to understand the system representation in each IAM. Following a scenario analysis is conducted. Each IAM is run with a baseline and a mitigation scenario (4.5W/m<sup>2</sup>). The growth in biomass use as well as changes in CO<sub>2</sub> sources/sinks are assessed. A final scenario with the carbon price of the mitigation scenario and no biomass use is also run. The tradeoff between biomass production and land based mitigation as well as the resulting emissions gap gives insight on the contribution of biomass to reduce emissions. Results between the IAMs are compared and agreements or disagreements are explained.

**Results.** Despite vastly different land-energy system representations between the IAMs, they both broadly agree on the importance of bioenergy in reducing emissions. Areas of agreement include primary biomass use projection (60-80EJ/yr by 2100, approx. 10% of TPES), growth of biomass use in mitigation scenario (110-130EJ/yr), the importance of bioenergy with carbon capture and storage (CCS) and importance of fuel switching to reduce emissions as opposed to land based mitigation. Most importantly, the models agree that the resulting emissions gap when there is no-bioenergy is approximately 15%. The models disagree on the potential of land-based mitigation, a disagreement arising due to differences in land-system representation.

**Conclusions.** Bioenergy can play a significant role in reducing anthropogenic emissions. Depending on system representation, there may be a tradeoff between biomass availability and land-based mitigation. However, both models agree that the potential emission reduction from displacing fossil fuels as well as using CCS technology vastly outweighs the potential for land-based mitigation.



## Efficient forest biomass handling at terminals with focus on bio-refinery and fuel wood supply chains

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**Introduction.** Traditionally, forest terminals served as storage and transition points for round wood deliveries to the forest industry. However, according Forest Industry's IT Company (SDC), since 2000, biomass deliveries for energy have increased by 20 % (SDC 2013). Also today, from the perspective of combined heat and power (CHP) plants terminals play a role as storage and buffer. The use of biomass terminals in the procurement chains of forest biomass may reduce the total supply costs of CHP plants by 18.3% due to centralized procurement procedures (Palander and Voutilainen 2013). A study done by Kärhä (2011) indicated that terminal use for chipping operation will increase between the years 2006 and 2010. The aim of this paper is to characterize the existing forest biomass terminals in Sweden.

**Methodology.** A quantitative questionnaire was carried out by SDC among forestry companies. Data about terminal locations, assortment volumes, equipment, delivery methods and inventories were gathered. All biomass assortments were converted to oven-dry tonnes by using WeCalc converting tool developed by the Swedish University of Agricultural Sciences.

**Results and Conclusions.** The average terminal size is 2 ha from which 0.9 ha are paved. The average biomass density per terminal is 0.6 ODT/m<sup>2</sup>; however some terminals reached even 8.8 ODT/m<sup>2</sup>. Comminution of biomass is carried out at 88 % of terminals. The range of taken in assortments is rather wide from 1 to 8 assortments per terminal and on average a Swedish forest terminal will take in 2.3 assortments. The most common inventory method is visual assessment which counts for 44 % and only 32 % of terminals are doing qualitative inventory assessment. 55 % of terminals have measuring facilities and 7 % of terminals use drying ovens to determine the moisture content of biomass. Description of forest biomass terminals is the first step before more complex simulation and optimization models can be applied. One of the major optimization objectives will be to optimize the sharing of measuring facilities between different terminals when a new regulation will come into force in the Swedish forestry sector.

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## **Ammonia emission and control potentials in the Pearl River Delta (PRD) / Guangdong province, China**

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**Introduction.** Ambient air pollution issues in the Pearl River Delta (PRD) region of Guangdong Province, China (including Hong Kong) persist as major public environmental and health challenges. NH<sub>3</sub> together with SO<sub>2</sub> and NO<sub>x</sub> is a precursor compound of PM<sub>2.5</sub> which is concerned for human health and haze pollution. In recent years, local government agencies have implemented measures on reducing SO<sub>2</sub> and NO<sub>x</sub> emissions and control strategies have been evaluated using regional air quality models to understand impacts of emissions reduction. However, only few studies in this region are available on NH<sub>3</sub> emission inventories or potential control measures for NH<sub>3</sub>, compared with SO<sub>2</sub> and NO<sub>x</sub>.

**Methodology.** During the YSSP period, the study of identifying NH<sub>3</sub> emissions as well as control potentials for the PRD/Guangdong, China, following the methodological of the GAINS model were conducted. By localizing the emission factor, the improved PRD/GD county-level NH<sub>3</sub> emission inventories were developed, including 9 source categories and 45 sub-categories for the base year-2010. To provide air quality model-ready emissions input, a case of PRD agricultural NH<sub>3</sub> emissions inventory was spatially allocated to 3km×3km grid cells with GIS technology. And by investigating the cycle of NH<sub>3</sub>-N mass-conservation for livestock-specific (housing, storage, application and grazing) and the urea substitution, the NH<sub>3</sub> control options and potentials of agriculture sources were identified for the year of 2020 and 2030.

**Results and Conclusions.** Results show that livestock is by far the most important NH<sub>3</sub> emission source that contributes about 50.9% of the total NH<sub>3</sub> emissions in GD province, followed by N fertilizer applications (~34.7%) and non-agricultural sources (~14.4%). Most emissions from livestock were distributed over rural residential and crop areas and the distribution of N fertilizer application presents intensive emissions on arable land. The projection about agricultural sources showed that the emission steady climbed in 2020-2030 based on the state of development in the year-2010. When changing the different ration of farming system in 2020/2030 like increasing the ratio of intensive farm, the livestock emissions were both falling compared with the projections. By assessing the emission reduction potentials under the proposed control option in 2020/2030, for the major sources of agricultural ammonia emissions (i.e., animal manure and urea fertilizer application), these measures were control effective.

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## Representing the Spatial Diffusion of Technologies in an Energy System Optimization Model

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**Introduction.** Historical experience indicates that technologies diffuse gradually, often according to S-shaped logistic growth trajectories. To ensure that new technologies diffuse in roughly this manner, energy system optimization models typically impose crude constraints on activity or capacity growth from one period to the next. This simple approach neglects important spatial aspects of diffusion, namely the observation that technologies diffuse at different times, at different rates, and to different extents in different regions. As a result, model outputs often feature technology diffusion pathways that are inconsistent with historical experience and intuitive expectations. Schmidt's Law offers a framework for thinking about spatial technology diffusion. A technology is first developed in a core region. Rim and periphery regions adopt the technology later but benefit from the earlier experience of the core. As a result, the rate of diffusion accelerates in the rim and periphery regions. The goal of this study is to represent spatial technology diffusion in an energy system optimization model to bring diffusion projections more in line with reality.

**Methodology.** This study uses a four-region version of the MESSAGE model implemented in GAMS. For a given electricity supply technology in a particular region, new capacity installation is constrained by the region-and-technology-specific knowledge stock. This stock reflects all prior capacity additions, with more recent additions weighted more heavily than earlier additions to capture knowledge depreciation. This soft constraint can be exceeded but at significant and marginally increasing cost. Diffusion from the core region to rim and periphery regions is controlled by a knowledge stock spillover effect. Rim and periphery regions begin with no ability to install capacity of a new technology and must rely on spillovers from the core in the early phases of adoption. Ability to add new capacity as a function of knowledge stock and the spillover magnitude are estimated using historical data on coal, gas, nuclear, and wind power.

**Results and Conclusions.** Relative to standard diffusion formulations, the novel representation implemented in this study generally induces smoother and more gradual diffusion trajectories featuring spatial patterns consistent with Schmidt's Law. Dependence on knowledge spillover from the core delays adoption of advanced technologies in the rest of the world. Technologies preferred by the core (e.g. coal with CCS) diffuse rapidly and persistently once they enter other regions. The spatial diffusion of technologies that are less suitable in the core (e.g. biomass with CCS) suffers significantly in the presence of the spillover requirement. It is globally optimal for the core to increase deployment of advanced technologies in light of the positive spillover externality. Developing nations should consider which technologies are likely to be deployed heavily by the innovative economies, as knowledge spillover will likely make these technologies easier to adopt than technologies that must be invented or refined domestically.

## Scaling Dynamics and Cost Trends of New Technologies

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**Introduction.** Research of the spatial and temporal diffusion of technologies and their performance trends offers important insights for patterns, drivers and constraints of future technological change, for instance the one required to achieve climate stabilization. The research project aims to further the understanding of the historic change of such technologies which could present analogies for new environmental add-on technologies (e.g. Carbon Capture and Storage, Direct Air Capture).

**Methodology.** Following the methodology of Wilson (2009), a historic scaling dynamics analysis is conducted for a range of chemical industry production processes (e.g. for ammonia, ethylene, benzene, chlorine, caustic soda). A 3-parameter logistic function is fitted to time-series data at industry and unit levels using IASA's LSM2 software. The estimated parameters (saturation level, inflection point, time period over which  $y$  grows from 10% to 90% of the saturation level) allow for the comparison of the rates and extent of scaling between the industry and unit levels of a technology as well as between different technologies. Linking production capacity to the energy intensity of production over time enables comparability of the extent and rates of scaling of chemical industry technologies with scaling patterns found e.g. for energy technologies.

**Results and Conclusions.** The analysis is highly dependent on data availability and quality. Data search and preparation turned out very time-consuming, so that at this point only preliminary results are available. (Originally, the project had envisaged a cost trend analysis of environmental add-on technologies for traditional air pollutants (like flue gas desulphurisation units) in Germany and Japan. A lack of publicly accessible cost data inhibited the continuation of this line of research.) Preliminary results suggest similar scaling dynamics of chemical industry technologies to the ones found for energy technologies. An analysis of the relation of cost dynamics and scaling dynamics is yet to be performed.

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## Systemic Risk with Strategic Interactions

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**Introduction.** In recent years, there has been an increasing interest in the study of systemic risk, which was intensified by the financial crisis. Systemic risk is a property of systems of interconnected components in which the failure of individual components can lead to the failure of others. Such cascades of failures can occur in various types of systems, including power grids, computer networks, financial or interbank systems as well as human populations in the case of epidemics. Most of the current literature in this field is descriptive and much less emphasized is the role of strategic interactions. The goal of this paper is to study how the strategic solicitation and provision of insurance can affect systemic risk.

**Methodology.** The theoretical tools used to study this problem lie at the intersection of statistical physics and game theory. Agents are assumed to be connected through a network and each can choose to insure or not against the failure of a neighbor. A Bayes-Nash equilibrium, in which agents form a mean-field expectation of a neighbor's effective failure probability, is derived. In a subsequent stage, each agent can also act as a provider of insurance, resulting in the creation of an insurance network. A co-epidemic model is then used to study the interaction of cascading failures on the contagion network and on the insurance network.

**Results.** It is found that this strategic decision to insure, as well as the mechanism by which the insurance network is formed, has the effect of endogenizing the quality of insurance. The latter is related to the risk that an insurer will fail to fulfill her obligation. This in turn affects the quantity of insurance that is demanded. Some counter-intuitive features predicted by this model include the fact that a suboptimal insurance network will tend to increase demand for insurance, as a result of the presence of network effects.

**Conclusions.** The model provides insights into how to design mechanisms to control the formation of an insurance network so as to achieve a smaller and more effective one. It also provides an insurance-based argument to the enormous size of the credit-default swap (CDS) market, which supplements the current speculation-based arguments.

## Evolution of Mediated Cooperative Interactions

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**Introduction.** Mutualisms—positive interactions among individuals of different species—are ubiquitous in nature and essential in the evolution and ecology of all life<sup>1</sup>. Previous empirical and theoretical studies of these interactions are severely limited by their typical casting of mutualisms as strictly pairwise interactions despite the growing recognition that the vast majority of mutualisms involve multiple partners, often with the exchange of different services and important evolutionary tradeoffs. Attempts to understand this interaction complexity have typically considered assemblages of mutualists that provide functionally similar rewards and/or exploit the same resources in a similar way, such that even multispecies systems are reduced to functionally pairwise interactions. Thus, previous theoretical work may not capture the true dynamics of many mutualistic associations. Here, we include one additional player in models of interspecific mutualism and consider the effects of interaction asymmetries in order to explore the role of functional diversity on interaction dynamics.

**Methodology.** Using a game theoretical approach, an individual-based model was constructed in which two concurrent pairwise games are played between a focal player and two lateral players. Players receive as payoff the sum of their own investments and the investments of the other players in the game, transformed with a saturating benefit function. This payoff structure approximates the ranking of payoffs in the classic Snowdrift game<sup>2</sup>, but with continuous investments and independent benefit functions for each of the pairwise games. Players' investment strategies were compared under several biologically motivated scenarios: 1) symmetrical parameters for each of the pairwise games, 2) asymmetrical benefit functions, 3) asymmetrical allocation of the focal mutualist's investments, and 4) increasing the resources available to the focal mutualist.

**Results.** In the 2-player game, one player acted cooperatively at intermediate levels while the other player became a parasite (these roles emerged stochastically). Interaction outcomes were similar in the 3-player symmetrical game; however, when asymmetries were introduced either in benefit functions or the focal mutualist's investments to lateral players, the outcomes became deterministic, and the identity of cooperative versus parasitic players was shown to be sensitive to model parameters.

**Conclusions.** Embracing the prevalence and complexity of multispecies mutualisms is predicted to have extensive influence on the field of biology<sup>3</sup>. With the addition of a third player into a classic model we have demonstrated that interaction asymmetries can have important effects on interaction outcomes, suggesting that studies that overlook functional diversity (i.e., most previous theoretical work) are not applicable to many mutualisms. Given the ubiquity of mutualisms, including those among conservation targets (e.g., corals), economically important groups (e.g., pollinators), and ecologically dominant organisms (e.g., ants), such conceptual improvements can have broad influence on predictive ecology, ecosystem and resource management, and biodiversity conservation.

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## Solutions in optimal control models for resource productivity

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**Introduction.** The limited reserve of natural resource has been a critical constraint for sustainable economic development. Research on resource productivity has been challenged by either economics or environmental study. There is urgent need to explore new approaches in economics which takes natural resource into the analytical framework. Moreover, the impact of economic structure on economic growth is now a new research frontier which will provide a possible way to break the black box of economic system. The aim of this project is to construct multi-sector economic growth model for the core indicator, resource productivity, to analyze the substitution of non-renewable natural by capital and technology, and to establishing optimal investment strategies for capital goods and raising resource productivity.

**Methodology.** For reaching the goal, we adopt optimal control theory with combination of economic growth model to look at the problem. In line with theory of optimal control and economic growth, we construct and modify a basic optimal control model to reflect the inter-relationship among different sectors, production factors, and other basic economic variables, as well as their dynamics. The optimal control problem for investment process is studied within the Pontryagin maximum principle. First we look at the optimal control problem in one sector system as a special case. Due to the difficulties in solving high dimensional problem using Hamiltonian system, we introduce proportional approach to the solving process to explore the further solution method of current model.

**Results.** Based on the basic model framework for resource productivity in multi-sector economic system, in one sector system with capital and natural resource as the main production factors, we get the stationary solution of investment for raising resource productivity (R&D investment) and for capital goods. At steady state, output of the system tends to stability, consumption of non-renewable natural resource tends to be 0, and reserve of non-renewable natural resource also tends to be 0. The investment intensity for raising resource productivity is in direct proportion to rate of technical progress, and inversely proportional to the elasticity of natural resource in production function. By introducing proportional approach to solving process, we successfully reduce the dimension of variables and get the same investment intensity for raising resource productivity as at steady state.

**Conclusions.** The stationary optimal solution shows that it is possible to obtain sustainable development by raising productivity and substituting non-renewable resource by capital and renewable resource. The proportional approach provides us one possible way to deal with high dimensional economic optimal control problem which can be applied in further study.

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## **Social networks and fertility behaviour among women in rural Uttar Pradesh, India**

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**Background.** Although fertility has declined across several Indian states since 1970s, with varying historical points of onset and pace of decline, women in Uttar Pradesh (a state in Northern India) still bear, on average, around four children in their reproductive lifetime due to the interplay of a complex set of demographic, socio-economic and cultural factors. However, apart from investigating the standard set of socioeconomic factors, little attempt has been made in the past to examine the role of diffusion on precipitating fertility change in the Indian context in general, and Uttar Pradesh in particular. The contemporary explanations of fertility transitions in developing societies have recently recognized the crucial role of informal human relationships/social ties in reshaping the reproductive decisions of individuals/couples embedded within specified social. In fact, a range of information, experiences and authority shared or exercised by network members (alters), the reproductive choices which significant others make and the resultant consequences on their lives may present tremendous reason for individuals (egos) to weigh, learn and choose similar or alternative fertility strategies. This social interaction effect may become even more powerful particularly with regard to any innovative behavior attached with unforeseen magnitude of risks and benefits. Social networks effects are likely to play a key role in social and demographic changes particularly in contextual settings with low education, limited mass media exposure, and weak social welfare systems.

**Data and Methods.** Using ego-centric social network data of more than 567 currently married women (18-35 years old) collected from the field, this research investigates the association between informal social interactions with network members and fertility experiences of women in Chandwak, a village of Uttar Pradesh with about 700 women in the age range considered. We used set of bivariate and multivariate techniques in the analysis. Furthermore, the study also discusses the potential policy relevant issues and its wider implications emerging from the present research.

**Results and Discussion.** This study provides new insight by empirically exploring the potential role of social networks in shaping fertility behavior of women in rural India. The descriptive results suggest that ego-centric social networks of women largely evolve along socioeconomic and cultural lines that rarely exhibit any cross overs. In other words, women from similar socioeconomic and cultural characteristics were predominantly forming social networks. Furthermore, multivariate analysis shows that average family size of close social network members was strongly associated with actual fertility of interviewed women, net of the effect of fertility behaviors of weak social ties and mother, and of the desired family size of the husband and of the mother-in-law, controlling for individual background characteristics. This clearly points towards a crucial role of social networks in determining fertility choice of women. Therefore, it's crucial from policy perspective to consider these factors while designing/implementing any behavior communication strategies of fertility awareness and family planning.



## Towards Sustainable Consumption of a Renewable Resource by a Network

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**Introduction.** In this work, we consider the social planner's problem of influencing the consumption of a renewable resource by a network of consumers, in order to ensure sustainable consumption. We propose that by understanding the factors driving the dynamics of individual consumer behavior, we can identify policies which are favorable for sustainability. The scope of this research is two-fold. The first part consists of construction and evaluation of a dynamic model of individual consumer behaviors, coupled with the resource dynamics. The second part consists of posing the problem as an optimal control one, maximizing consumption utility. We look for conditions under which a stable optimal path exists, and analyze the solutions. These conditions can be used as guidelines for policy making.

**Methodology.** Although the problem of resource consumption has been studied extensively in the past, a mathematical model describing the evolution of individual consumption rates and the quantity of the resource has not yet been developed (at least to our knowledge). To do this, we review previous studies regarding consumer psychology and identify factors which prompt individuals to alter their consumption behaviors. We find that consumers consider both ecological and social factors before altering their consumptions accordingly. Ecological factors are represented by the perceived resource quantity and social factors by the consumption of other individuals present in the consumer network. The extent to which each individual effects the consumption of another individual depends upon the strength of the tie between the two individuals. Based on this, we are able to develop a system of ordinary differential equations describing the process. We then formulate the optimal control problem, with the objective of maximizing the consumption utility, over an infinite horizon. After an equilibrium analysis of the Hamiltonian system, we are able to identify conditions under which sustainable consumption is possible.

**Results.** Assuming a homogenous consumer network, we were able to obtain a simplified and easy to analyze version of the model. This simplified model fulfills the verification criteria we set for the equilibrium points and the flow of the trajectories hence validating it. There exist 2 equilibria, an unstable one representing depletion of the resource, and a stable one representing sustainable consumption. From a similar analysis of the Hamiltonian system, we observe that sustainable consumption is possible only when the discount rate, is lower than the intrinsic growth rate of the resource. This essentially means that when discount rate is high, the future is so unimportant that it is more efficient to consume as much as possible today. Thus in order to ensure sustainability, the government must either increase the intrinsic growth rate of the resource (if possible), or decrease the discount rate of the objective functional.

**Conclusions.** Our results adhere to what intuition suggests. For sustainability, governments must either increase resource production, or plan long term. The problem has much room for expansion. We hope to get more interesting results as complexities are added to the model.

## The joint evolution of cooperation and information gathering

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**Introduction.** Even though it is often costly to engage in cooperative behavior, we observe cooperation in many biological and social systems. Some of the mechanisms that have been proposed to answer why this may be include punishment, reciprocity, and reputation (Nowak 2006, Nowak and Sigmund 1998). These mechanisms differ in their details, but they are similar in that some individuals observe the behaviors of their peers and use this information to decide how to behave in the future. It is often assumed that if there are such discriminating individuals, they have perfect information. Even so, the presence of discriminators is not always sufficient to prevent defectors from invading the population. This leaves us with two main research questions. First, is it possible for discriminators to stabilize cooperation? Second, how does this depend on how much information the discriminators store and use?

**Methodology.** I studied the dynamics of a population consisting of three interaction types—cooperators, defectors, and discriminators—using standard replicator equations. The agents play several rounds of the donation game. The cooperators always donate, the defectors never donate, and the discriminators donate only to those agents who they believe to have to be good. The discriminators can observe some fraction of the other agents and remember these observations probabilistically. After several rounds of the game, each agent receives a payoff that depends on how many donations he gave and received. Each interaction type, then, will have an expected payoff, averaged over all of the agents of that type. These expected payoffs determine how the frequencies of the three types change over time.

**Results.** When the discriminators have perfect information, depending on the initial frequencies of the three types, there are two possible outcomes. If there are few discriminators, eventually the population will be made up entirely of defectors. If there are sufficiently many discriminators, on the other hand, the population will eventually exhibit cyclical fluctuations in which all three interaction types are present. The model is somewhat robust to imperfect information: if the discriminators only observe some fraction of the games and only remember some fraction of those observations, it is still possible for the population to cyclically fluctuate with all three interaction types present. But if the discriminators observe too few agents or remember too few of their observations, defection will always dominate. However, if the discriminators are less likely to observe other interaction types than they are to observe themselves and the frequency of discriminators is high enough, it is possible for there to be a stable mix of cooperators and discriminators, which the defectors cannot invade. Thus, by reducing the information the discriminators have about the other types of agents, cooperation can be stabilized.

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## **Spatially explicit downscaling of future land use change from GLOBIOM model in the case study region of Heihe River Basin**

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**Introduction.** Land use and land cover changes have become a major driver of global and local environmental changes. In particular, they affect water consumption and quality what is of great concern to international, national, and local policy makers. International and national policy-making will continue to influence land use and have implication for local land users. Identification of future land use changes can assist planners in coping with the uncertainty associated with planning for future landscape development. Over the last decades, a range of models of land-use changes have been developed to meet land management needs. But many models focus on specific land use changes at global and regional scale, which is insufficient to establish a link with local case studies. Hence, how to derive detailed spatio-temporal estimates at required resolutions at local scale remains a challenge. The Heihe River Basin, a typical inland river basin located in the arid regions of Northwest China, was selected to study a downscaling model to project future land use changes from global/regional level to local level at fine resolution.

**Methods.** We applied an integrated methodology combining the GLOBIOM model with a dynamic recursive cross-entropy based probabilistic downscaling model to derive spatially detailed projections of land use changes from 2000 to 2050 in the Heihe river basin at 1x1 km resolution, consistently with aggregate land demand projections generated by GLOBIOM. SSP 2 and SSP 3 scenarios were selected to study the future land use changes. Then, the simulated land use in 2000 was compared with the observed land use in 2000 to validate the downscaling model by Kappa statistic. The results of downscaling will be used by the GEPIC/SWAT model for projecting future water use and the analysis of water security in the case study region.

**Results.** Different dynamic land uses changes in the Heihe river basin (including cropland, grassland, forest, planted forest, deserts, wetlands, permanent ice and snow) from 2000 to 2050 with a time step of 10 years under different SSPs scenarios were derived using the downscaling model at 1km resolution.

**Conclusion.** This dynamic recursive cross-entropy based probabilistic downscaling model integrated with the GLOBIOM model allows the downscaling of global or regional scale land use change assessments at the local level. The model provides strategic planners with the tools that are required to envisage the outcome of global and national trends and assess the implications of alternative decisions and planning strategies at fine spatial scales for the analysis of sustainable land use and water management strategies.

## **Understanding the implications of water harvesting on upstream-downstream social-ecological resilience: a case study in the Lake Tana Basin, Ethiopia**

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**Introduction.** Droughts and dry spells are among the major factors for famine and environmental degradation in sub-Saharan Africa. Field research has shown that water harvesting practices can reduce crop failures and also improve agricultural yields. Sub-Saharan Africa has enormous potential for water harvesting. However, little research is performed to investigate the implications of large scale water harvesting on upstream-downstream social-ecological resilience at a meso-scale basin. This research presents the implications of intensifying water harvesting on upstream-downstream social-ecological resilience in case study in the Lake Tana basin, Ethiopia.

**Methodology.** The Soil and Water Assessment Tool (SWAT) was used for this study. Model calibration and validation at Megech River gauging station showed reasonable model performance (i.e. Nash-Sutcliff efficiency of more than 0.7). A subbasin in Megech watershed was chosen for detailed investigation of the consequences of water harvesting on the upstream-downstream social-ecological systems. This subbasin was further subdivided into finer scale subbasins (of size 0.8-6ha) to accurately represent water harvesting ponds over suitable areas. The suitable areas for water harvesting have slope of <8%, soil type of luvisols and vertisols, and agricultural land use types. Irrigation was applied to avoid crop water stress for teff (*Eragrostis teff*) during rainy season, and growing vegetable crop (onion) during dry season. Different rates of fertilizer application were applied to explore the implications of water harvesting and nutrient application. The change in water balance, sediment, and crop yield before and after water harvesting was investigated.

**Results.** The impacts of irrigation and different rates of fertilizer application varied across the watershed and between years. Water harvesting with baseline nutrient application increased the crop yield between 24-85% during dry years, while in wet years the change in crop yield can range between 4.5-29%. Water harvesting with the recommended nutrient application in the study area increased the yield significantly (180%-250% during dry years, and 150%-185% during wet years). Onion production was up to 8 tons/ha. Intensifications of water harvesting systems reduced peak flows during the wet seasons and increases stream flows during the dry season. Sediment loads at the outlet of the watershed reduced significantly.

**Conclusions.** Benefits to farmers in the irrigated area will be large and overwhelmingly positive due to increased crop production, reduced soil erosion, and increased stream flows in the dry season. Downstream farmers will benefit from reduced flood damage in the wet season, reduced stream bank erosion, reduced sedimentation of stream channels, and increased stream flows during the dry season. However, total annual flows to downstream reservoirs would be reduced, possibly reducing electricity generation and/or irrigation from downstream reservoirs.

## Species dispersal and the spatial insurance hypothesis

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**Introduction.** Being linked to ecosystem functioning and the resulting flow of ecosystem services, species biodiversity plays an important role in ecological and economic processes<sup>1</sup>. One explanation for the effect of biodiversity lies in the spatial insurance hypothesis, which suggests that the stability of primary production in a meta-community increases with the biodiversity of each of its spatially distributed communities<sup>2</sup>. Despite mixed empirical evidence, Loreau *et al.*, in an influential theoretical analysis, present an illustration and corroboration of this hypothesis<sup>3,4</sup>. They show that at low dispersal rates, the species with the highest initial consumption rate will competitively exclude all others, resulting in low local biodiversity and high global biodiversity. High dispersal rates cause the meta-community to function as a single patch; the species with the consumption rate closest to the average will exclude all others in the meta-community. At intermediate dispersal rates, source-sink dynamics increase local biodiversity while preserving global biodiversity, leading to the highest net primary productivity and stability of productivity. However, little work has been conducted testing the robustness of this pivotal model. In this paper, we re-evaluate the Loreau *et al.*<sup>3</sup> and updated Gonzalez *et al.*<sup>4</sup> models and test the robustness of their results.

**Methodology.** We numerically simulate the Loreau *et al.*<sup>3</sup> and Gonzalez *et al.*<sup>4</sup> models using the Euler approximation method. We reproduce the original results, and test their sensitivity to initial conditions and simulation time.

**Results.** We find that the species coexistence result disappears at higher initial resource values - species experience unbounded exponential growth, then a steep decline in per capita growth rates that causes greater species extinction than if the resource was initially set to equilibrium values. Biodiversity also decreases as the number of iterations increases, but maintains the same trend. Net primary productivity and stability are robust to initial resource biomass and the number of iterations, suggesting that the net primary productivity and species coexistence results may not be as closely linked as previously believed.

**Conclusions.** Our work provides new insights to a pivotal ecological model and perspective on the spatial insurance hypothesis.

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## Contingent dispersal and the formation of cooperative groups

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**Introduction.** Cooperation can be observed at all levels of biological and social organization. This is puzzling, since simple theoretical models predict that, while cooperation is the most beneficial for a group, non-cooperation is always the most successful strategy for the individual. Since we find such discrepancy, it is of interest to identify conditions that actually give rise to altruism. This has been addressed in game theoretical frameworks with the typical assumption of dyadic interactions, where cooperation may be stabilized via mechanisms such as memory (Axelrod and Hamilton 1981), reputation (Nowak and Sigmund 1998), or kin assortment (Hamilton 1964). An extension to dyadic games is the Public Goods Game, where interactions occur among several players. Typically, the size of cooperative groups are assumed constant, however, it has been showed that relaxation of this assumption is of significance to the maintenance of cooperation. Garcia and De Monte (2012) showed that solely the physical distribution of group sizes can promote cooperation. However, explicit mechanisms of group formation processes, as well as the evolution and consequences of such, have yet to be explored, which is the objective of this study.

**Methodology.** Mathematical formulations of the time development of group-size distributions are used to determine the expected structure of group sizes. The success of individuals with different strategies can be derived via the structure of group sizes. The level of success determines the evolution of the strategies, which is analyzed in the framework of adaptive dynamics.

**Results.** A general analytical formalization of group formation processes has been derived which allows for realistic creation and dissolution of groups, as well as a realistic flow of individuals between groups. From these processes joint probability distributions of the number of cooperators and non-cooperators in groups have been derived. A simplified method of deriving invasion-fitness in structured populations has been developed, and has been used to calculate the evolutionary trajectories of individuals' group formation traits. This has allowed identifying conditions for various configurations of the expected number of cooperators, and non-cooperators, in the population, of which some configurations allow for coexistence between cooperators and defectors or even an immunized cooperative population.

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## Dynamic modeling of migration flows between Russia and CIS countries

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**Introduction.** Management of migration flows is a necessary condition for the sustainable development of Russian regions and the Commonwealth of Independent States (CIS) countries. The experience of the EU and the USA shows that that current international migration appears to be characterized by growing complexity as migration connects people and societies over larger distances and over an increasingly diverse array of countries and places of origin and destination. In the process the migratory load increase, the problem of migration management becomes more complicated from year to year. A decisive step towards liberalization of the migration policy in Russia was made in 2007, when a simplified procedure of entry and registration was introduced into force. This has led to the increase of migration flows from neighboring countries into Russia due to higher wages and overall life quality there.

**Methodology.** The idea of the model is based on several economic concepts. The liberal development model assumes the removal of all barriers for free movement of the labor force. According to neoclassical economics, migration is caused by the difference in wage levels between countries, due to difference in labor and capital inputs between countries. In this context, the model is based on constructions of the dynamic games theory. The wage differential stimulates workers from countries of low wages to move to countries with a high salary, while the investment in capital, which is essential for creation of the expected income, flows into a country with low wages. The concept of the standard theory of equilibrium is that inflow of migrant labor force to the region reduces the relative wage of native workers. The model takes into account such demographic factors as age and educational groups and allows to estimate the consequences of migration on socio-economic situation.

**Results.** The dynamic model combines economic and demographic factors, such as growth of labor force, age groups and skill groups. The result consists in construction of equilibrium trajectories, calibration and testing on real data and analysis of the results of modeling.

**Conclusions.** The result of work is a dynamic multiregional model that includes both economic and demographic factors. The model fits quite well to the real data of migration flows in Russian and CIS regions. It provides reasonable prognostic results both in trends and quantitative estimations. The analysis of modeling results can be used by policy makers in assessment of impact of migration flows on socio-economic situation in CIS countries.

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## Integration of Vulnerability-Assessments into the satellite-derived Combined Drought Index

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**Introduction.** Droughts statistically exceed all other natural disasters in spatio-temporal extent, number of people affected or financial loss. Triggered by crop failure, food insecurity is a major manifestation of agricultural drought and water scarcity. However, other socio-economic precursors, such as chronically low levels of disaster preparedness or hampered access to food are equally important factors. Consequently, new and more holistic drought preparedness strategies have to link atmospheric anomalies to real-time assessments of socio-economic vulnerabilities

**Objectives.** This study has two main objectives. The first one is focused on the development of a new, transparent drought index, which is derived from satellite data and based on precipitation, temperature, soil moisture and vegetation. The second one concentrates on the development of a mobile phone application to speed up the assessment of food security-related vulnerabilities. All developments are carried out in collaboration with Doctors without Borders (MSF).

**Data and Methodology.** The revised Combined Drought Index (CDI) is based on temperature, rainfall, soil moisture and vegetation health. Temperature and Rainfall measurements are derived from the Global Land Data Assimilation System (GLDAS). A smoothed version of the Normalized Difference Vegetation Index (NDVI) was obtained from University of Natural Resources and Life Sciences (Vienna, Austria). The soil moisture component is provided via the Climate Change Initiative of the European Space Agency (ESA). The application of an infiltration model facilitates the estimation of global root zone soil moisture. The Geo-Wiki land cover product is used to create a mask for further investigation. Time series analysis and the identification of time lags between all parameters enable the adjustments of weights for each variable (rainfall, temperature, etc.) in the overall index. Based on “hindcasts”, a higher weight is assigned to index values that are ahead of actual observations. The questions in the mobile phone application were chosen based on discussions, literature review and internal documents of aid organizations. By combining the alert levels of the drought index with the results of the mobile phone assessments a more holistic and quicker picture of food security levels can be obtained.

**Results and Conclusions.** The revised CDI is tested over East Africa and Southeast Asia. First results indicate the suitability of satellite-derived soil moisture as a proxy for future conditions of vegetation. Surprisingly, calculating the vegetation component with a simple z-score (standard score) yields better results (forecasting capabilities) than with the original method from UN FAO. The implementation of a mobile phone app to provide outputs of the index to staff in the field is currently in the process of development. In its final version the app will also facilitate on-site validation via GPS-tracking and photo-upload. The key questions on socio-economic vulnerability can be answered anytime and will be uploaded automatically when a network is available.



## What if the Dutch started worrying about flood risk?

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**Introduction.** The Netherlands is one of the most flood prone countries in the world. Its current flood risk management strategy involves a combination of high safety standards and an ex post compensation mechanism, meaning that the public sector has assumed all risk. Projected effects from climate change, including sea level rise and an increase in river discharge, has led to a rethink of the flood risk management strategy. One particular concern is that the current strategy provides few incentives for individual mitigation efforts. This is worrying as increasing concentration of population and assets in areas at risk is a main driver behind disaster losses.

**Research question and methodology.** In this study we wish to analyse the macroeconomic impacts on the economy from a partial shift in the allocation of risk from the public to the private sector. We make use of a recursively dynamic Spatial Computable General Equilibrium model for the Netherlands (RAEM-E3) where the inter-temporal dynamics are driven by capital accumulation due to investments. We modify investment decisions such that they take into account disaster risk. As investment decreases in risky regions, productive activities are relocated to less risky regions. These relocations trigger labour migration as workers move to regions where they can find employment. In a second step we investigate how the shift in allocation of risk affects disaster losses and welfare. This is carried out by simulating a flood for the following two scenarios: (i) the government assumes all risk (risk is implicit) ; (ii) flood risk is taken into account in investment decisions (risk is explicit).

**Results and conclusion.** Our results suggest that shifting the allocation of risk from the public sector to the private sector leads to a reduction of productive activities as well as population in risky regions, but the migration movements are of a much smaller scale than the reductions in production. The reason is that the initial migration of workers from risky areas lowers housing demand which again reduces prices. Workers who stay are therefore partly compensated for the loss in job opportunities with lower housing prices. Our flood simulations yield quite different results for the two scenarios. In scenario (i), the flood causes a large reduction in aggregate output as well as welfare reductions spread over the whole country. In scenario (ii), the loss in aggregate output is recovered within 2 years. Welfare losses are concentrated in the affected region, but are of a far larger magnitude than in scenario (i). We conclude that the partial shift in allocation of risk to the private sector reduces disaster losses, but it also inflates welfare losses in affected areas.

## **Coupling of Climate models with Hydrological models for decadal projection of water resources over mountainous region**

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**Introduction.** There are gaps of climate and hydrological modeling capability over mountainous regions especially in Hindu-Kush and Himalayan. Glacier melt in the Himalayas is projected to increase flooding within next two to three decades. This will be followed by decreased river flows as the glaciers recede (IPCC AR4 2007). Pakistan is at high risk of flooding from last four years. In recent month Pakistan is under flood and 93 deaths are reported. Indus Basin is play significant role in the availability of water of Pakistan and most of floods happened in this basin. About 60% of the inflow to Upper Indus Basin is contributed by Glaciers melting. In the view of the above statements there is a need to study climatic and hydrological changes over Himalayan region and Upper Indus basin. The objective of this study to explore the performance and sensitivity of climate and hydrological models over Himalayan region for decadal projection of Climatic and hydrological changes.

**Methodology.** REGIONAL Climate Model 4.3 (RegCM4.3) of ICTP and hydrological model of University of British Columbia (UBC) is used in this study. RCM model was run at horizontal resolution of 20 km with ERA-Interim15. Six different simulations were carried out for the periods 1997-2002 with all available options of convective parameterization scheme in the model. UBC model is first calibrated with observed data from 1995-2004 and achieved higher correlation of 0.9. RCM data is used as input to hydrological model after bias correction from 2001-2010, 2041-2050 and 2071-2080 as base period, future one (F1) and future two (F2) respectively under IIASA scenario RCP8.5 and RCP4.5.

**Results and conclusion.** The models results are compared with TRMM, station, CRU and runoff data. The results show that RCM is performing very strange over Himalayan region, however after bias correction the results are with close agreement with observed data for the spatiotemporal change of precipitation and temperature. Three climatic variables i.e. maximum temperature, minimum temperature and precipitation show that there is climate change in the region. The results of UBC model are quite satisfactory and showing higher increasing trend during 2041-2050 while increase trend in 2071-2080 is relatively low. The possible reason for this may be faster glacier melt and reduction in size during first half decades of the century. In last half decades of the century, as the size of the glacier will be decreased so it will contribute less to inflow.

## Transformation and fragmentation of forests: effects on species population trends

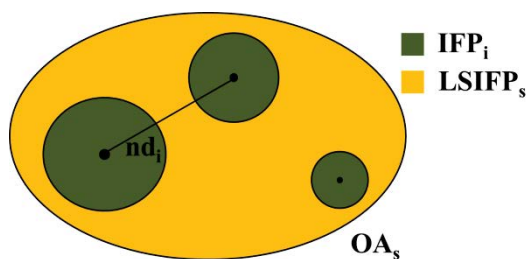
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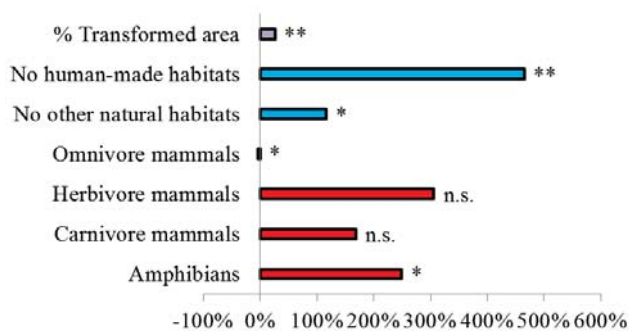
**Introduction.** Transformation and fragmentation of habitats are the major drivers of biodiversity losses. The two processes are almost always simultaneous and their combined effect on population trends is yet unaccounted for. We quantified to which degree habitat transformation and fragmentation drove decreases of red-listed animal populations worldwide. Shifts in population trends may serve as early warnings for future extinctions and may help guiding the efforts by nature conservation institutions.

**Methodology.** We determined the remaining intact forest area still available for species subsistence and their degree of fragmentation by employing maps of species extent of occurrence and of the world's intact forests (illustration in Fig. 1). We then determined the odds of species population decreases with increasing transformation and fragmentation of forest habitats. Additional explanatory variables included taxonomic class, feeding habits, additional suitable habitats to species, and quality of land surrounding intact forest patches.



**Figure 1.** Intact forest patch  $i$  ( $IFP_i$ ) as the remaining suitable forest habitat for species  $s$ .  $OA_s$ ,  $LSIFP_i$  and  $nd_i$  represent, respectively, the original area available for  $s$  (prior to land transformation), the land cover type surrounding IFP and the nearest distance of patch  $i$  to another suitable patch for  $s$ .

## Results



**Figure 2.** For every 10% of habitat transformation, the odds that species will undergo a decrease in their populations will increase by 26% and the odds are 917% higher if they cannot survive in additional suitable habitats. Compared to reptiles, amphibians and omnivore mammals have, respectively, higher and lesser odds of population decreases. Fragmentation did not explain additional model variability.

**Conclusions.** In the absence of additional suitable habitats (that are either natural or human-made), amphibians are most likely to undergo population decreases. Also, the statistical model performed better with habitat transformation alone instead of combined transformation and fragmentation effects.

## Evolution of multilevel cooperation: analogies between social and medical systems

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**Introduction.** While cooperation is common at many levels of life, ranging all the way from micro-organisms to complex social structures, cooperative behaviors are fundamentally vulnerable to selfish defection. Hence, their prevalence in nature is often considered puzzling. In multilevel systems, individuals may act as cooperators or defectors depending on the level at which they meet their partners. We refer to mixed roles of this kind as the dual face of cooperation. Other mechanisms, like tag-recognition can also lead to dual-faced cooperation. In either case, a differentiation of cooperation levels between in-group and out-group may occur. Such complex interactions, involving multiple levels and the possibility of discriminating between interaction partners of different type, are present in cancers and have their counterparts in the social world. Here we investigate, first, when it is beneficial to invest into in-group and/or out-group cooperation, and second, whether in-group and out-group individuals should best be defined based on being neighbors or on sharing the same tag. Our research also contributes to the long-lasting debate on the relative importance of kin selection versus group selection as driving forces of cooperative behaviors.

**Methodology.** We combine two existing approaches to the study cooperation, multilevel selection [1] and tag-based cooperation [2]. In our model, individuals play continuous pairwise prisoner's dilemma games and reproduce based on their payoffs. While stochastic events constitute the individual-level dynamics, assuming infinitely many demes (assemblies of individuals), we express our population-level model using forward Kolmogorov equations. The evolving strategies are quantitative and multivariate, with elements describing the levels of cooperative investments into in-group and out-group games. On this basis, we allow the group-defining criterion to evolve, ranging from being neighbors to sharing the same tag. To investigate the resultant evolutionary dynamics of dual-faced cooperation, we apply the framework of adaptive dynamics theory.

**Results.** First, if all individuals share the same tag, in-group cooperation is typically beneficial. Quite surprisingly, also out-group investments may evolve to be positive: this occurs particularly when not all neighbors are considered to be in-group members. These evolutionary outcomes change when we allow new tags to appear. Then, a mutant with a tag different from the resident may invade only if it sufficiently differs in its investment strategy from the resident, towards larger in-group or smaller out-group investments.

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## The future environmental impact of divorce

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**Introduction.** Earlier studies considering the effect of divorce on energy use have argued that since divorce increases the number of households (and decreases average household size), the rising prevalence of divorce increases domestic energy use (Yu and Liu 2007). These estimates, however, do not take into account that the childbearing patterns of those that divorce differ from those that do not. Divorce may affect family formation patterns through increasing spacing of children, greater celibacy levels, a later onset of childbearing and lower childbearing ideals. This work aims to include this mechanism in order to assess the impact of changing divorce patterns on domestic energy use.

**Data and Methodology.** We compute a household forecast with alternative scenarios that differ only with respect to divorce rates, employing data from the Danish household register. We consider a benchmark projection with transition rates that are constant across projection intervals and equal to the rates observed in the five year period preceding the jump-off year. In addition we consider four scenarios with different assumptions about couple dissolution in the years to come, two with higher divorce and union dissolution rates and two scenarios with lower divorce and union dissolution rates. We then combine the projected household numbers with information about household energy patterns from the Danish consumer expenditure survey.

**Results and Conclusions.** Given the current pattern of fertility by household position of the mother, increasing levels of divorce and union dissolutions can have a depressing effect on domestic energy use in the long run. We find that after around 40 years domestic energy use is lower in the scenarios with higher divorce and union dissolution rates than in the benchmark scenario and vice versa. In the short run increasing levels of divorce and union dissolutions is likely to drive up domestic energy consumption through increasing the number of one person households. We argue that although in the short run the conclusions of Yu and Liu, that divorce escalates energy consumption, hold true, in the long run the potential fertility depressing effect of divorce might be the dominant effect.

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## **Earthquake Risk Financing and Possible Earthquake Insurance Options: A case study in Shiraz**

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**Introduction.** Recent earthquakes in Iran have caused huge losses, both in human and economic terms, due to high seismicity and vulnerability of the structures. To increase the resilience of the risk bearers, including the public sector as well as private sector entities, the resources to cope with the event as well as their interdependencies during the occurrence have to be assessed. Additionally, to pro-actively act against possible future extremes, the underlying risk has to be determined too. This paper attempts to combine both, the coping dimension as well as the risk dimension, to determine possible risk management strategies which may be feasible in the Iranian context. The focus is specifically on risk spreading instruments, such as insurance, for Shiraz city.

**Methodology.** In this research, financial vulnerability of the society against earthquake losses in a quantitative manner is estimated in order to make some decisions to finance it in future events. In the next part, Average Annual Loss of the all classes of buildings in district 1 of Shiraz are calculated. As government already act as quasi-insurers by bundling and paying for the reconstruction of their own assets by purchasing XL-Insurance, it is assumed that they protect their portfolio of assets by purchasing Excess of Loss Insurance (Hochrainer, 2006). Two kinds of XL-Loss insurance systems are proposed and the risk-based premiums are calculated. Finally, the affordability of the premiums to be accepted by households is investigated.

**Results.** Two kinds of earthquake insurance systems have been proposed which are flexible in structure and can be chose by decision makers. In these insurance systems, buildings related to the year before 1991 have the most premiums than other group of building classes and in both proposed earthquake insurance systems are Un-affordable and also have the smallest critical return periods. The buildings constructed after 2005 in the first insurance system, which is a kind of public-private partnership, don't need to have any insurance coverage but in the second insurance system they will pay small premiums.

**Conclusions.** Risk modeling approach has shown a big difference between current premiums and risk-based premiums. This means the real risk of earthquake is needed to be considered in future decision making and financing processes. The premiums for structures constructed before 1997 are too high and un-affordable, therefore looking for other issues like mitigation measures in order to decrease the Underling risk of this group of buildings and increases the resilience of the households is ongoing research.

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## The impact of concurrent partnerships on HIV transmission dynamics

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**Introduction.** Many societies have monogamous partnerships as a social norm, with most individuals having at most one partner at a time. If, instead, a society has concurrent partnerships as a social norm, so that individuals may have multiple partners at a time, does this enhance the spread of sexually transmitted infections such as HIV? Opinions differ on this. This debate is particularly important with regard to the HIV epidemic in sub-Saharan Africa. In this region, HIV is widespread among heterosexual populations. This is very different from the rest of the world. If concurrency is driving the HIV epidemic in this region, then prevention and intervention programs will need to account for their epidemiological implications. Therefore, we need to understand how concurrent partnerships actually impact the spread of HIV.

**Methodology.** In previous work, I developed a mathematical framework for dynamic sexual networks that incorporates demography and allows for concurrent partnerships (Leung et al. 2012). In this same work, two measures for concurrency have been defined. Finally, UNAIDS (Joint United Nations program on HIV/AIDS) proposed a consensus indicator for concurrency (UNAIDS 2010). In this project, we focused on understanding these three measures theoretically in the context of the mathematical framework and studied if they would capture disease dynamics in the same manner. The second part of the project was using linear regression analysis in trying to understand the correlation between the concurrency measures and the epidemiological quantity called the basic reproduction ratio.

**Results.** We found that all three concurrency measures increase when increasing expected lifetime number of partners and expected partnership duration. Concerning the disease dynamics, we found that the expected lifetime number of partners is a very good predictor for the basic reproduction number. The prediction improved if we would add a concurrency measure as explanatory variable.

**Conclusions.** The three concurrency measures behave according to interpretation, as far as expected lifetime number of partners and expected partnership duration are concerned. The concurrency measures all seem to correlate positively with the basic reproduction number. Concerning this epidemiological quantity, all three measures capture this part of the disease dynamics in the same way.

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## The Implications of National Catastrophe Financing Policies for Households

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**Introduction.** Natural disaster cause serious economic losses that have the potential to affect not only the insurance and public sector but especially private individuals. In the last years single natural hazard caused multi-billion dollar economic losses such as the Tsunami in Japan (210 bn in 2011), the storm Katrina in USA (125bn in 2005), and the earthquake in China (85bn in 2008). These yearly economic losses are expected to increase to the fact of growing cities, increasing infrastructure development, and climate change.

This research describes and compares strategies of the governments in Austria, France, Germany, Netherlands, New Zealand, Norway, Spain, Switzerland, Turkey and USA. These policies differ with respect to the existence of catastrophe funds, public and private insurance. The accessibility and the details influence both: pre-disaster risk management and post-disaster compensation schemes. This research focuses particularly on the consequences of different strategies on households.

**Methodology.** Based on a desktop survey of different national parameters for disaster management in the selected countries, national strategies are compared with respect to how the losses are absorbed by the state or individuals. Details of these policies are analysed with respect to who imposes the losses on society, for example, by locating the household in a hazardous area, and who pays to mitigate the risk, for example, for re-locating the property out of the hazard zone. In this way, disaster policy can be analysed from the view of the Coase theorem. Post-disaster compensation schemes are compared for four different amount of damage. The damage range from small (EUR 1,000), medium (EUR 10,000), up to high damages (EUR 100,000 and 500,000).

**Results.** The policy terrain is wide: It ranges from very hierarchical strategies such as in the Netherlands with government compensation, to policies with focusing on the individual responsibility such as Germany with a pure commercial solution, and also includes programs rewarding communities complying with national floodplain management requirements such as the USA.

The parameters are often a mix, for example with flat rate premiums providing cross subsidies and deductibles placing responsibility for a layer of risk on the household. The financial burden households have to bear after a natural disaster ranges from 0 to 100 % depending on the size of the damage and the governmental policy.

There is no single best case but countries with a mix of strategies such as governmental controlling of first loss damages, individual responsibility for taking insurance and involvement of communities to reduce the risk may have the potential to be most successful on the long term.



## Forecasting Time Series through Functional Principal Components Analysis

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**Introduction.** Spain is a highly heterogeneous country with different historical, cultural and linguistic identities throughout the country. Previous period and cohort analysis of fertility trend highlighted the persistence of heterogeneity in fertility trends across the different provinces. This analysis prompted the idea to investigate whether such trends would persist in the future.

**Data and Method.** The data used for the analysis is a 1975-2011 time series of age specific fertility rates (ASFR) for Spain, 17 Spanish Regions - NUTS2 - and 52 Spanish provinces - NUTS3. The approach used is a Time Series Forecasting using Functional Principal Component Analysis (Hyndman & Booth, 2008; Hyndman & Shahid Ullah, 2007). The method uses time series of period fertility schedules and consists of three stages. In the first stage we smooth the fertility schedules using Ediev (2013). We then apply the principal component analysis (PCA) to obtain PC, further used for the forecasting. The final results consist of forecasted ASFR and Total Fertility Rates 15 years into the future. We first forecasted Spain, then the various regions and then the provinces. To check the reliability of the model we have implemented 3 different methods. The first approach considers the forecast of Spain fertility schedules using the 1975-2000 time series and forecasting it first 5 years and then 11 years. We then measure the difference between the observed and the forecasted schedules. The second approach, “top-down”, explains the changes in sub-national TFR through the explanatory framework of the national trends. The third approach uses sub-national estimates of fertility and adds them up to measure the accuracy of the model. This way we obtain estimated ASFR that can be compared to observed ASFR. The third approach is a “bottom-up” approach. We first use the truncated time series to forecast fertility up to 2011 and then use the estimated ASFR and compare them with the national ASFR.

**Results.** Even though period and cohort fertility analysis suggests heterogeneity among different provinces and shows recuperation of fertility in some selected areas, the recent economic crisis tempo effects on TFR is rather severe. This is reflected in the forecasts of national, regional and provincial fertility schedules, where fertility shows a stable and slightly declining pattern, with the exception of the North-Western area.

**Conclusion.** A further step in this project would be to further investigate the effects of the economic crisis by employing cohort fertility schedules and parity ASFR.

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## **An analysis of Religious Conversions and Secularization**

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**Introduction.** Since the last four decades, we have witnessed an era of global resurgence in every major world civilizational religion that has effected a striking increase in religious influence within the public sphere and dominant global political structures. (Toft, Philpott, Shah 2011) Due to a combination of higher fertility rates, migration trends and the intergenerational transmission of values of those who are religious, it is projected that there may occur a stalling and possible reversal of secularization within the United States and Europe around 2050. (Kaufmann, Skirbekk 2012) Within this context of the resurgence of religion, the goal of this research project is an analysis within a global perspective of religious conversions and secularization and its overall impact on population dynamics, with the intent to use these findings to create scenarios for the Pew-IIASA religion model, and apply them as case studies for specific countries and regions.

**Data and Methodology.** We take data from the United Nations Human Development Index, the World Religion Database, and IIASA-VID Education. We looked at the correlations in trends between education, income and life expectancy and the share of the religious unaffiliated for the period 1960-2010. Based on these trends, and on projections of secondary education, we created scenarios for possible outcomes of the growth of the unaffiliated by region and world.

**Results and Conclusions.** There were correlations with human development, education and the growth of the unaffiliated, with certain regions, such as Europe and North America exhibiting strong growth up 2010. We created two regions that underwent communist rule, and witnessed the opposite effect of a resurgence of religious affiliation. The scenarios created were based in education, a proxy of modernization. The scenarios suggest decrease in the unaffiliated, though with variation.

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