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Urban ecology in a developing world: why advanced socioecological theory needs Africa

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Abstract

Socioecological theory, developed through the study of urban environments, has recently led to a proliferation of research focusing on comparative analyses of cities. This research emphasis has been concentrated in the more developed countries of the Northern Hemisphere (often referred to as the “Global North”), yet urbanization is now occurring mostly in the developing world, with the fastest rates of growth in sub-Saharan Africa. Countries like South Africa are experiencing a variety of land-cover changes that may challenge current assumptions about the differences between urban and rural environments and about the connectivity of these dynamic socioecological systems. Furthermore, questions concerning ecosystem services, landscape preferences, and conservation – when analyzed through rural livelihood frameworks – may provide insights into the social and ecological resilience of human settlements. Increasing research on urban development processes occurring in Africa, and on patterns of kinship and migration in the less developed countries of the “Global South”, will advance a more comprehensive worldview of how future urbanization will influence the progress of sustainable societies.

Urban ecological theory is based on studies of cities that represent advanced economies (Cilliers *et al.* 2009; Lubbe *et al.* 2010; McConnachie and Shackleton 2010); however, the developing world is playing an increasing role in global urbanization (UN–HABITAT 2008; Angel *et al.* 2011). Projections show developing nations increasing five times as fast as those nations where socioecological systems (SES) theory first emerged (Angel *et al.* 2011). Despite these rapid changes, the socioecological study of urbanization in developing nations remains rare, especially in sub-Saharan Africa, where these changes will be the most dramatic.

The “Global South”, representing the less developed countries of the Southern Hemisphere, cannot simply be treated as a case study for a Northern theory based on modernist trends in urbanization (Robinson 2002). Such theories often incorrectly assume that sub-Saharan Africa and the developing world will “catch up” with urbanization in the Global North, a region of the world surmised to have generally achieved some kind of equilibrium. Although urban studies associated with the fields of cultural anthropology (Dawson and Edwards 2004), planning (Shatkin 2007), architecture (Koolhaas *et al.* 2001), and history (Fourchard 2011) have acknowledged that the cities of the Global South may represent alternative stable states, little of the work in these places informs urban ecological theory.

Comparisons among the drivers of urbanization are necessary to plan and build sustainable communities (Grimm *et al.* 2000, 2008; Vale and Campenella 2005), but at what scale are we imagining this sustainability? By 2030, there may be 770 million Africans living in cities, “more than the total number of city dwellers in the entire Western Hemisphere today” (Fourchard 2011). Furthermore, urban land cover in sub-Saharan Africa is expected to increase more than 12-fold by 2050 (Angel *et al.* 2011). An understanding of urban heterogeneity and sustainability must take into account the drivers impacting not only the Northern Hemisphere but also the principle variables influencing current development patterns at multiple scales globally (Grimm *et al.* 2008; Fourchard 2011). Urban ecologists need to expand their comparative paradigm to encompass the developing world, including sub-Saharan Africa. This broader focus will advance urban ecological theory, as well as providing for a more sustainable and environmentally just future around the world.

Urbanization in sub-Saharan Africa – rural is the new urban

Expanding the comparative urban paradigm to analyze cities in sub-Saharan Africa would help to determine whether the current understanding of urbanization developed in the Global North is relevant in Africa. To that end, a review of the urban literature set in sub-Saharan Africa would be a useful starting place and would likely reveal some important similarities in resource consumption (Gasson 2002; Kennedy *et al.* 2007) and biodiversity distribution (McKinney 2006; van Rensburg *et al.* 2009; Meek *et al.* 2010) in cities – like Cape Town, Pretoria, Harare, and Nairobi – that have colonial or settler origins (Muronda 2008). Furthermore, such an analysis would expose the obvious key difference between cities in the Global North and those in the developing world – the large percentage of the population living in informal settlements.

In this paper, however, we present a different but equally relevant framework for understanding urbanization processes in the developing world; this alternative framework shows that projections of urbanization in Africa grossly overestimate rural-to-urban migration and, therefore, confound the true definition of urbanization (Potts 2012). In fact, studies have shown that permanent urban migration is decreasing, not increasing, in Africa (Ferguson 2007; Potts 2009) and growth in established cities is a function of higher-than-normal birth rates in urban areas (Cohen 2004; Potts 2010). So what do we make of Angel *et al.*'s (2011) projections of a 12-fold increase in urban land area in sub-Saharan Africa? Arguably, this increase in urban land area will actually be due to the reclassification of rural areas as urban, resulting from an ever-increasing rural population. Literally, rural is the new

urban. Not only is the urban/rural dichotomy inadequate for addressing the needs of the growing populations in Africa, but the rural migration occurring on the continent is overwhelmingly toward smaller cities and towns (Simon *et al.* 2004; Collinson *et al.* 2007).

Here, we identify how these new rural/urban areas defy current definitions of both rural and urban, and explore what this means for the study of urbanization gradients in the developing world. We then examine how SES theory can be advanced through an integrated rural livelihoods framework, exemplified by studies along the western edge of South Africa's Kruger National Park (KNP). These analyses illustrate several key themes in urban ecology – including conservation of biodiversity, landscape preferences and resource use, and sustainability and resilience of human–natural systems – that could benefit from an improved understanding of these rural/urban transitions.

South Africa and the Greater Kruger SES

Sub-Saharan Africa is exceptionally diverse, and we do not believe that any one region of the continent could be used as a model study system; nevertheless, South Africa encompasses a multitude of circumstances that make it an interesting case study to help expand the comparative paradigm. First, South Africa has one of the largest economies in Africa yet is characterized by greater levels of unemployment than under apartheid (the nation's historical policy of racial segregation and discrimination), extreme rural poverty, political corruption, xenophobic violence, and a prevalence of HIV and AIDS (Bond 2005; Seekings and Natrass 2005; Ferguson 2007). At the same time, South Africa's progressive constitution includes pioneering guarantees of rights, access to resources, and quality of life for its diverse population. Finally, the legacy of apartheid, and its links to global economic forces, remain visible in the distribution of people and resources across the landscape, providing an opportunity to understand sustainability in the context of environmental justice.

The intertwined distribution of people and resources is illustrated by the relationship of conservation to urban–rural transformations. Although South Africa originally followed the Northern Hemisphere-inspired “hands off” strategy for conservation, its political history has now led to a more anthropogenic focus on the preservation of biodiversity (Venter *et al.* 2008). The country's premier conservation agency, South Africa National Parks (SANParks), envisions increasing the health and well-being of people living adjacent to the country's protected areas (Swemmer and Taljaard 2011). This strategy depends heavily on SES theory, and the Greater Kruger region serves as a testing ground for a new understanding of conservation practices in the context of coupled human and natural systems. Along KNP's boundaries, where urban and rural meet in multifaceted transitions, research on rural livelihoods is providing a wealth of information – regarding the consumption of limited resources – that can enhance our understanding of urban sustainability (Figure 1).

Rural, urban, or rural/urban?

Development in the South African countryside makes it hard to understand the spatial extent of what is considered to be urban. Most urban ecologists would expect rural areas surrounding urban centers to be economically dependent on the city's productivity and

prosperity, even in “younger” cities. Meanwhile, despite their remoteness, vast areas of rural South Africa are strongly connected to urban cores. For instance, many of the households along KNP’s border depend on metropolitan government subsidies or on remittances from family members who have moved to the city for work (Collinson *et al.* 2007). This is seen in a development pattern in the rural regions, in which half-built homes across the landscape remain continually a “work-in-progress”, as households wait for more remittances before resuming construction (Figure 2).

This urbanization pattern is common to developing nations dependent on migrant labor. Therefore, an urban–rural gradient analysis in this region of South Africa, as well as in developing nations worldwide, might actually have a more spatially dispersed configuration than both the linear arrangement of “older” cities or the sprawling, complex conglomerations associated with contemporary development, as often seen in the Global North. Patterns observed in South Africa may be better predictors of large-scale urbanization in the near future.

Furthermore, urban socioecological studies could benefit from the social sciences’ concept of the urban continuum. As with the livelihoods framework, the continuum philosophy states that urban and rural are actually the same; people, no matter where they are, depend on and consume resources in the same way, on a daily basis. More critically, this philosophy also declares that people can exist in both phases of development simultaneously (Funnell 1988; Ross 2005). The potential for concurrent, place-based identities undermines a more conventional understanding of the “family” as a fixed point of reference. Simply, one or two members of a household or family unit are chosen to migrate for a job opportunity and will send remittances back home – such households thus inhabit both urban and rural identities. Whether in the informal settlements fringing Cape Town or in the urbanizing areas previously designated as homelands under apartheid, family and kin affiliations may stretch over great distances; households may be large, with “value” concentrated in the elderly and in children, who receive income via social grants distributed by the government (Ross 2005; Ferguson 2007).

In fact, separating rural and urban identities in South Africa’s Limpopo and Mpumalanga Provinces is not easy. Not only is there constant movement of people, migrating from rural to urban and back again, but the KNP border is developing so rapidly that there are entire rural districts that resemble urban agglomerations (Figure 1). These regions (dubbed “rural/urban”) follow most standard definitions of rural: they have low resource availability, poor services, and very little manufacturing. However, these inequalities also owe much to the legacy of apartheid-era spatial planning, which forcibly removed and relocated at least 3.5 million people across the country, driving many of them into ethnically conceived homelands governed by dubiously installed, compliant, traditional leaders (Ramutsindela and Simon 1999; King and McCusker 2007). The local municipality of Bushbuckridge, which straddled the two homelands of Lebowa and Gazankulu, was a dumping ground for “surplus” farm laborers; its population density doubled every decade between the 1950s and 1980s and was further swelled by an influx of 50 000 Tsonga-speaking refugees from Mozambique (Polzer 2004). Yet this area also hosts bustling centers of activity and informal economic production (eg street markets specializing in food, art, and other goods and

services, and homes temporarily converted into restaurants), notwithstanding the extremely high population density that, in some areas, exceeds 300 people per square kilometer (Pollard *et al.* 2003). Akin to squatter developments, where people build what they need from the ground up, such zones might very well be the “urban centers” of the future.

Urban sustainability and rural livelihoods – contrasting socioecological frameworks

Numerous frameworks have been developed for interdisciplinary studies of the relationship between human and natural systems in urbanizing environments (Grimm *et al.* 2000; Pickett *et al.* 2001). One well-cited SES framework, called the Press–Pulse Dynamics (PPD) framework, emphasizes the mechanisms that link human and natural systems in order to guide long-term research (Collins *et al.* 2011); however, models like these illustrate assumptions associated with the way in which researchers view Northern systems. For this reason, we compare a socioecological framework created to study rural livelihoods in the Greater Kruger SES with that from a temperate urban system (Panel 1).

One main difference between the PPD (Collins *et al.* 2011) and the integrated rural livelihoods framework (presented here) is the way in which human and natural systems are connected. In the PPD framework, the human system is influenced by the provision of ecosystem services while also affecting pulse and press events, such as fire and drought. Alternatively, the integrated rural livelihoods model shows that human and natural systems overlap and are both influenced by livelihood strategies (Figure 3). This may represent a fundamental conceptual distinction in understanding the nature of human–ecosystem interactions. Highlighting human livelihoods as central in the human–natural system emphasizes the point that individual humans make daily decisions that have substantial impacts on the ecosystem (Panel 1).

An example of these conceptual differences is clearly demonstrated when considering issues of land-use change in the Greater Kruger SES. Using an SES framework such as the PPD, ecologists and institutions interested in establishing a “wildlife economy” (ie stimulating the local economy through wildlife tourism projects) outside of KNP propose regional land-management strategies based on generalized evaluations of ecosystem services at large scales. However, when these assessments are presented to traditional and local authorities in South Africa, communities and their leaders are not able to properly assess what these ecological evaluations mean. First, there is an issue of scale, where the impacts of land-use decisions on village-level dynamics are different than the effects on regional populations and ecosystems. Also, the way in which the residents use and value the ecosystems where they live differs from typical economic evaluations of ecological services. To resolve these issues, a livelihoods approach would include the economy of households and the values of the people within them, local perceptions of land-use change issues, and the changes in human consumption and resource use associated with the urbanization process.

This conceptual shift toward livelihood strategies acting as a framework connecting human and natural systems is key to achieving sustainability. In Africa, sustainability emerges from a different philosophical context, in which people have perceived themselves as being a

major part of ecosystem dynamics on large scales throughout human evolutionary history. Indeed, the science addressing Africa has always been amenable to this overlap, as in the well-established anthropocentric understanding of savanna ecology (Laris 2011).

Conservation of biodiversity

Fundamental ecological theories, such as the intermediate disturbance hypothesis and island biogeography, have been applied to urban biodiversity trends, predominately in large cities in the Global North, with varying degrees of success (Niemela *et al.* 2009). There has been a call for these types of ecological analyses to be extended to tropical rain forests, where species are especially sensitive to human development (McKinney 2002). In contrast, it is also important to conduct analyses of biodiversity along gradients of urbanization, in areas where wildlife have had a long history of evolving with humans. So, for instance, moving directly west from the KNP into the Bushbuckridge local municipality, one crosses the boundary of a national park, into flanking communities that experience incursions by “damage-causing animals”. Most of these homesteads are heavily reliant on savanna wild foods, and even those located in the more urbanized environments are dependent on safari tourism, social grants, remittances from migrant labor, local biodiversity, and dwindling fuelwood supplies as their primary energy resource (Shackleton 2000, 2004; Shackleton and Shackleton 2000; Twine 2005; Giannecchini *et al.* 2007). Although these settlements are typically associated with environmental degradation and resource depletion, positive associations with species richness have been observed (Shackleton 2000; Smart *et al.* 2005).

Sub-Saharan Africa has a unique set of conditions that are useful for gaining a better understanding of human–wildlife–domestic-animal interactions (Hartnett 2010), but the distinctive relationship between the KNP’s boundaries and large human populations also provides a compelling set of circumstances in which to study biodiversity trends. KNP’s primary mandate is to preserve bio-diversity by managing heterogeneity. Although a fence surrounds this semi-closed experiment, it isn’t effective at keeping people out or nature in. As one of the largest conservation areas in the world, the KNP can serve as a critical “seed source” for biodiversity in the region and for ecosystem services to its neighbors.

There are also locations within the KNP that are worth studying in terms of SES. Often, scientists and conservation agencies focus on biodiversity in conservation areas or parks of various sizes that are surrounded by a matrix of urban settlements. In the KNP, the network of tourist facilities and residential neighborhoods developed for park staff are “urban-like” areas, surrounded by a matrix of preserved savanna. The effects of even a few people living in the park are obvious from satellite imagery; for instance, a riparian zone has been artificially expanded in the region where people built houses (Figure 4). Preliminary analyses on bird and butterfly species in the area have shown significant differences in both the number of species and abundance of individuals near the small residential neighborhood of Skukuza, in contrast to the nearby, undisturbed savanna (McHale/OTS unpublished data).

Landscape preferences and rural livelihoods

Many researchers, managers, planners, and advocacy groups are concerned about the distribution of reduced woody canopy cover in lower socioeconomic status neighborhoods

across many different urban systems. Because this pattern could be a function of environmental injustice, recent studies have looked at the underlying mechanisms behind these relationships. For instance, studies in the US city of Baltimore, Maryland, have shown that these patterns may actually be a legacy of past racial segregation, and an analysis in Phoenix, Arizona, suggests inequities associated with the landscape may worsen over time (Boone *et al.* 2009, 2010; Jenerette 2011).

On the other hand, there is evidence that culture plays a role in determining where people like to live, with certain ethnic groups seeming to prefer open areas without a large amount of tree cover (Grove *et al.* 2006; Troy *et al.* 2007; Petersen *et al.* 2012). Alternatively, lower socioeconomic status groups, no matter their ethnic affiliations, may not envision tree cover as providing ecosystem services and instead see trees as a burden because of the costs of tree maintenance, or harbor misconceptions about denser cover as a driver of higher crime rates (Nasar and Fisher 1993; Buckley 2010).

Can these findings be generally applied? In South Africa, households that experience the greatest economic deprivation, and which have the fewest resources to dedicate toward landscaping, still plant, care for, and even water trees (Figure 5). This could be a function of their direct dependency on the resources trees provide (Banks *et al.* 1996; Twine *et al.* 2003; Paumgarten *et al.* 2005; Lubbe *et al.* 2010). Of particular interest in the region is the reliance on wood as a source of fuel for cooking, even where residential electricity is available (Madubansi and Shackleton 2007; Matsika *et al.* 2013). There are other indicators that potentially drive landscaping choices, called “cues to care” (Nassauer 1995). If it is important to show others that one cares enough to maintain one’s property, even low-income earners can do this by keeping large open areas swept and clean, a common cultural tradition of some ethnic groups in Africa (Figure 5; Cilliers *et al.* 2009).

To understand the complexities of human relationships with landscape and the potential cultural foundations for the observed patterns, we argue that rural and urbanizing South Africa can provide a great deal of information about people’s landscape choices (Zobolo and Mkabela 2006; Lubbe *et al.* 2010; Molebatsi *et al.* 2010). How people make decisions in reference to natural resource acquisition is a major component of human livelihood analysis. Furthermore, how landscape preferences influence environmental quality is not just a question for the communities outside of KNP’s fence. In the neighborhoods within the headquarters village, in the park itself, there are some obvious disparities between social groups and their landscape designs, even though none of the KNP residents actually pay for amenities like water (Figure 4).

Sustainability and resilience

Although flexible, the meaning of “sustainability”, in most scientific literature, implies a focus on the utilization of resources. In particular, an emphasis on consumption per capita has led to the common belief that densely populated urban areas may actually contribute positively to sustainability (Jabareen 2006). While it is not clear whether this is true, it is obviously important to understand the change in resource use that occurs with urbanization. In contrast to that in classical urban areas, much of the consumption of natural resources in

rural/urban SES is localized; communities meet many of their domestic needs for food, cooking energy, medicine, construction material, and water from their immediate environment. These communal areas are also subject to increasing commercial harvesting of resources to meet the demand in more densely settled areas. The local sustainability of resource use, especially fuelwood, is therefore of serious concern in these systems (Matsika *et al.* 2013). The scientific community must begin to understand rural areas as a baseline for comparison; only then can researchers start to provide answers on how resource use changes with improved quality of life, as well as encouraging local solutions to reducing consumption.

Societies in sub-Saharan Africa have a prolonged history of using migration as an adaptation to change (Collinson *et al.* 2007; Tacoli 2009). It has been suggested that this phenomenon of migrants moving to and from cities may even lead to the degradation of urban infrastructure. But what if it is this generalized perspective on permanent cities that is limiting our ability as urban ecologists to understand the real function of migration in urban development? Maybe scientists, policy makers, and city planners must simply accept that certain cities will fail, that others will evolve over a longer period of time, and that some will be in a constant state of flux between collapse and recovery. Perhaps this new focus on adaptation to change – again a centerpiece of rural livelihood studies as well as a revolutionary conservation management strategy in the KNP region (Rogers and Biggs 1999) – can inform recent conceptualizations of the city (Roberts 2010; Roberts *et al.* 2011) and contribute to a more realistic approach to building sustainable societies in the face of global climate change.

Conclusions

An understanding of urbanization in the world's developing nations is necessary if there is to be any hope of achieving a sustainable future. Urban socioecological theory will be advanced only by a paradigm that embraces urban–rural connectivity globally. The Greater Kruger SES shows how people live and depend on biodiversity, how they perceive landscape design to have status and aesthetic dimensions, how they manage yards for their own well-being, and how they adapt to ecological and economic challenges by migrating to and from urban areas. In studying the urbanization process in areas where it is now occurring more rapidly than anywhere else, scientists, policy makers, and natural resource managers may find new solutions to the contradictions that exist between the conservation of biodiversity and the livelihoods of people. Africa, or more generally sub-Saharan Africa, is certainly not the only place where issues of poverty, resource availability, and urbanization exist. However, since the trend has been generally to overlook Africa, we provided examples of how urban ecological theory could be advanced by examining this rapidly urbanizing continent. Citizens and governments in the Global North have a moral obligation to pay attention to Africa, given that consumption from developed nations has precipitated changes in the global climate that are expected to be most devastating to people in this part of the world (Warner *et al.* 2010). Here also exists a rich foundation of human livelihood analyses, as well as a unique combination of cultural and political patterns, that can help to achieve a greater understanding of the role that cities play in the evolution of human societies over time.

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In a nutshell

- Urban socioecological theory is a product of research carried out in the Global North's temperate, industrial cities
- In contrast, the greatest growth in terms of numbers of cities and urban residents is in the Global South
- Examples of South African urbanization in areas that are currently considered rural can help broaden urban ecological theory and make it more applicable to the social and environmental conditions relevant for developing cities and towns globally
- New urban theory benefits from an understanding of the convergence of dense rural settlements with African cities, fueled by two-way movement of people and resources in an attempt to support livelihoods throughout the whole range of environments, from urban to rural

Panel 1. Socioecological systems (SES) frameworks for research and sustainability

Socioecological frameworks have been developed over time to represent key interdisciplinary issues and research questions associated with sustainability and the provisioning of ecosystem services (Collins *et al.* 2011). The Press–Pulse Dynamics (PPD) framework has been considered one of the few that allows for developing integrated research hypotheses across disciplines linking human and natural systems. This framework has been very useful for rendering the broader impacts associated with social or ecological research questions, and it is therefore often used for broad research agendas outlined by programs like the Long Term Ecological Research sites, as well as in the development of new programs such as Long Term SocioEcological Research sites and Urban Long Term Research Areas.

Following the PPD framework, however, it is possible to continue developing and conducting disciplinary research that is linked only in theory. In particular, it is very easy to simply answer questions on one side of the framework, or to just focus on one specific hypothesis. Because scientific research is often carried out to investigate one hypothesis or research question at a time and address, at best, three to five related research questions in each publication, the PPD framework remains an effective tool for connecting disciplinary research objectives. Nevertheless, it can also become a crutch; it is much easier to connect disciplinary work to other disciplines with arrows than to actually develop questions across disciplines that implement different, sometimes contrasting methodologies. This is troubling, because the questions that cross disciplinary boundaries are the ones that really need to be addressed to solve our most pressing environmental and societal issues.

We believe that at this stage the scientific community can learn from work on rural livelihoods that puts humans at the center of complex SES (Figure 3). Because livelihood analyses often focus on questions regarding human health and well-being, whether aligned more with social or ecological disciplines, these questions evolve from a standpoint that is concerned with how people live. As urban ecological analyses move from a generalized understanding associated with the impacts of land-use change to fine-resolution household- and parcel-level socioecological dynamics, there is something to gain from considering rural livelihood studies.

Furthermore, the role of human livelihoods in perpetuating environmental degradation and the consequences of these consumptive lifestyle strategies for the provision of ecosystem services is what sustainability science specifically has to address. This is why it is important not to envision a system where the human and natural systems are self-contained and separate, but instead are overlapping and encapsulated by one system. These issues must also be considered at multiple scales, including individuals, households, villages, towns, cities, and watersheds, while bearing in mind all the potential feedback mechanisms of resource management decisions over time. In this way, the livelihoods framework, which includes both scale and time, reminds researchers that there are both temporal and spatial impacts that have to be assessed.

The livelihoods framework does not provide guidance for how to outline hypotheses; however, we consider this to be advantageous, because it forces the conceptualization of interdisciplinary questions. For instance, to understand the availability, reliability, and quality of drinking water in rural communities, a major issue in the Greater Kruger SES, scientists can develop hypotheses across disciplines that can be tested only with a combination of social and ecological methodologies. One potential hypothesis is that the present water shortages and poor reliability of water distribution systems is influenced by lack of communication among local governing agencies and stakeholder groups in the region, but future availability will be mostly a function of ecological limitations imposed by climate change. These types of questions and hypotheses being addressed in the rural/urban communities along the western border of KNP need to be imagined globally.

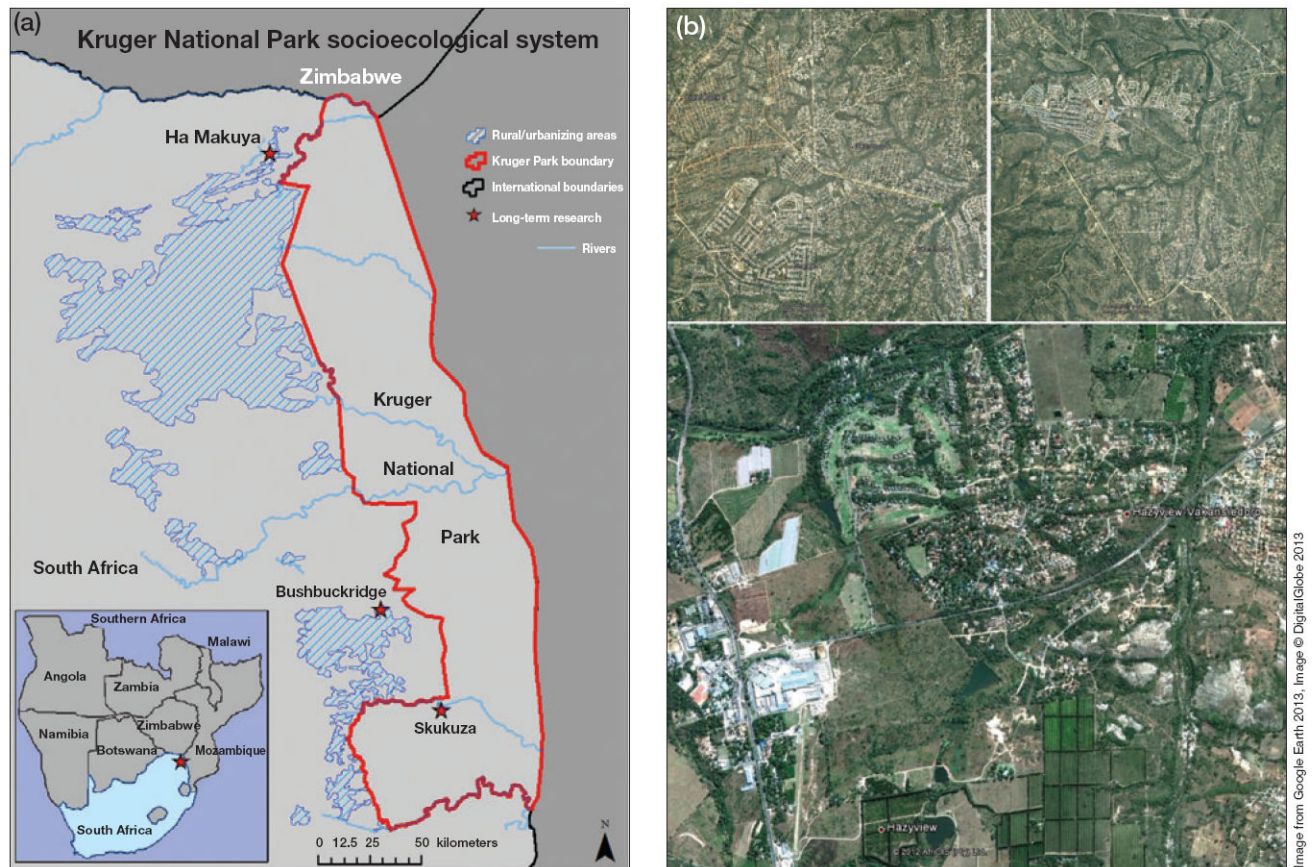


Figure 1.

(a) The greater Kruger National Park (KNP) socioecological system, South Africa, displays complex dynamics between one of the world's largest conservation areas and neighboring "poverty nodes" that have their origin in older, deliberately underdeveloped resettlement regions, established during the apartheid era (map created by S Beck). (b) Aerial image showing the rural/urban land cover along the western boundary of KNP.



Figure 2.
Half-built homes in a rural Vanda community exemplify the staggered development that occurs in areas that depend on money sent home by migrants.

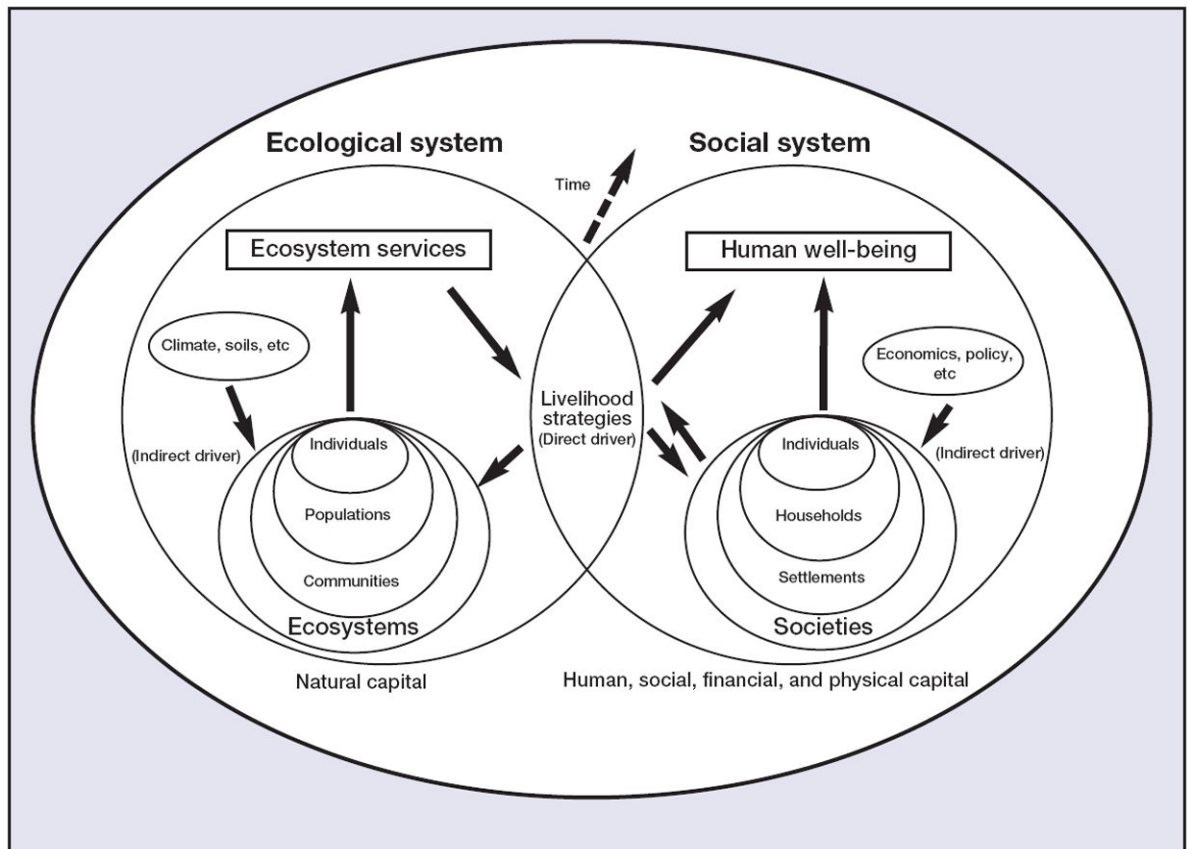


Figure 3.

A theoretical framework developed by Twine and others for a research program called “Sustainability in Communal Socio-Ecological Systems” in the rural district of Bushbuckridge, South Africa. This framework integrates SES theory with that of the sustainable livelihoods framework (DFID 1999).



Figure 4. Residents living in Skukuza, Kruger National Park, have artificially extended the riparian zone adjacent to their community. Two different socioeconomic status housing facilities can be distinguished: one with high vegetation cover and a golf course (upper left), and the other exhibiting high-density housing and sparse vegetation cover, called the workers’ “compound” (lower right).



Figure 5.

Examples of landscape preferences where water availability is the major limitation on the cultivation of plants in home gardens. (a) Protection of valuable indigenous trees such as marula (*Sclerocarya birrea*) in yards and cultivated fields is a hallmark of these landscapes. (b) Soil sweeping used to maintain clean common areas also serves as a visible cue that the residents care about the surrounding landscape and environment. (c) Bricks and other materials are used in landscape design. (d) Higher socioeconomic status households will add lawns to their landscapes, despite water limitations.