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Land-use, landscape management and environmental services in the Mountain Mainland Asia: Introduction

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Abstract: Mountain ecosystems cover about one-quarter of the earth's surface, and support a diverse range of ecosystems and life-forms. These mountains provide essential environmental services, useful products and also serve as the world's water towers. Asian continent comprises a vast complex of mountain ranges around Tibetan Plateau known as the Mountain Mainland Asia (MMA). The MMA extends in the south by the Himalayan arc, by the Pamir in the west, the Tian Shan in northeast and the complex of mountain ranges in the east. More than ten major rivers originate from MMA including the Tarim, Indus, Ganges, Brahmaputra, Irrawaddy, Salween, Mekong, Hong (Red River), Yellow River and Yangtze. These river systems provide ecosystem goods and services that sustain the lives and livelihoods of people in Asia both those living in mountains and plain areas of the basins. This introductory paper discusses on understanding the land use changes and ecosystem services also considering the transition from the changing market economies in the region. Impacts of driving forces especially on conservation and development, and challenges faced by the region are presented. Examples of landscape management approaches demonstrating the ecosystem services and livelihoods of the mountain peoples are illustrated. Lastly, the paper explores the possibilities of payments for ecosystem services especially on sustainable land-use management and conservation linked strategies and development.

Resumen: Los ecosistemas de montaña cubren alrededor de una cuarta parte de la superficie de la tierra y sostienen una gama diversa de ecosistemas y formas de vida. Estas montañas brindan servicios ecosistémicos esenciales, productos útiles y también funcionan como las torres de depósito de agua del mundo. El continente asiático comprende un vasto complejo de cadenas montañosas alrededor de la Meseta Tibetana conocido como las Montañas de Asia Continental (MAC). Las MAC se extienden por el sur a través del arco de los Himalaya, por el Pamir en el oeste, el Tian Shan en el noreste y el complejo de cadenas montañosas en el este. Más de diez grandes ríos se originan de las MAC incluyendo el Tarim, el Indus, el Ganges, el Brahmaputra, el Irrawaddy, el Salween, el Mekong, el Hong (Río Rojo), el Río Amarillo y el Yangtze. Estos sistemas fluviales proporcionan bienes y servicios ecosistémicos que sostienen la vida y los medios de subsistencia de la gente en Asia, tanto de los que viven en las montañas como de los que habitan en las partes bajas de las cuencas. En este artículo introductorio se discute acerca del entendimiento del cambio de uso del suelo y los servicios ecosistémicos, considerando también la transición de las cambiantes economías de mercado en la región. Se presentan los impactos de las fuerzas directrices cobre la conservación y el desarrollo, así como los retos que experimenta la región. Se ilustran ejemplos de enfoques para el manejo del

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paisaje que demuestran los servicios ecosistémicos y los medios de subsistencia de la gente de las montañas. Finalmente, el artículo explora las posibilidades de pagar por los servicios ambientales, especialmente a partir de estrategias que liguen la conservación y el manejo sustentable del uso del suelo con el desarrollo.

Resumo: Os ecossistemas de montanha cobrem cerca de uma quarta parte da superfície terrestre e suportam uma gama diversa de ecossistemas e formas de vida. Estas montanhas providenciam serviços ambientais essenciais, produtos úteis e também funcionam como torres de abastecimento de água do mundo. O continente asiático compreende um complexo vasto de cadeias montanhosas ao redor da Meseta Tibetana conhecida como as Montanhas da Ásia Continental (MMA). As MMA estendem-se para o sul através do arco dos Himalaia, para o Pamir no oeste, o Tian Shan para noroeste e o complexo de cadeias montanhosas para este. Mais de dez grandes rios têm origem nas MMA incluindo o Tarim, o Indus, o Ganges, o Brahmaputra, o Irrawaddy, o Salween, o Mekong, o Hong (Rio Vermelho), o Rio Amarelo e o Yangtze. Estes sistemas fluviais proporcionam bens e serviços ambientais que suportam a vida e os meios de subsistência dos povos na Ásia, tanto os que vivem nas montanhas como os que habitam nas partes baixas das bacias. Neste artigo introdutório discute-se quanto ao entendimento das mudanças do uso do solo e dos serviços ambientais, considerando, também, a transição das mudanças nas economias de mercado da região. Apresentam-se os impactos das linhas de força especialmente na conservação e desenvolvimento, assim como os desafios que a região enfrenta. São apresentados exemplos de alternativas de gestão da paisagem demonstrando os serviços ambientais e meios de subsistência dos povos de montanha. Finalmente, o artigo explora as possibilidades de pagamento dos serviços ambientais, especialmente a partir de estratégias que liguem a conservação e a gestão sustentada do uso do solo com o desenvolvimento.

Key words: Agroforestry, conservation, economic development, forest transition, landscape approach, protected areas.

Introduction

Asian continent comprises a vast complex of mountain ranges around Tibetan Plateau known as the Mountain Mainland Asia (MMA). The MMA extends in the south by the Himalayan arc, by the Pamir in the west, the Tian Shan in northeast and the complex of mountain ranges in the east. More than ten major rivers originate from MMA including the Tarim, Indus, Ganges, Brahmaputra, Irrawaddy, Salween, Mekong, Hong (Red River), Yellow River and Yangtze. About 250 million people inhabit the MMA and nearly 1.5 billion people in Asia depend, directly or indirectly, on mountain ecosystem services for freshwater, hydropower, watershed services and other livelihood activities. Maintaining healthy ecosystems and associated services is the main challenge faced in the development of the region. Globalization and environmental change is an underlying driver of land use changes and the transition towards urbanization, commoditization and regionalization (Moseley 2006; Xu 2006). These changes have raised questions on the sustainability of livelihoods of the mountain people and at the same time posed serious concerns on the availability of ecosystem's services in the region.

The MMA spreads over a wide spectrum of ecological zones having a diverse socio-economic potential. It harbours four of the world's 34 biodiversity hotspots, with an array of unique plants and animals of global importance (Myers *et al.* 2000). Furthermore, the glaciers, wetlands, rangelands and forests of the MMA sustain many rivers which are the lifeline of downstream provinces and countries. These landscapes provide valuable ecosystem services not only in the form of supply and purification of water, but also in the form of provisioning, supporting and regulating

services such as production, soil retention, climate regulation, and carbon sequestration and as reservoirs of pollinators, natural predators and others. Pastoralism, agro-pastoralism, mixed farming systems, shifting cultivation and commercial cash crop cultivation including plantations are the five major farming systems operative in the region (Sharma & Kerkhoff 2004).

There is an increasing debate in the region about the need to balance possible over-exploitation of the natural resources against the sustainability of the MMA's ecosystem services. Rising population and consumption will drive competition for diminishing resources, requiring trade-offs between ecosystem goods and services among different stakeholders at different scales. Land use decision-making is politically and economically driven; therefore, to understand these issues, it is necessary to identify and quantify the links between changes in land use, ecology, and socio-economic situation (Xu *et al.* 2006).

This special issue of *Tropical Ecology* comprises of papers that deals with the central theme on "Land Use Change, Landscape Management and Environmental Services in Asian Mountain Ecosystems" for understanding the process of change and impacts. These papers were presented and discussed during the Symposium organized as part of the Conference of the "Association for Tropical Biology and Conservation (ATBC)" in July 2006 at Kunming, China. Rapid transformation of the region resulting from globalization and land use changes are challenges demanding multi-disciplinary approaches. Articles in this issue focus on transformations, transitions, conservation approaches and ecosystem services of land use and land management systems of the MMA region.

Land use change and consequences

Land use change has been one of the major concerns on the global change analysis. Land use and cover change (LUCC) research is an important component in the study of global environmental change. Land use pattern and land cover changes affect the structure and function of ecosystems, altering the movement of soil, water and nutrients. Changes at the local and regional scales ultimately contribute to global processes (Houghton 1994; Vitousek *et al.* 1997). LUCC is influenced by geophysical, socio-economic, and institutional factors, with the scale and intensity of human impact dramatically increasing over the last few decades (Ediger & Huafang 2006). The global land use and land cover change trend is evident in the MMA region and consequences of change show distinct impact in the region both in terms of structural and functional alterations influencing on the delivery of ecosystem services.

Land use changes both in-terms of pace and intensity have tremendously increased during the 20th century, and more rapidly over the past 3 decades because of climate change and increasing human activities, including migration, land conversion to other usage and agricultural intensification (Lambin & Geist 2006). Land use transitions are pervasive at a variety of spatial and temporal scales; they significantly affect ecosystem services and thus livelihoods, economics, and trade policies. To understand current changes and predict future ones, it is essential to adopt a long-term view of land use history. For these reasons it is necessary to consider the mechanisms of transitions, both environmental and economic. Land use and forestry transition theory derives from the notion of 'environmental Kuznets curves' that predict non-linear transitions in resource use as incomes rise over time (Xu *et al.* 2006). The forestry transition theory posits that over time, forest cover exhibits a U-shaped curve: an initial decline in forest cover due to deforestation is later reduced, offset, and eventually outweighed at some point by forest recovery and secondary forest expansion. Mirroring this, agricultural expansion may initially rise, but later starts to decline through increasing agricultural adjustment to land quality technological improvements. Such transitions now seem to be occurring rapidly since 1990s: forest areas have reportedly expanded in many countries including in MMA region (Rudel *et al.* 2005).

The economic growth and forest transition in China has geopolitical implications beyond the national boundary (Grumbine 2007). Converting arable land to urban construction and tree plantation directly affects domestic food security with the potential to influence global commodity markets. China imported substantial animal feed during 1999-2003 from South America, such imports have potential implication to land

use/cover in the countries outside China like in biodiversity rich Amazon (Brown *et al.* 2005). Free trade can export the impacts of one nation's timber consumption to another nation that harvests the timber (Mayer *et al.* 2005). With the implementation of "Natural Forest Protection Programme" or logging restrictions in 1998 and tariff reductions on forest products in 1999, China's annual timber product imports from Myanmar have more than tripled between 1997 and 2002 (Kahrl *et al.* 2005; Sun *et al.* 2004). Open market economies and free trade can have direct influence on land use regionally and globally.

In this issue we find papers describing that MMA region have experienced wide-spread and dramatic land use changes. Land use transition from traditional use to plantations and other forms are also evident in the MMA region (Kerkoff & Sharma 2006). Deforestation, agricultural expansion, conversion to plantations (e.g. rubber), urbanization, export and import of forest based and agriculture products, and more recently re-forestation have resulted from changing government policies and modernization. Such changes are exemplified by Nepal's devolution policies for community forestry, and China's push to develop industry and become more self-sufficient in natural resources. Some of these examples are elaborated in this issue by papers on watershed management, land use transitions and land use change systems especially describing rubber plantations in China and policy changes.

Landscape management: Paradigm shift in conservation

Globally, protected areas alone are proving to be inadequate to effectively conserve the Earth's biodiversity, including species, communities, and ecological processes and services. More than 102,000 protected areas have now been established worldwide, covering 11.5% of the global land area, against IUCN's target of 10% of the terrestrial habitat (Chape *et al.* 2003). In Asia alone there are 5,305 IUCN level protected areas and 3.712 national level protected areas, covering a total of 4,281,155 km^2 accounting for 10% of Asia's total landmass (WDPA 2005). However, this target still does not include or represent many ecosystems or adequate areas within them (CBD 2004). Due to their isolation in fragmented habitats, poor management, and lack of monitoring, the effectiveness of protected areas for global biodiversity conservation has also been questioned (Brooks *et al.* 2002; Rodrigues *et al.* 2004). This indicates that the conservation measures taken to safeguard biodiversity for its sustainability are ineffective and not sufficient (Chape *et al.* 2005). Moreover, it also reveals that the conservation of biodiversity through establishment of protected areas with conventional regulatory mechanisms alone is ill-suited in developing countries due to the higher dependency of rural communities on these resources for their subsistence economy (Chettri & Sharma 2006a; Maharana *et al.* 2000; Nepal & Weber 1995).

Communities living in remote biodiversity rich areas are economically, physically, and socially vulnerable. As a result, landscapes are under acute pressure (Chettri & Sharma 2006 b). This is an important factor to be considered for effective conservation measures. However, conservationists to date have often been reluctant to incorporate land occupied by people into conservation plans because of social disputes and the associated cost of managing conflicts (Bawa *et al.* 2004; Nepal & Weber 1995). The conservation initiatives taken so far are often ecologically oriented and ignored social driving forces and the relationship between conservation and human needs (Chettri *el al.* 2002). Since most of the protected areas in the developing countries are either inhabited or neighbouring people are dependent on them for their subsistent livelihoods, the conventional exclusionary approach has endangered profound social costs to the link between human dependency with environmental degradation and biodiversity loss (Ives 2004; Myers *et al.* 2000; MEA 2005). Therefore, it is recently realized that the balance between natural habitats and human needs at a landscape level has become necessity to determine the sustainability and effective conservation of biodiversity (McNeely 2004; Vanclay *et al.* 2001).

Landscape level biodiversity conservation is an evolving concept and an important paradigm shift in the global conservation scenario (CBD 2004; Smith & Maltby 2003). The beauty of the landscape approach in conservation is that it involves all levels of stakeholders, including local communities, in conservation efforts in hopes of

ensuring that they benefit to make 'conservation' truly sustainable (Bennett 2003; McNeely 1999).

In the Hindu Kush-Himalaya we have seen some initiatives of landscape conservation developing recently. Tarai Arc Landscape, Sacred Himalayan Landscape and Kangchenjunga Landscape have received concerted efforts in developing approaches for balancing conservation and economic development (Chettri *et al.* 2007; Gurung *et al.* 2006; GON/MFSC 2005).

This special issue while dealing with the landscape management approaches gives examples of Kangchenjunga Landscape and Bhutan Biological Conservation Corridors. Results of these two initiatives in the MMA are shared where we will find that landscape approach provides opportunity to adapt to climate change and in enhancing the ecosystem services.

Ecosystem services for human wellbeing

During the last few decades, human activities have dramatically altered natural ecosystems due to the increasing demand for food, fresh water, energy and other resources (Daily 2000; Galloway *et al.* 2003). Activities such as clearing forests, practicing subsistence agriculture, intensifying farmland production, or expanding urban centers are having large impacts on ecosystems (Foley *et al.* 2005). Several decades of research have shown that how land use can impact the environment. The changes that land use can have range from minor modifications of the local ecosystem to far reaching impacts on the global atmosphere.

Human 'wellbeing' is a multifaceted quality that encompasses: good life, health, good social relations, security and freedom of choice and action all of which ultimately depend on sustained ecosystem services and contribute to political stability. These ecosystem services can be subdivided into four types such as supporting, provisioning, regulating and cultural (MEA 2005). Until recently these ecosystem services were available in sufficient abundance, however, the growing environmental pressure are causing rapid degradation and depletion.

The conversion of forests into other forms of land use has been the general trend in mountainous areas. Such changes in land-use have been conspicuous in recent decades in the Hindu Kush-Himalayan region (Rai *et al.* 1994). Forest-dominated watersheds have been converted into agrarian watersheds. This type of conversion was induced by increasing population pressure and the limitations of productive agricultural land (Rai & Sharma 1998). The goal of forested watershed and landscape management is the rational utilization of land and water resources for optimal production, with minimal disturbance to natural resources (Chettri *et al.* 2007; Sundriyal *et al.* 1994). Land management in the catchment areas and watersheds in a mountainous region like the Himalayas, essentially relates to the ecosystem services that the area provides to the mountain people and downstream population. Such ecosystem services specifically involve the conservation of soil and water by proper land-use, protecting the land from deterioration in soil quality, conserving water for drinking and other farm uses, thereby achieving the optimum productivity of land-uses (Sharma *et al.* 1992). Soil without tree cover on steep upland farming systems, such as those associated with more intensive agricultural practices, is vulnerable to soil erosion and reduced soil fertility (Rai & Sharma 1995). The recent challenges in the field of sustainable development are linked to the degradation caused by large-scale land use and the transition towards meeting the growing demand for food and other services.

The majority of the population who depend on forests and tree resources in the MMA region for their subsistence have become vulnerable. In such a situation, agroforestry offers multiple opportunities to farmers, while also improving farm production and income, and providing productive and protective forest functions. In this special issue a paper on alder based cardamom agroforestry provides an example on how agroforestry can contribute to ecosystem services in transforming forested landscapes.

There is a need for enhancing expertise and human resources, institutional (formal and informal) capacities and partnerships on ecosystem services in the region. The ecosystem services demands more multidisciplinary and integrated approaches which needs to be programmed in the region. Examples of good payment schemes for ecosystem services in the region is limited for up-scaling, therefore, more piloting would be required. Guidelines, policies

and legal instruments specifically supporting ecosystem services have to be developed for accruing more benefits in the region.

Conclusions

The Mountain Mainland Asia is very rich in natural resources, scenic beauty, diversified people and their culture, and provider of enormous values and services to the human well being. Environmental change in the region is affecting the livelihoods of its people, as well as impacting ecosystems downstream and the lives and livelihoods of inhabitants there. The role of the MMA in providing climatic, environmental and natural resources for the region and the world is under threat. Intervention is needed to sustain this region and its people. Land use change and land management transition are the major trend that the region is facing primarily by bringing policy changes. In many cases traditional land use systems are transformed into commercial plantations or other forms that in general have shown negative impacts. However, there are examples of policy supporting the devolution of natural resources management to communities that positively impacted in bringing back the forests. The community forestry in Nepal is an excellent example. Economic development and off-farm opportunities are one of the pathways facilitating forest transition in China. Biodiversity conservation and services generally have been achieved by creating protected areas and in recent years it is realised that the approach is not effective for being people exclusionary. Instead, the landscape approach of conservation is becoming a popular approach for linking conservation with economic development where participatory processes are encouraged. Applied research on biodiversity conservation, valuation of services, payments for ecosystem services and landscape management are the emerging areas and interest for the future.

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