THE GLP INTERNATIONAL PROJECT OFFICE

GLP REPORT

GLP – A IGBP & IHDP PROJECT NO. 5, 2012

THE UGEC INTERNATIONAL PROJECT OFFICE

UGEC REPORT

UGEC – A IHDP PROJECT NO. 6, 2012

Urbanization and Global Environmental Change
AN IHDP CORE PROJECT

Global LAND Project

Land teleconnections in an urbanizing world

A workshop report

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UGEC – The **Urbanization and Global Environmental Change** project is a core project of the International Human Dimensions Programme (IHDP) focusing on the bi-directional interactions between urban areas and global environmental change.

This GLP/UGEC joint report is based on the proceedings of the workshop "Sustainable Land-use in an Urbanizing World", which was funded, organized and coordinated by the International Project Offices of the GLP (in Copenhagen, Denmark at the time of the workshop) and UGEC projects. The workshop was held in June of 2011, in Copenhagen, Denmark.

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Refer to this publication as:
Fragkias, M.; Langanke, T.; Boone, C.G.; Haase, D.; Marcotullio, P. J., Munroe, D.; Olah, B.; Reenberg, A.; Seto, K. C.; Simon, D. (2012). Land teleconnections in an Urbanizing World – A workshop report. GLP Report No. 5; GLP-IPO, Copenhagen. UGEC Report No. 6; UGEC-IPO, Tempe. May 3 2012.

ISSN 1904-5069

Land teleconnections in an urbanizing world

A workshop report

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GLP Report No. 5, UGEC Report No. 6

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Workshop Rationale

This GLP/UGEC joint report is based on a workshop with the title "Sustainable Land-use in an Urbanizing World", which was funded through the Global Land Project (GLP) – hosted and organized through the previous International Project Office in Copenhagen, Denmark - and the Urbanization and Global Environmental Change (UGEC) project. The workshop was held in Copenhagen, Denmark on the 27-29th June 2011. In an effort aimed towards advancing the connectivity of land science and sustainability science, members of the GLP and the UGEC communities formulated new analytical frameworks for the study of land that explicitly incorporate urban and urban-rural dynamics. Very importantly, the workshop participants developed the concept of urban land teleconnections, bridging land change science with sustainability science, which resulted in a journal article publication in PNAS (Seto et al., 2012). The land research community has historically focused on rural and frontier landscapes, with relatively little attention on urbanization or the rural-urban connections across time and space. Many of the current analytical frameworks take a negative view of urbanization and its impact on land. However, urbanization can also present opportunities for increased efficiency of land and resource use, and yet there is no conceptual framework that fully addresses the linkages and bi-directionalities between urban and non-urban uses of land.

This workshop report contains contributions from all participants and editorial text. In the interest of readability we did not attempt to keep the individual contributions separate; instead, we attempted to synthesize the contributions into five distinct sections, introducing the subject matter, and discussing what sustainable land use means in a rapidly urbanizing world, the challenges present in the formulation of a new framework, complex interactions of urban and non-urban land uses as well as metrics or indicators useful in modeling and evaluating these teleconnections.

I. Introduction

The global population is increasingly concentrating in cities. The shift from rural to urban living has been a defining global trend of the last 100 years, and urban areas are emerging as the most popular form of human settlement worldwide. This new era of urbanization involves a wide array of trends that can be described as either the biggest, fastest, or the first in history: the size and number of cities; the rate at which populations and ecosystems are urbanizing; the geographic shift of the location of large urban areas from high-income to low and middle-income countries; the increased specialization of urban function; and growing dominance of urban areas in national and global economic system (see e.g. Seto et al., 2010, Grimm et al, 2008, Montgomery, 2008). In Europe, around 75 % of the population lives in urban areas, and this is projected to increase to about 80 % by 2020 (EEA 2006). Our cities and urban areas face many challenges — economic, social, health and environmental. The impacts of cities and urban areas are also felt in other regions which supply cities with food, water and energy, and absorb pollution and waste. However, the proximity of people, businesses and services associated with cities also creates opportunities for improving resource efficiency. Indeed, well-designed, well-managed urban settings offer great opportunities for sustainable living (Redman and Jones, 2005, Sattertwaithe, 2007). In contrast, much of the current literature, especially from the ecological community still implicitly or explicitly views urban growth as a "main obstacle to achieving sustainable development" (McDonald, 2008).

While land-use and land-cover change itself has been receiving much recent focus (e.g. Lepers et al., 2005, Foley et al, 2005, Lambin and Meyfroidt, 2011), for example in the context of reducing greenhouse gas emissions from deforestation and forest degradation (Miles and Kapos, 2008), a dynamic and complex interaction exists between land-use change and urbanization, that is less well studied. Land-use change outside urban areas can both be the cause for urbanization trends, as well as a result of trends related to legacies of past urbanization or evolving urban forms and functions. Given the increasing competition for land globally (e.g. for agricultural products, energy production, biomass, infrastructure and settlements, conservation and recreation, as well as a large range of other ecosystem services) it is important to understand the interlinkages between land-use and urbanization.

II. Sustainable land-use in an urbanizing world

II.1 Land systems and urban land-use

Land is a finite resource, and the way it is used is one of the principal drivers of environmental change. Urbanization as one of the important drivers of land-change "alters the connectivity of resources, energy, and information among social, physical, and biological systems" (Grimm et al., 2008). Land-use in most places is multifunctional and has significant impacts on food systems and food security, energy and biomass production, biodiversity, the climate system, provisioning of freshwater, regulation of biogeochemical cycles, pollution, ameliorating infectious diseases, maintenance of soil fertility, cultural services and many others (Brandt & Vejre, 2001). Assessing the trade-offs between land-use change for human use and the unintended consequences for other ecosystem functions remains a challenge in a globalizing world (DeFries et al., 2004 and Foley et al., 2005). Balancing those trade-offs depends on societal values and has to consider a range of spatial and temporal scales and increasing teleconnections.

Competing pressures on the finite land-resource in a world with a population are projected to reach the neighborhood of 9 billion by 2050 - see for example the medium variant of the 2010 Revisions of World Population Prospects by the UN (UN, 2010), or slightly lower numbers (Lutz and Samir, 2010). These pressures lead to trends of large scale land acquisitions or "land-grabs", both by nation states and private investors. It is estimated for example that current (2010) land acquisitions in Africa could be as large as 51-63 mio ha, an area equivalent to France (Friis and Reenberg, 2010). Pressure on land resources shows large geographic variation however, with simultaneous (but at a significantly smaller scale) trends for land abandonment in economically declining areas, for example in parts of Eastern Europe (Kuemmerle et al., 2009).

Although the absolute land-area used for urban areas was estimated at less than 0.5% of the total land surface of the Earth in year 2000 (Schneider et al., 2009), this area is rapidly expanding and expected to at least double – and probably triple by 2030. (Seto et al., 2011). This expansion is expected to occur at the cost of high quality agricultural- and often also highly biodiverse riverine wetlands (Tockner and Stanford, 2002). Lambin and Meyfroid (2011) estimate the urban expansion to require between 48-100 Mha (additional land demand for 2030 as compared to 2000). The strongest trends for urban growth can be observed in South and Southeast Asia as well as in parts of sub-Saharan Africa (UN, 2011). At the same time there are regions that currently show trends of urban shrinkage and de-population (particularly parts of eastern and central Europe). Notwithstanding, globalization, population growth and increasing urbanization are embedded in the general phenomenon of the "Great Acceleration", the sharp increase in human population, economic activity, resource use, transport, communication, and knowledge-science-technology that triggered in many parts of the world after WWII and continues today (Costanza et al., 2007).

All of these factors have a direct relationship to the land-use system, but they are however, local and limited geographically. If we envision the urban part of the land-use system as a series of connections to other land-uses, the set of effects will lie closest, if not within the urban land-use area. Then, one might also consider second order effects, such as wealth generation, environmental degradation, increasing social diversity and ordering (and rising inequality), demographic shifts (changes in changes in fertility patterns), etc. These second order effects have a larger geographic scale potential. Certainly, urban areas of greater wealth can reach farther away for resources than those that are poorer. Another layer of complexity arises, however, as each of these (first and second order) effects has interactions. That is, as dense settlement continues, the changes associated with increasing urbanization influence the outcome trends directly. How they affect each other varies. So for example, while it is hypothesized that urbanization leads to high rates of population turnover, high levels of social, demographic, cultural and ethnic diversity and therefore leaves communities weakly equipped to maintain social order, there are also economic effects, such as poverty, relative deprivation, and unemployment that also affect social disorganization. These secondary economic factors are not completely dependent upon urbanization and can be separated from urbanization processes, but have impacts on the direct effects of urbanization. Furthermore, these aspects of the economy do not affect other urbanization – factor linkages in the same way.

II.2 Sustainability and land-use systems

A sustainable land-use system needs to consider the national system, teleconnections and increasingly also transboundary spaces that straddle national borders in terms of functional integration (as with transfrontier parks or urban corridors, e.g. Hong

Kong/Shenzhen/Pearl River Delta; San Diego/Tijuana; the Lagos-Accra corridor; Geneva/Gex) in an integrated manner so as to ensure adequate land-use mixes for the present and future. Conflicting land-use demands will require decisions that will involve hard trade-offs. It is often implicitly assumed that locally or regionally sustainable land-use configurations add up to sustainable outcomes on higher (aggregated) spatial scales, but this is by no means necessarily the case (Turner 2010

Expanding cities absorb more land in order to accommodate larger populations and their urban activities, but also have growing urban (ecological) footprints that stretch further into their hinterlands in terms of the areas from which resources are extracted and into which waste is disposed of. For megacities, "global" cities and primate metropolises, such hinterlands may be the entire national territory and increasingly also beyond in terms of globalised commodity and service flows. Crucially, too, a large proportion of urban dwellers, especially among relatively recent migrants and in poor countries, retain viable links of various kinds with rural areas of origin – including for livelihood activities – so that their activity spaces straddle different places and categories of place. They perceive these loci as being integrated; it is only the bureaucratic and academic mindsets that persist in keeping them separate.

Integrated conceptualization and planning are essential for long-term sustainability, particularly in view of the increasing challenges posed by global environmental change. Other preconditions for sustainability are (a) retaining sufficient natural areas to serve not just as witness areas but viable biodiversity reservoirs and corridors; (b) minimizing new land take for urban-type activities, and maximizing brownfield (land recycling) usage; (c) planning for land-use succession/recycling in non-urban areas too – e.g. turning exhausted gravel pits into watersport/recreational/or conservation assets; rehabilitating old mine works and slag heaps; (d) ensuring that forestry practices are sustainable, in terms of logging regimes, selective felling, sustainable replanting, etc – in line with certificated requirements for FSC or equivalent recognition (e) in order to achieve these, rethinking urban and rural land-use design, e.g. urban structure and functions; rural landholdings and intensities of use; minimizing the amount of land that is quarantined through landfill, toxic waste, dereliction or juxtaposition of incompatible land-uses.

Furthermore, process-based conceptualizations of urbanization, teleconnections, and sustainability allow us to measure and understand the dynamics rather than the state of the system. In turn, such conceptualizations open the possibility of interventions to achieve desirable, plausible futures. Intervening in the processes that create teleconnections is likely to have much broader and long lasting effects than focusing on the outcomes of a single place (maybe something on structural adjustment policies). The means of achieving desirable futures should also be conceived as a process rather than an end state. An early lesson from the environmental justice movement is that justice is as much a process as an outcome. Fairness in decision-making, recognition of constituents, and participation of stakeholders is a form of justice in itself, and critical to avoid future injustices (Boone 2010). Growing activism about climate justice underscores the need for addressing justice arguments of a teleconnected world.

The workshop participants agreed that we need a new analytical framework covering the linkage between sustainability and urban land-use that works at different scales: global for budgeting the impacts of the urbanizing world – regional for operationalizing sustainability in planning – and local for assessing trade-offs between urbanization and individual quality of life. The next section of this workshop report addresses the major challenges in formulating such a framework while the last section discusses concrete steps towards implementation.

II.3 Challenges in conceptualizing a new framework for sustainable land-use in an urbanizing world

There are a number of important challenges related to conceptualizing sustainable land-use in an urbanizing world. The issue can be separated into two parts; the first is the challenge to define what we mean by sustainable land-use, and the second asks us to consider how we do so in the context of a world that is more urban than rural.

Regarding the science of sustainability, we must first define sustainability of what, for whom, at what scale, and over what time horizon? These questions are not just technical (i.e., requiring sophisticated quantitative analysis), but are necessarily normative and subjective (Mansfield, 2009). Therefore, we can't conduct scientific analysis of sustainability without attention to these acutely political considerations. In particular, we have to pay attention to the multidimensional perspective on sustainability:

- economic: how do we avoid using the most productive agricultural land for urban growth; how do we make the most space-efficient use of land for urbanization;
- social: how do we account for quality-of-life aspects and individual preferences and values?
- ecological: how do we take into account changing material flows related to urbanization; how does urbanization influence land-ecosystem services; how does urbanization impact landscape structures/land architecture;
- institutional: how does sustainable land management structures enable smooth change/transition processes and desirable pathways of change;
- cultural: how do we account for preservation of e.g. cultural heritage embedded in the landscape (rural or urban)

Sustainable land-use must be conceptualized across long temporal intervals, over multiple spatial scales, and with crossing administrative or jurisdictional boundaries. The concept sustainable land-use within jurisdictional boundaries (e.g., city, province, nation-state) has little utility, since resource flows (including of people and materials) are not limited to a single jurisdiction. Especially in a time with globalized economies and teleconnected resources, we must consider sustainable land-use with an issue or resource base in mind. This does not mean that we should not try to optimize land-use within a jurisdiction. *We need to optimize land-use* *across administrative scales, but sustainability can only be achieved at the planetary or resource-base scale over long time periods*.

Secondly, in an increasingly global world, it is all the more challenging to conceptualize sustainability because what we buy and use on a daily basis comes to us through multiple, interlinked information, labor, commodity and financial flows. These flows are highly dynamic, continually responding to (and creating) changes in demand, resource availability, political instability, etc. Gathering adequate data to describe or predict these processes is a challenging task. "Sustainability" must be defined for a network, not a place.

Our community's strength in confronting global change is our ability to use integrative thinking about the multiple chains of causation, across spatial and temporal scales, driving urban changes and their associated social and environmental effects. How do we best leverage our technical know-how and work toward something inherently normative like "sustainability"? Part of our analysis should be to investigate how and why particular human-environment interactions are good or bad, and to critically review our own underlying assumptions (Benner, et al., 2011). Sustainability always brings with it political implications at multiple levels. Confronting these political challenges requires developing criteria by which to evaluate which outcomes are better for people and for the environment, acknowledging that the impacts of these outcomes are often highly differentiated across various groups of stakeholders. Deciding what to sustain means reaffirming, and justifying, what we value (economic growth? income and quality of life equality? particular ecologies?), and the constraints we face are defined by the values we prioritize.

Our current conceptualizations of urbanization and its relationship with global change through land-use does not provide us with an integrated understanding that moves us towards sustainability solutions. Sustainability of land-use in an era of global change (encompassing the global and local environment, urbanization, etc.) requires addressing the prospects for an increase in economic, social and environmental wellbeing for both rural and urban populations on the planet. We can move forward by:

- examining the potential for co-existence of effective and resource saving urban settlements with other land-uses in the non-urban, providing for vital ecosystem services
- dealing with difficult trade-offs in a situation with increasing competition for limited land resources
- clarifying issues of political economy of urban land but also incorporating challenges that arise through interactions with national systems but also with institutions and policies in rural areas
- further considering issues of fairness and (distributive) justice in the context of urban ecology and global environmental change

III. Interactions between non-urban and urban land-use: process, pathways, peri-urbanization

Cities, due to their concentration of people and activities, matter for global sustainability. Their problems cannot be solved at the local level alone. Better policy integration and new governance, involving closer partnership and coordination at the local, national and regional levels, are required. Through rethinking urban design, architecture, transport and planning, we can turn our cities and urban landscapes into 'urban ecosystems' at the forefront of climate change mitigation (e.g. sustainable transport, clean energy and low consumption) and adaptation (e.g. floating houses, vertical gardens and greenhouses). Furthermore, better urban planning has the potential of assisting in the improvement of quality of life by designing quiet, safe, clean and green urban space (Schetke et al., 2010; Lorance Rall & Haase, 2011). It also creates new employment opportunities by enhancing the market for new technologies and green architecture. However, we must keep in mind that the urban concept may vary in different geographical locations thus instead of designing one-for-all model we should focus on formulating rules for sustainable urban design through which local context based solutions would emerge.

The impact of urbanization on land-use and the wider goal of sustainability depends on local factors, such as the area of land taken, the form of built-up areas and the intensity of land-use, for example the degree of soil sealing and the population density. Land devoted to urban and infrastructure is generally irreversible and results in soil sealing – the loss of soil resources due to the covering of land for housing, roads or other construction work. Converted areas become highly specialized in terms of land-use and support few functions related to socio-economic activities and housing. Urban land take consumes mostly agricultural land, but also reduces space for habitats and ecosystems that provide important services like the regulation of the water balance and protection against floods, particularly if soil is highly sealed. Land occupied by man-made surfaces and dense infrastructure connects human settlements and fragments landscapes. It is also a significant source of water, soil and air pollution. In addition, lower population densities – a result of urban sprawl - require more energy for transport and heating or cooling. Sprawl is not inevitable though – several cities that are currently booming have experienced densification; examples include London, Munich and Amsterdam (Kabisch et al., 2011). The consequences of urban life styles, such as air pollution, noise, greenhouse gas emission and impacts on ecosystem services, are felt within urban areas as well as in regions far beyond them.

Thus, the impact of urbanization can also be conceptualized using a systemic approach. The notion of “sustainable land-use in an urbanizing world” can be conceptualized as a system. We can ask the question “What are the elements, linkages and processes within a local / regional / global land-use system?” From this starting point we can then start identifying and describing the system. Ideally, a simple system would include various important land-use classifications: urban (industrial, commercial/governmental), mining, and agriculture and various ecosystems/biomes (arid, polar, forest, etc). The choice of which type of ecoregion classification may not be trivial, as in some cases the ecoregions overlap (as in the Millennium Ecosystem Assessment classification) and sometimes they are unique, as in FRA Global Ecological Zones (FAO 2001). Importantly, different classifications serve different purposes and may yield different results (for a review see, Mace et al. 2005).

Land-use changes, dominated by agricultural land transformation has been particularly rapid in the last 300 years, with a marked increase in the 20th century (Ramankutty et al., 2006, Ramankutty and Foley, 1999, Klein-Goldewijk 2001 and Klein Goldewijk & Ramankutty, 2004). The late 20th century was characterized by a shift from agricultural expansion to intensification. The most important types of change today include deforestation, forest degradation, forest regrowth, changes in croplands and grazing lands, as well as in the intensity of use, and changes in drylands. Some of these types of land-use changes attract a lot of research interest (e.g. tropical deforestation), but many are much less well understood, such as changing grazing lands and drylands, or changes in complex mosaics of smallholder agriculture. This is particularly evident when land-use change is not a dramatic shift from one use to another, but a more gradual intensification or extensification process.

There is some evidence for example, that deforestation in the neotropics and southeast Asia is now driven not so much by rural population growth (as it was in most of the twentieth century's), but instead by urban population growth and agricultural trade (DeFries et al., 2010). These interrelationships between global trade and urbanization and deforestation can be described as teleconnections. At the same time deforestation in much of sub-Saharan Africa is still more related to expanding subsistence agriculture, and the extraction of wood, fuel, timber and charcoal for domestic use.

As Cardille and Bennet (2010) stress: "Although the underlying connection between agricultural trade and forest loss is clear, the mechanistic link between urban population growth and forest loss is less certain". Nonwithstanding regional differences in these links, there are important policy and governance implications for teleconnections such as those leading to tropical forest loss. Policies aimed exclusively at managing local or regional rural populations will not be sufficient. In addition to the potential of these teleconnections to cause negative land-change (e.g. deforestation) in distant places very rapidly, there is also potential for markets and finance institutions more effectively demanding better environmental and social performance (e.g. from soy and beef producers in Brazil) (Nepstad et al., 2006)

The peri-urban interface refers to spatially and structurally dynamic transition zones where land-use, populations, and activities are neither fully urban nor rural (Simon, 2009). Although it is often assumed that populations and economic activities can be sharply divided between urban (industrial) and rural (agricultural), peri-urban households may be multispatial, with some family members living in rural areas but not employed in agricultural activities and others living in urban areas but engaged in agriculture. As such, peri-urban areas are hybrid landscapes: a juxtaposition of traditional and rural with modern and urban. In these areas, there is an intense interaction between rural and urban economies and lifestyles. Peri-urbanization is usually initiated by an influx of non-local capital in industries or housing development and can take place as far as hundreds of kilometers from the urban core. Note that this concept of peri-urbanization refers to both a place and a process, not just regions in the periphery of existing urban areas.

According to economic theory, an "exogenous" increase of urban population in a specific area (rural-to-urban migration) pushes the urban frontier outwards – towards areas that are considered sub-urban, peri-urban or ex-urban and encroaching on forested and agricultural lands. A similar effect is present when the incomes of urban core dwellers rise but this is also an effect of urban agglomeration, thus this can be also thought as an endogenous process of the influx of urban dwellers in peri-urban rural landscapes. Life styles and values of people with an urban orientation (living in the apparently rural area) will impact the priority setting with regard to land-uses as well as landscape elements in rural areas. This type of impact may be far reaching. Generally, in capitalist land markets, urbanization creates ripple effects of increasing land values at and beyond the urban fringe as the likelihood of urban development increases and the risk or viability of rural production declines. This can lead to speculative development, often in ribbon or leapfrog fashion, with subdivisions later increasing densities and resource demand. Such value/price changes displace weak and poor groups, thereby increasing socio-economic differentiation and often tensions and contests over access to land and resources.

Form, function, and the process of peri-urbanization is also increasingly connected to the environmental effects of urban growth given the nature of peri-urban landscapes. Urbanization processes create greater resource demands from peri-urban and rural areas, the most direct impact being a change from agricultural or otherwise vegetated area, to a use for housing, industry or infrastructure. Other key resource demands that increase include water (hence land take for more reservoirs, often affecting river ecosystem integrity and water availability for farming, ecosystem services, biodiversity conservation etc.), food, wood, minerals, etc. Disposal of urban wastes require landfill sites etc, although recycling and incineration are now reducing the scale of this problem in many contexts (especially in high income countries). Urban land-use change is seen to affect biodiversity, net primary productivity, nutrient and material cycling and disturbance regimes; we now have more evidence on the spatially explicit impact of urban spatial structure – form and density – on the environment and ecosystem function. The impact on the environment comes at multiple scales including regional precipitation patterns (affecting productivity and profitability of peri-urban lands), loss of wildlife habitat and biodiversity (necessitating substitution of natural capital for maintenance of services), conversion of agricultural land, increase in air pollution coupled with increased automobile dependency and congestion, and greater demand for water, energy, and agricultural resources.

The decentralization and de-concentration of cities in recent decades has been attributed to the "natural evolution" of cities, shifts in transportation and telecommunication technologies, and sorting processes based on individual preferences - with urban dwellers selecting municipalities and neighborhoods with the preferred mixture of public expenditures, taxation and/or natural amenities (Tiebout, 1956). While the above processes are critically important, they suffer from some biases, including a limited scope, focusing too narrowly on the rural-urban interface (Clark et al., 2009) and by naturalizing the “choice” of “individuals” to move to peri-urban areas seeking a higher quality of life. Generally missing from these explanations is an attention to urban expansion associated with segregation by race, class and ethnicity and other flight-from-blight processes, including deindustrialization and environmental degradation; individuals are differently positioned in their ability to escape inner-city urban ills. In the US context, rustbelt to sunbelt migration also reflects segregation processes at a interregional scale (Graves, 2006). Moreover, local political economy depends critically on urban growth policies (Downs, 1999).

While we have a reasonably good handle on some of the economic fundamentals of land development, we tend to ignore the political and the social. If urbanization and peri-urbanization in Southern countries is happening in similar ways to the Northern experience, but at an accelerated speed and scope, how are the social and political dynamics of these changes contributing to the patterns we observe? Because we are not paying enough attention to unevenness within and inequality produced by the increasing stratification of people in the North, we must be that much more wary of our interpretation of these processes in the Global South. Thus, peri-urbanization literature coming from a North-American context might not easily be transferable to other regions/cultures/governance regimes (Schneider and Woodcock, 2008).

The dynamics of demographic pathways and lifestyle changes have specific effects on land consumption in the peri-urban space. New gradients of ‘urban costs’ (housing, rent, energy, accessibility) determine type and intensity of land-use in the peri-urban parts. In many parts of the world areas classified as ‘peri-urban’ have the same amount of built-up land as urban areas, but are only half as densely populated. Multiple studies have pointed to the risk of increasing urban sprawl. For example, projections of built development in peri-urban areas of Europe are for 1.4 – 2.5% per year, if such trends continue. Thus, total built development in peri-urban areas could double from 2040-2060. Modeling the impacts of urbanization shows that land fragmentation, loss of habitats and amenity values will become more serious in the peri-urban in the future. Simultaneously, peri-urban areas are also a place of innovation and increasing employment in the service and IT sectors: 25% of peri-urban regions are classified as ‘highly innovative’.

IV. Teleconnections and sustainability: new conceptualizations of global urbanization and land change

The current report focuses on this systemic approach on sustainable land-use in an urbanizing world and argues both for a focus on process-based definitions and conceptualizations of the interlinkages between land-change and urbanization, and for the use of the concept of teleconnections. Here we propose and elaborate on the use the concept of urban-rural teleconnections to conceptualize the linkages and flows between urban and rural places. In climate science, teleconnections refer to large climate anomalies that are correlated over large geographic distances. For example, El Niño, the warming of the Pacific Ocean currents that occurs every 3 to 7 years, is connected with weather events in distant places. Examples of El Niño teleconnections include spatial patterns of rainfall variation in Africa and precipitation patterns in Western United States. Similar to climate teleconnections, the concept of urban-rural teleconnections refers to urban-rural flows and connections of people, economic sectors, money, goods or services that are not geographically co-located. Urban-rural teleconnections are urban and rural processes that are correlated but occur over distant places. Historically, urban centers were tightly connected with the surrounding rural communities. Today, urban centers in mega-deltas can be less connected to the peripheral areas immediately surrounding the city than to rural areas in distant locations. Change in one urban location can underlie variations in multiple rural locations, or change in multiple urban locations can explain variation in one rural location.

Some working definition(s) for the use of the term "teleconnections" in the sense of our workshop discussions
• distal flows and linkages of people, economic goods, information and services with implications for land systems, driving and responding to urbanization • Process based continuum of interconnections of spatially distant processes, drivers, markets, flows of energy and materials between land systems and their urban connections.

In the previous section, we showed how the relationship of urbanization and socio-economic, biophysical and urban form transitions can be conceptualized. In terms of connections of urban land-uses to other land-uses, we may want to ask, why populations agglomerate initially. This has a lot to do with trade (connections). Originally, or more traditionally, urbanists have associated the emergence of cities with the production of surplus (Carter 1983). Jacobs (1969), however, has a more interesting story about the emergence of cities, as she pinpoints the importance of connection. If one subscribes to this way of thinking, and there is increasing evidence that the earliest cities traded, then the question becomes, how do these changes associated with increasing dense settlement impact the scope, intensity and speed of these connections? Importantly, however, we need to tease out from these questions the roles of the other factors that accompany urbanization and development (interactive effects).

Urban systems are typically conceptualized as networks of nodes (cities or metropolitan areas) and linkages (flows of goods and services). The degree of interconnections between the nodes can vary but typically, small changes in specific nodes can be experienced across the system (Berry, 1964). The tradition of urban systems analysis is grounded on an epistemology that cities, when analyzed as a set, can be treated within a general systems research/science theoretical framework, utilizing a wide array of scientific models. A significant portion of urban systems research sprung from the need of a better understanding of a wide range empirical regularities (or, stylized facts) in the location and size distribution of human settlements within nations, their hierarchy in the urban system and properties of order; these regularities were first identified in the early 20th century.

One important motivating force behind urban general systems theory approaches is the empirical finding of regularities across national systems of cities. That is, addressing urban places as nodes in general systems theory was mandated through the identification of empirical regularities that urban places exhibited across space and time. That cities display surprising empirical regularities in their size distributions is a longstanding finding, with a law-like relationship between the size of a city and the frequency (or, the rank) of a city within a national system of cities (Berry and Garrison 1958a). Systems of cities typically are consisted of a few large cities and a large number of smaller cities (Berry 1964).

The concept of urban-rural teleconnections is informed by, and draws -on a number of theoretical frameworks from the literature on urban systems, such as a) innovation diffusion theory, b) central place theory, c) complex adaptive urban systems, d) world city systems theory, e) urban metabolism/urban material and energy flow studies and f) commodity and value chains and networks.

Teleconnections takes from **diffusion theory** the notion that flows cannot be modeled empirically without a larger theoretical framework. The movements of goods, services, people, information, to and from land areas and urban spaces most be associated with way to understand both why some movements do not occur as well as how differential movement and resistance can be linked to issues of political power (Johnston, Gregory, and Smith 1994).

A reconceptualization of urban land teleconnections can benefit from the **central place theory** concepts by adopting an explicit consideration of the hierarchical structure of urban systems (Berry and Garrison 1958a, 1958b) and the understanding of the "sphere of influence" of urban places (albeit in a limited geographical sense). Furthermore, introducing **complex systems thinking** for urban teleconnections provides advantages as it positions centrally issues of feedback loops, non-linearities, and emergent phenomena (Wilson, 2000),.

The elements from **world city systems theory** that pertain to teleconnections include the emphasis on flows of goods and services across scales based on a global urban network. Those that have subsequently advanced these studies have identified these flows and quantified connections amongst cities based upon the intensity of these flows (be they airline passengers, information, capital, images, illegal substances, etc) (Castells 1996; Taylor 2004). At the same time, the teleconnections concept goes beyond WCSs in two ways: 1) it includes connections of cities to non-urban places; and 2) it includes non-economic valued goods and services. In these respects it shares much with urban metabolism, or urban material and energy flows accounting studies.

While the **urban metabolism** model has been useful in helping to identify the amount and types of material and energy flows through a city, it treats urban centers as black boxes; hereby processes of metabolism are rarely examined. Urban metabolism may also underestimate the relative importance of some materials within cities (Huang and Hsu 2003). Moreover, the biological analogy can create misleading interpretations (such as equating urban feedback processes with those of an organism) (Golubiewski 2010).

The notion of teleconnections includes the larger flows of energy and materials that are examined in urban metabolisms studies. At the same time, however, the notion of urban land teleconnections attempts to move away from the input-output black box approach. It does so by focusing more on the processes that occur within these different spaces that influence the flows.

The idea of teleconnections, with the emphasis on process attempts to incorporate the idea of **networks,** as with world city system networks. We emphasize the importance of linkages, actors and institutions in the relationships that develop within cities and their connections to activities, actors and institutions in other land-uses. Moreover, as with networks, we attempt to incorporate an ethical analysis. In this aspect we are inspired by the work in environmental justice.

V. Measures and indicators

In terms of practical research on teleconnections and land change in an urbanizing and globalizing world, a number of challenges are present:

- Land-changes linked to teleconnections are happening fast, while research planning and funding are typically slow. For example, as Herrick and Sarukhan (2007) mention: “Extractive industries, for example, can establish new international operations in less time than it takes to get a research grand proposal written and accepted, and in far less time than it takes to develop new funding sources”.
- Both land-change and urbanization research is often based on individual case studies that usually use different methodologies, data, spatial and temporal

scales. They are therefore often difficult to use for comparative purposes, or to get a broader (regional to global) scale overview on processes. This leads Grimm et al. (2008) to argue for a "continental research program across multiple gradients, within and radiating out from both small and large cities" (for the US). In a similar spirit Liu et al. (2007) argue for "planned comparisons across sites and macrolevel analysis with existing and emergent data across local, regional, national, and international levels. Kabisch and Haase (2011) argue for the use of a urbanization-intensity gradient to capture and monitor different trends from mega-growth to shrinkage.

- Restrictions of national funding agencies to fund international and global research. Most funding agencies have very strict rules that restrict funding of researchers that are not based in the country. This is true also for EU funding, although here at least a block of countries is referring to the same funding rules and sources.

The development of sustainability indicators should involve stakeholder participation to acknowledge the fundamentally normative nature of these exercises. Indicators may need to be multidimensional, i.e., sustainability can be the net outcome of the drivers, pressures, impacts, and the interactions of all of the above. Indicators should be grounded in theory, not purely inductive. Indicators must integrate data and information across various temporal and spatial resolutions; we may need to work both from the ground up and the macro down to the micro. Finally, what is the unit of analysis? A bounded geographical region? A network? An economy? Can we integrate processes across scales and extents?

Researchers have developed a range of approaches dealing with indicators for sustainable land-use (change): Schwarz (2010) tested a range of landscape metrics (LSM) and dissimilarity indices to assess the urban form, Schwarz et al. (2011) used the ecosystem service approach (surface emissivity, f-evapotranspiration) to measure the climate-sensitivity of land-use planning, Schetke and Haase (2008) developed an indicator set to evaluate sustainability impacts of urban shrinkage and, finally, Lorance and Haase (2011) developed an integrated approach to evaluate sustainability targets of urban interim land-uses. In the EU-project PLUREL, benchmarks for sustainable land-use governance were developed including the expressed need of an appropriate mix of policy means of influence and relative power over lower level authorities, various policy arrangement, discourses, rules of "the game", use of resources and coalitions (www.plurel.net).

With regards to the concept of teleconnections, we need to be able to track, spatially and over time, the flows of resources (people, goods, energy, materials) and to be able to link consumption with production across all the different steps and temporal dimensions.

Measuring sustainable land-use requires the operationalization of sustainability in the context of land-use models. In particular, one has to resolve dilemmas and tradeoffs in the choice of suitable context-specific modeling tools. Efforts to operationalize a new framework on sustainable land-use that can be considered policy-relevant should follow known criteria established in the past for operational sustainable development models. Assuming that environmental concerns are integrated in the modeling approach, choice can be assisted by the evaluation of criteria on the multi- and inter-disciplinary potential, a longer-term (intergenerational) focus, uncertainty management, capacity to handle local vs. global or intra- vs. inter-metropolitan scales and the centrality or active participation of the policymaker.

Similarly to all human-environment interaction frameworks, an urban land teleconnections approach will have to be informed by an integrated understanding of effects on human well-being. A short literature review suggests that a large number of potential measures of human and environmental well-being could be used, from economic indicators (household income, Gini coefficient, poverty rate, unemployment rate etc.), to social indicators (e.g. health indicators, population density, crime rate etc.), as well as ecological indicators (water and air quality etc.) and indicators on governance efficiency and environmental services (Choon et al., 2011). A related question would be, if such indicators should be so broad that they could be used for international and global comparison, or so specific that they might have to be developed for each individual city or region.

VI. Strategic/fundamental issues addressed in the workshop, especially with regard to research and knowledge gaps

Explicit attention to urban teleconnections permits a broader normative assessment of land change and urbanization processes, and thus provide a means of operationalizing equity principles of sustainability. Teleconnections can serve as interventions that promote justice, a core sustainability principle, in an increasingly urbanizing world. Several strategic directions and knowledge gaps remain in this new conceptualization of urban teleconnections:

- What is the normative basis for urban sustainability? How can we, those with technical know-how, best help in agenda setting?
- How to create a viable systems approach that integrates urban, peri-urban and rural land and associated strategic perspectives.
- Does it make sense to talk about sustainable land-use at any scale below the global level?
- What should be the visions of sustainable land-use at multiple spatial scales, especially in a world with 8-10 billion people by 2050.
- A sustainable land-use concept should address apart from 3 traditional pillars (society, economy and environment) also governance. It is governance, which along with economy, sets the rules of the game. Policies (via legal legislation) regulate human activities but their main drawbacks are that they are sector oriented and geographically restricted. Thus their positive impact to complex environmental issues is limited.

- How do we reconceptualize rural-urban connections to move beyond categorical thinking? Can we trace for a given urban system its functional interdependence to the rest of the world? Given the global extent of urban-rural teleconnections in a globalized and urbanizing world, how do we conceptually and methodologically deal with displacement (or leakage) effects (a spatial displacement of environmental costs to other locations and territories), as well as complex cascade effects (Lambin and Meyfroidt, 2010)
- How do we integrate the different forms and approaches of urban modeling with other approaches? How do we conceptualize and theorize processes that are not easily represented in spatial data?
- Peri-urbanization is a key process: do we know enough about the regional differences/characteristics in processes of land change per se around urban cores? We need better linkage of drivers of peri-urbanisation and rural-urban relationships at different scales (local, regional, national, global); How do we study peri-urbanization and its effects holistically without privileging a specific population doing the moving, and ignoring processes of urban blight and environmental justice?
- A new overall framework for sustainability in an urbanizing world capturing processes of political economy, social and environmental justice, urban ecology, and global environmental change
- What are the consequences of current and projected urban growth on competition for scarce land resources (and the associated environmental consequences), both globally and regionally, and how can these consequences be alleviated by more sustainable ways of urban development? What are the main factors that will enhance trends towards urbanization or de-urbanization respectively? Does it make sense to perceive the trends across the globe as uniform? (as regards driving forces)
- Do we aim at solutions based on technological improvements – regardless of possible medium-long-term resource constraints?
- Methodologically, better analyse and assess uncertainties, externalities, spillovers and tradeoffs in land-use policy in urban regions

The localized concept of urban sustainability tends to neglect distal influences, especially on land use and land use change. Furthermore, land change science tends to not fully address the linkages to global and regional urbanization processes. Neglecting the complex, overlapping and diverse nature of urbanization and land use change processes and in particular, the role the distal connections between them can lead to misguided sustainability policies and practice, deviations from paths of sustainable development and missed opportunities for increases in human well-being. Urban land teleconnections are critical for bringing about correct conclusions and findings, and avoiding unintended negative consequences in distal places.

Seto et al. (2012) propose a conceptual framework and portfolio of methods that link land change to urbanization dynamics beyond the local scale. The authors offer a platform for a holistic analysis of the underlying and variety of spatial effects of production and consumption, and development of policies that promote viable and fair solutions. Moving away from isolated conceptualizations in urban sustainability and land change science can lead to an integrated understanding and solutions for sustainability. By bringing together the land change and urban literatures and offering a conceptual framework to incorporate the “teleconnections” concept to understand the links between land change and urban processes, Seto et al. (2012) make significant headway in the examination of the tradeoffs and consequences of decisions that extend beyond the local immediate area.

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Acknowledgements

Funding for the workshop was provided by the Urbanization and Global Environmental Change (UGEC) Project and the Global Land Project (GLP). UGEC acknowledges the support of the U.S. National Science Foundation, Arizona State University and the IHDP. GLP acknowledges the support of the University of Copenhagen, IHDP and IGBP.