Re-imagining the Rural-Urban Continuum

Research Gap Assessment

by
The Desakota Study Team

Re-imagining the Rural-Urban Continuum

Re-imagining the Rural-Urban Continuum

Understanding the role ecosystem services play in the livelihoods of the poor in desakota regions undergoing rapid change

Research Gap Assessment

by
The Desakota Study Team

August 2008

Published in August 2008
by
Institute for Social and Environmental Transition - Nepal (ISET-Nepal)
GPO Box 3971, Kathmandu, Nepal. Tel: 977-1-5528111, 5542354, Fax: 977-1-5524816
E-mail: iset@wlink.com.np
for
the Desakota Study Team consisting of research partners from:
Institute for Social and Environmental Transition - Nepal (ISET-N), Institute for Social and Environmental Transition - International (ISET-International), Boulder, Colorado. USA; King's College London, Department of Geography, London, United Kingdom; Centre for Global Change (CGC), Dhaka, Bangladesh; Chinese Academy of Agricultural Sciences (CAAS), Beijing, China, Institute of Agricultural Economics and Development, Beijing, China; Institute of Agricultural Resources and Regional Planning, Beijing, China; Institute for Social and Environmental Transition (ISET-Pakistan); International Centre for Tropical Agriculture (CIAT), Cali, Colombia; Rhodes University, Consortia for Ecosystem Services and Poverty Alleviation in Sub-Saharan Africa, Grahamstown, South Africa; University of Cape Town, Department of Historical Studies, Cape Town, South Africa; and Winrock International India, Delhi, India.

ESPA Study Conducted for
NERC, DfID, ESRC
UK

Citation as:
DST, 2008: Re-imagining the Rural-Urban Continuum: Understanding the role ecosystem services play in the livelihoods of the poor in desakota regions undergoing rapid change. Research Gap Analysis prepared by the Desakota Study Team (DST) for the Ecosystem Services for Poverty Alleviation (ESPA) Program of Natural Environment Research Council (NERC), Department for International Development (DfID) and Economic and Social Research Council (ESRC) of the United Kingdom. Published by Institute for Social and Environmental Transition-Nepal (ISET-N), Kathmandu, Nepal.

Pages 124
ISBN: 978-9937-8019-1-1

Layout design: Format Graphic Studio, Naxal Kathmandu
Cover Photo by Fawad Khan: Woman entrepreneur with donkey cart and mobile phone selling straberries in Lahore, Pakistan.

Contents

Executive Summary **i**
Objectives and Methodology i
Desakota Concepts ii
Ecosystem Science ii
Desakota, Ecosystems and Poverty iii
Points of Entry For Change iv
Research Themes iv
Research Entry Points ix
Audiences and Communication Strategies xi

1. Introduction **1**

2. About the study **3**
2.1 Purpose and Objectives 3
2.2 Methodology 3
2.3 Structure of the Report 5

3. Desakota **7**
3.1 The Concept 7
3.2 Desakota Criteria 12
3.3 The Drivers of Desakota Dynamics 15
3.4 Desakota in the Regions 18
3.5 Thematic Lines of Enquiry 23

4. The Ecosystem Context and Relationship to Desakota **25**
4.1 Ecosystems: Linkages Across Scales 27
4.1.1 Vegetation and Land Cover Change 28
4.1.2 Land use, Water Stores, and Flow Regimes 30
4.1.3 Water-related Diseases 34
4.2 Institutions and Desakota 36
4.3 The Informal World 43
4.4 Thematic Lines of Enquiry 47
4.4.1 Environmental Science Research Needs: 47
4.4.2 Institutions Managing Ecosystems Research Needs: 47

***5*. Desakota, Poverty and Ecosystems Services** **49**
5.1 Rethinking Poverty 49

5.2 Themes in the Ecosystem Services and Poverty Nexus 52
5.2.1 Decreasing access to provisioning services: 54
5.2.2 Increasing exposure to health and disaster risks 56
5.3 Translation on the Ground – Field Cases 58
5.4 Thematic Lines of Enquiry 62

6. Critical Research Gaps and Priorities 63
6.1 Lines of Enquiry 63
6.1.1 Critical Thresholds in Interlinked Socio-ecological Systems 64
6.1.2 Natural Systems under Stress in Desakota Regions 66
6.1.3 Economics of Ecosystems and Poverty 68
6.1.4 Knowledge Systems 69
6.1.5 Drivers of Desakota 71
6.1.6 Understanding Cross-Scale Impacts, Vulnerabilities & Opportunities 72
6.1.7 Desakota and Poverty 75
6.1.8 Governance and Institutions 78
6.2 Points of Entry for Change 80
6.3 Audiences and Communication Strategies 83

7. Conclusion 85
Postscript: Cape Town Review 87
References 89
Desakota Study Team and their Institutions 100
Acknowledgements 102

List of Tables, Figures and Boxes

Table 1: Matrix Comparison of Desakota Regions 19
Table 2: Linkages Between State Changes in Water related Ecosystems and Human Well-being 26
Table 3: Comparative Matrix of Conditions in Case Areas 59

Figure 1: Rural Penetrating the Urban 5
Figure 2: Desakota: the co-penetration of rural and urban systems. 8
Figure 3: Desakota: shapes intervening processes in socio-ecological systems 8
Figure 4: Ecosystem Services and their links to Human Well-being (MEA, Reid *et al*. 2005) 9
Figure 5: Conceptual Framework of Interlinkages in the Desakota Phenomenon 11
Figure 6: Daily Migrant Woman: selling strawberries in Lahore Pakistan 13
Figure 7: The Expanding Road Network of West Africa 15
Figure 8: Transiting to High Value Vegetable Economy 24
Figure 9: Pishin-Quetta-Mastung Corridor: schematic representation of the reach of urban formal and rural informal/customary institutions 36
Figure 10: Diesel Imperialism 38
Figure 11: Contribution of Remittances to Household Income (x109 NRs) 51
Figure 12: The Transformation of Ecosystem Services: farm soil being baked into bricks for export to urban development in Kathmandu, Nepal 53
Figure 13: More Expensive by the Liter for the Poor 55
Figure 14: Fuelling Desakota Transportation 73
Figure 15: Stinky Weed *neelgandhey* 74
Figure 16: Technological Innovation 79

Box 1: Changing Resource Demands and Ecosystem Stress 10
Box 2: Water Quality and Desakota in Bangladesh 18
Box 3: Increased Industrialisation Causing Pollution Problems 32
Box 4: Water Mining in Balochistan 33
Box 5: Technological and Institutional Transitions: water resources under desakota conditions in Balochistan province of Pakistan 39
Box 6: Tanzania: changing notions of community management 40
Box 7: Governance, Management & Institutions in Miyun Basin, China 43
Box 8: Marginalizing the Informal Sector in Tanzania 45
Box 9: *Kodonomics* 45
Box 10: Changing Perception of Poverty along the Mustang-Gorakhpur Corridor in Nepal 50
Box 11: Bangladesh Fixed Income Poor 54
Box 12: Vulnerability, Poverty, and Disaster Risk in Desakota Areas 57

PART II

(These Sections of Part II are large and are provided only in electronic form)

A. Reinterpreting the Urban-Rural Continuum

B. Vulnerability, Disasters, and Poverty in Desakota Systems

C. Natural Science Global Literature Review

1. Introduction
2. Ecosystem Services
3. Global Scale
4. Regional Scale
5. Meso Scale
6. Research Needs

D. Social Science Global Literature Review

E. Regional Literature Reviews

1. Sub-Saharan Africa
2. China
3. Amazon/Andes

F. Case Studies – Field Based

1. Satkhira-Khunla-Jessore-Dhaka (Bangladesh)
2. Sabarmati Basin (Gujarat, India)
3. Mustang-Gorakhpur (Nepal/India)
4. Pishin-Quetta-Mastung (Balochistan, Pakistan)

G. Case Studies – Literature Based

1. Mwanza, Tanzania, Sub-Saharan Africa
2. Miyun Basin, China
3. Fuquene Watershed, Colombian Andes
4. Peruvian Amazon

Acronyms

DfID	Department for International Development (of the United Kingdom)
ESRC	Economic and Social Research Council (of the United Kingdom)
ESPA	Ecosystem Services and Poverty Alleviation
FAO	Food and Agriculture Organization
FMIS	Farmer Managed Irrigation Systems
GHG	Greenhouse Gas
HIV/AIDS	Human Immunodeficiency Virus/ Acquired immune deficiency syndrome
IDP	Internally Displaced People
IPCC	Inter-governmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
LAC	Latin America and Caribbean
MEA	Millenium Ecosystem Assessment
NEPAD	New Partnership for Africa's Development
NERC	Natural Environment Research Council (of the United Kingdom)
NFRE	Non-Farm Rural Employment
NGO	Non-Governmental Organization
NRs	Nepali Rupees
NTFPs	Non-Timber Forest Products
PES	Payment for Ecosystem Services
REDD	Reducing Emissions through Degradation and Deforestation
SEPA	State Environmental Protection Administration
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESC	United Nations Economic and Social Council
UNFCCC	United Nations Framework for the Convention on Climate Change
WEAP	Water Evaluation and Assessment Planning
WHO	World Health Organization

Executive Summary

In many parts of the world the relationship between ecosystems and livelihoods is changing in fundamental but poorly understood ways as economic systems diversify across the urban-rural spectrum creating what we call mixed-economic "desakota" systems. Understanding these changes and their implications for vulnerable populations, particularly the poor, is essential to inform policy and action at all levels. Specifically, over the coming decades, two interacting forces will influence ecosystems services and their role as a foundation for livelihood systems across developing countries: (1) *Intensifying processes of technological and economic globalization*. These processes are increasing pressures on ecosystems while, at the same time, often shifting patterns of dependency on ecosystems from the local to more global levels; and (2) *Environmental degradation at all levels from the local to the global scale including the impacts of climate change*. These changes will undermine the ability of coupled ecological and social systems to provide critical services.

These forces are reshaping the livelihoods of vulnerable populations, particularly the poor who are often the most directly dependent on water-dependent ecosystem services. They are also reshaping both the pressures on ecosystems and the nature and effectiveness of institutions for their management. As a result, dynamic research strategies to generate new knowledge coupled with effective mechanisms for interactive experiential learning are essential to inform and enable responsive and effective development, environmental management and poverty alleviation strategies.

Objectives and methodology

The purpose of this study is to increase understanding of the relationships among patterns of global economic and demographic changes, the nature of ecosystems services, and the role of such services in increasingly interlinked urban/rural livelihood systems, particularly those of the poor. Our objective is to inform DfID, NERC, ESRC and other actors regarding specific knowledge, experience and capacity gaps where a strategically targeted research program could have a major impact on the ability of society to address poverty through maintenance of ecosystems and the services they provide. Methodologically, our approach involves a combination of extensive global and regional literature reviews combined with detailed case studies. We focus particularly on water-based ecosystem services. Water is a crucial part of ecosystem services, not just as a resource but as a contributor to climate, chemical and biological systems. Complex spatial and temporal interactions within hydrological systems mean that pressures imposed at any one place or point in time can be propagated through the system and may have implications for future ecosystem function over varied spatial scales. We therefore use water as an entry point for studying the relationship between desakota development and ecosystem services.

Desakota Concepts

We argue here that it is in the mixed-economy region between "rural" and "urban," captured by the Bahasa Indonesia term "desakota" (meaning village-town), where the trends in ecosystem stress can best be observed (McGee, 1991). These regions are linked to major urban centres by cheap transport axes where much more intense commercial agricultural and non-agricultural economic activities take place than in purely rural areas. The desakota phenomenon encompasses more than the term "peri-urban." It refers to closely interlinked, co-penetrating rural/urban livelihoods, communication, transport and economic systems. Desakota systems occupy, and radiate out from a spectrum of conditions that have purely urban and purely rural as the two extreme ends. The characteristics of this emergent mixed economy have fundamentally changed the context in which both formal and informal institutions for environmental management and service delivery have evolved, often leading to their decline or undermining their effectiveness. In many cases it has also fundamentally changed the proximate relationship between livelihoods and ecosystems. Where populations were once dependent on locally produced food, now prices and access reflect global markets and conditions in distant ecosystems.

A number of macro-level drivers appear to be fuelling the desakota phenomenon. The extension of transportation and communication systems, improved access to energy and more affordable private and public transport have allowed penetration of economic and other networks into previously remote areas at an increasing rate, facilitating space-time collapse. Enabling the movement of goods, people, information and finance between sites of production and consumption has strengthened linkages between product and labour markets in desakota systems. As these "pull" factors grow, "push" factors driving populations out from both rural areas and urban centres are also intensifying. Conflicts, whether the harsh day to day friction found in decaying urban cores and slums or the large wars and lower intensity conflicts that have spread over many rural areas, have been a major catalyst pushing people to migrate and seek opportunities elsewhere. In addition, climate-related changes of lower and more variable precipitation, increases in the intensity or frequency of extreme weather events, and changes in temperature leading to water-stress, flooding and changes in vegetation will negatively impact agro-ecosystems and drive migration and economic diversification.

Ecosystem Science

Expanding desakota systems and associated land cover changes feedback into climate change, at least at the regional scale, and also tend to concentrate pressures on ecosystems and the services they provide. Water-related ecosystems in many peri-urban or mixed economy areas are subject to severe pressure from a combination of agricultural, local non-farm and urban demands. This pressure stems from fundamental changes in land use, increasing demands for water and increasing pollution from all sectors.

Since the desakota phenomenon is characterised by major changes in the nature, intensity and spatial pattern of land use, it has far-reaching implications for surface-atmosphere interactions that could significantly accentuate biome shifts and severely impact on water-related ecosystem services within and between biomes, and across spatial scales from entire ESPA regions to small catchments. In particular, the changes in land use and intensity mosaics, water resources, and

water quality that typify desakota areas alter all key environmental processes at the catchment level. These desakota effects cascade from catchment to floodplain to river channel, severely impacting water-related ecosystem functioning and services.

Basic scientific research is required to understand these water ecosystems changes and their implications for health, food security, physical security and socioeconomic aspects of human well-being. Particularly critical questions involve the resilience of regional hydro-ecological systems and how they will respond to the complex desakota dynamics of mixed, often patchy, land use, mixed livelihoods and rapid rates of change. Critical management questions that emerge from this emphasize, at the local and river basin scale, strategies for maintaining landuse mosaics, surface and groundwater systems, and river-floodplain connectivity, in ways that maintain critical ecosystem functions. Management questions also involve the increasing dependence of local populations on services produced by distant ecosystems. Understanding of heterogeneity, thresholds and tipping points within interconnected ecological, economic and social systems represents a fundamental challenge for basic scientific research.

The rate of adaptation of institutions often falls behind those physical changes occurring in ecosystems in desakota environments. Existing formal and informal resource management institutions become less effective in these dynamic conditions with severe ecosystem pressures. In desakota areas, traditional resource management institutions may be declining as people, activities and products are increasingly mobile and separated from the condition of local ecosystems. Reach of formal management institutions becomes limited in the chaotic desakota environment. As a result, intermediary market institutions take on more predominant roles in provisioning of ecosystem services, such as local water markets. Research is required to identify and develop pro-poor and effective institutions to manage ecosystems, and the flow of ecosystem goods and services at local and global levels.

Desakota, Ecosystems and Poverty

The desakota context forces changes in perceptions of who are considered 'poor'. Economic measures such as the $1/day income standard do not capture the multiple factors that influence poverty, and are only weakly related to the factors that enable or constrain the ability of individuals and households to move out of poverty. Why people are viewed or view themselves as "poor" often can be tangibly related to specific causes that may range from household structure to education or access to common lands or common institutions. This broadening of perspective on poverty may assist in identifying more effective avenues for poverty alleviation that, while partially related to increases in income *per se*, needs to encompass a much broader set of definitions suited to local social and environmental contexts.

While desakota economies offer pathways out of poverty for some, development in desakota areas may exacerbate poverty and inequalities, particularly in relation to ecosystem services for others. Aggregated at a macro level, economic intensification and increased mobility in desakota environments may represent a critical nexus where energy use contributes substantially to greenhouse gas emissions with all the attendant implications climate change has for poverty around the globe. More locally, the intensification of industries and rapid processes of

urbanization are leading to increasing demands on and decreasing quality of, water- and forest-based ecosystems, limiting accessibility by the poor, and also the relatively wealthy who rely on resources to meet their livelihood needs. The implications of environmental and economic shocks on poverty are also changing as populations depend on distant ecosystems and second-order linkages for critical products such climate regulation, water supply and food.

More research is required to better understand these dynamic interconnections between poverty and ecosystem services in desakota environments. However, based on our analysis to date, we can begin to identify direct implications for poverty, particularly related to decreasing access to provisioning services, and increased exposure to health and disaster risks. In desakota contexts, access by the poor to essential water, food, fuel, fodder, fibres and medicines from ecosystems to meet daily livelihood and income needs is decreasing, exacerbated by lack of secure tenure. In addition, perhaps more so than in rural areas, in desakota environments intermediary market institutions are emerging to provide ecosystem goods, with significant implications for the accessibility and affordability of water, food, and other provisioning services by the poor.

Desakota development also is influencing regulating water-based ecosystem services, such as flood control, disease regulation, and filtering of pollutants. As a result, desakota induced environmental degradation is increasing health problems and exposure to disaster risks. Some areas, such as marginal flood plains, may also be sites of industrial or waste disposal, exacerbating health problems and disaster risk. Vulnerability of the poor may also be increasing in desakota environments as lack of secure land tenure and increasing market value of land lead further to marginalization, at times forcing the poor to shift to more hazardous geographical locations. Lack of political organization and bargaining power may add to vulnerabilities. Hence, development research also needs to consider mechanisms and conditions that may enhance agency, political representation or collective action within the dynamic and highly mobile social contexts that characterize desakota environments that may enable the poor to negotiate or lobby for rights and access to quality ecosystem services.

Points of Entry For Change

Where do insights from the ground realities of the case studies and the review of literature for understanding the linkages between poverty and ecosystem services under desakota lead? The research themes discussed and bulleted out below have been extracted from the larger integrated analysis discussed in detail within different chapters in the main report. They are not intended to be taken in a stand-alone manner but instead represent strands necessary for any integrated analysis of the relationship between poverty and ecosystem services influenced by or unfolding within desakota systems.

Research Themes

The desakota phenomenon, and related economic intensification, demographic concentration and mobility are leading to unprecedented dynamic interactions across scales between human and natural systems with major impacts on water-based ecosystems, livelihoods and sources of vulnerability. Existing research has not yet adequately tackled the complexity of challenges in

ecosystem services and poverty arising from these dynamic interactions. This is in part due to the focus on conventionally defined "rural" and "urban" regions and the accompanying lack of recognition for more mixed economy, desakota, areas; the absence of tools to evaluate development problems in such areas; the challenge of investigating complex interactions across scales; and the rapidly intensifying interactions within interlinked local to global systems.

This review points to eight major lines of enquiry where research is needed in order to catalyze major changes towards alleviating poverty and ensuring sustainability of ecosystems and the services they provide in desakota environments. These research themes are not mutually exclusive, nor should they be considered in isolation. In order to effectively challenge the complexities of ecosystem services and poverty linkages, any research program must address multiple themes. This said, as discussed further below, there are strong common points of entry for research related to concepts, data, interdisciplinary research across scales, and methodologies. These common points of entry could provide a strong platform for focused research that addresses multiple issue areas.

As the report documents, the desakota phenomenon is occurring in all of the ESPA study regions, but is articulated in different ways both at regional and local scales. Despite differing local manifestations many of the research issues identified are, however, relevant across different regions and contexts. Research in differing desakota contexts will generate new information, strategies and tools that will shed additional insights on regional and local specificities and will also inform the global knowledge on which strategies for poverty alleviation, development and responses to other major global challenges are based. Before listing these major research themes, however, clear criteria are required to identify the economic and other characteristics that define desakota environments. Although desakota dynamics cut across many regions and are not confined to tightly defined geographical zones, some basis for locating research activities is essential. As a result, perhaps the first priority for any research program will be the development of specific indicators that can be used to "map" desakota contexts either spatially or in relation to the dynamic interlinked nature of their socio-economic systems. Within such areas or contexts, the key lines of enquiry that our analysis suggests could prove catalytic include:

1. **Tipping points and thresholds**: Understanding and identifying critical threshold conditions in interlinked social and ecological systems that may lead to transformative changes is crucial. To be meaningful, this broad research theme needs to be grounded in specific tangible research points, but also challenge and refine conceptual frameworks. Starting with the most tangible and then moving toward wider issues, key research issues include:
    a. Define and monitor thresholds where changes in patchy land cover mosaics can lead to abrupt but sometimes delayed transformative changes in hydrological and ecological system dynamics and water quality. Identify ecosystem indicators that provide warning of proximity to particular thresholds. Such changes are usually difficult to reverse and have implications for moisture retention, floods, droughts and the productivity of woodland, pasture, cultivated land, fisheries and other ecosystems on which the poor depend;
    b. Commission and review case studies which may help to understand and theorize potential thresholds where desakota type changes affect the viability of formal and/or informal institutions for sustainable water and other natural resource management. This would require integrated social and natural science methodologies;

c. Using multi-disciplinary research techniques, investigate how regional or large watershed scale environmental systems may undergo transformative change because of economic intensification within more localized desakota areas;
d. Track desakota type transitional regions in sub-Saharan Africa, South Asia, and China (where the desakota type transition seems to be most intense) for evidence of vulnerable socio-ecological systems susceptible to the collapse of vital ecosystem services. Such tracking could be achieved through multi-disciplinary case studies and monitoring key surface and groundwater quantity and quality data. It could also involve the development of clear sets of indicators to track and possibly map desakota processes globally and in detail for high vulnerability regions; and
e. Investigate the role desakota dynamics may be playing as a locus of the greenhouse gas emissions that contribute to global climate change. In addition to pre-existing natural-resource based livelihoods, intensification of commercial, industrial, service and other economic activities coupled with increased mobility and transport specifically in desakota regions may be a significant factor contributing to the growth of greenhouse gas emissions. This may contribute to the potential for crossing tipping points or thresholds in global climate systems that have direct implications for poverty. Climate is a key arena where the ecosystems services on which local populations depend are affected by growing interlinkages between local and global systems.

2. **Ecosystem Stress**: Fundamental scientific research directed at understanding stresses on water-based ecosystems due to intensification of economic and human activity coupled with changes in landuse patterns. Particular emphasis on landscape mosaic – ecosystem service interactions in desakota regions. Starting at the local level and moving upward to regional and more modeling based approaches. Specific research issues under this theme include:
   a. Develop understanding of interactions between land cover and climate under the pressures of desakota, including analyses of changes in (i) the type, intensity, extent, distribution and patchiness of land cover types at different spatial scales, (ii) the sensitivity of different biome or eco-region settings to such changes under current and projected climate conditions, and (iii) establish indicators of desakota-affected systems approaching threshold conditions (e.g. extent of high biomass land cover types, vegetation health/vigour, soil organic content);
   b. Undertake research on river flow regimes that focuses on their controls and characterization, and the development of approaches to their distributed, local management which incorporate issues of riparian – surface water – groundwater connectivity;
      - investigate small scale, low cost distributed measures to support self-purification of water within the catchment drainage network, which could also improve the runoff regime and support aquatic and riparian ecosystem complexity and services;
      - investigate smaller-scale distributed approaches to water resource development within catchments that avoid the adverse regional impacts on water quality, quantity and ecosystems that typify large-scale manipulation of surface and groundwater systems;
   c. Advance modelling based research at the local scale on trends and interactions between the hydrology, geomorphology and ecology of ecosystems under changing and uncertain precipitation and temperature conditions;

d. Develop research that connects climate change, desakota and catchment river functioning to identify and develop interventions between water ecosystem processes and water-related diseases;
e. Refine the representation of vegetation/landcover feedbacks within climate models at a range of spatial scales.

3. **Valuing ecosystem services in the desakota context – moving beyond payment for ecosystem services**: Analysis of ecosystem service values and mechanisms for communicating those values in desakota contexts where it is difficult to implement payment for ecosystem services models. Specific research issues include:
   a. Development of improved approaches to estimating the benefits of water-related ecosystem services including, where existing climate information permits, probabilistic benefits such as those associated with flood and other disaster risk reduction; and
   b. Innovative approaches for reflecting the value of ecosystems services in day-to-day life, particularly for the poor, that go beyond the payment for ecosystems services model or polluter-pays principles. This will require close interaction between those understanding the basic science of ecosystems within landscape mosaics and those seeking to value the services generated.

4. **Knowledge Systems**: Exploration of social and ecological conditions and management processes in desakota areas requires a focus on knowledge systems that bridge divides between scientific and local lines of enquiry and decision-making processes. While this theme is very broad, tangible research issues include:
   a. Develop improved methods for measuring demographies and economies of desakota areas to address limitations of existing census and survey methods;
   b. Exploring changes in the underlying principles on which stochastic approaches to hydrology and civil engineering are based to identify new approaches to the design of water infrastructure and institutions in desakota regions that are resilient under uncertainty. Given the rapid pace of change in climate and patchy landscape mosaics, the scientific basis for probabilistic analysis of hydrologic systems may no longer be justified because future probabilities cannot be predicted based on the historical period of record. This may necessitate basic changes in the scientific and engineering knowledge systems on which infrastructure and institutional designs are founded;
   c. Collecting data on critical ecosystem characteristics and the services they produce through innovative techniques while also developing mechanisms to make the data (and the analyses based on them) accessible and useful to vulnerable groups; and
   d. Exploring avenues for incorporating systems dynamics and uncertainty in primary to higher educational curricula to prepare future environment and water managers for careers in a world where static categories and linear forms of analysis will be of limited value.

5. **Drivers of Desakota**: To understand the consequences for ecosystem services and poverty it is essential to identify key drivers that create or expand the desakota phenomenon. Research issues under this theme include:
   a. Investigating the role of improved communication, transport, banking, knowledge and

other systems in enabling economic diversification and the development of desakota dynamics under different demographic, institutional and cultural contexts; and

b. Exploring factors that underlie the development and reach of technologies and systems that enable the penetration of desakota dynamics into more rural areas. This could lead toward strategies for encouraging the use of "environmentally benign" energy, transport and water management systems and green technologies. This may represent a key entry point for both alleviating poverty and reducing negative impacts on climate, water and ecosystems and the services they provide in increasingly important desakota regions. The diversification and flexibility inherent in desakota environments may provide opportunities to enhance the ability to adapt to climate change while also reducing greenhouse gas emissions. Research that explores synergies between adaptation to climate change and reduction of greenhouse gas emissions in desakota environments may be particularly rewarding.

6. **Risks and Vulnerability**: Improved understanding of risk and vulnerability in desakota regions as local and global systems become increasingly interlinked. Again, moving from the tangible to the conceptual, specific research issues include:
   a. Identifying increasing dependencies within desakota livelihood systems on geographically distant ecosystem services (e.g. food production or water supply from distant regions), and through a combination of dynamic modelling, field cases and other research techniques improve understanding how rather than increasing flexibility and diversification, this may introduce new sources of risk. Exploration of economic and other mechanisms for managing such globally interlinked systems is required;
   b. Identification and management of disease vectors in desakota regions as industrialization increases, particularly in China and South Asia. Specifically, understanding disease vectors associated with land and water use intensification and climate change is vital in reducing poverty-related health impacts; and
   c. Identifying the factors that encourage dispersal and colonisation of invasive species, measuring the economic, cultural and health costs and benefits as well as ecological impact of colonisation, and identifying mechanisms to control colonisation in desakota contexts.

7. **Poverty in Desakota Systems**: Improve understanding of desakota and poverty relationships to address inequities of the poor to income, resources, and services. Moving from impacts to potential responses, specific research issues on poverty include:
   a. Identifying how the desakota phenomena may be shifting the relationship between ecosystem services and poverty away from provisioning of resources to more systemic and equally important regulating services, e.g., exposure to environmental extremes, health risks, etc.;
   b. Improving understanding of factors contributing to changing patterns of vulnerability for the poor, particularly women, children and other social groups that face exclusion, in desakota regions such as those associated with decreasing water quality and quantity, increasing pollution and increasing exposure to disaster risks;
   c. Increasing understanding of the role and function of secondary and tertiary intermediary (market) institutions for provisioning of water, food and fodder in desakota type transitional contexts;

d. Documenting through case studies the opportunities, constraints and vulnerabilities for the women, children and the poor in desakota environments. Identify actions and policies to address inequities in access to opportunities, such as skills, education, and training allowing the poor to take advantage of new economic opportunities in the cash economy;
e. Exploring the significant remittance incomes in these regions in relation to the constraints faced as well as the potential for investment of household savings into environmentally sustainable production rather than consumption, especially in the formal economy;
f. Developing understanding of the implications of desakota dynamics for specific vulnerable and poorly understood socio-ecological systems, such as those found in many highly mobile pastoralist societies, fishing communities and high-mountain regions;
g. Developing new and refined methods and indicators (at local and regional scales) to capture region, culture and gender specific definitions of poverty that include income with other material and social assets, education, health and access to services in desakota environments;
h. Exploring the underlying reasons people move into and out of poverty: case studies at the micro and regional scale in desakota contexts could help improve understanding of this question;
i. Documenting, through commissioned case studies as well as re-visiting primarily 'grey literature', strategies of collective action by the poor – and the conditions that enable such democratic processes – that may have enhanced their access to quality ecosystems services in desakota contexts. Regional and inter-regional comparisons need to be made to help generalize policy conclusions; and
j. Since much of the innovative activities within desakota contexts occur within the informal economy, undertaking policy focused research to tap into this adaptive mechanism.

8. **Institutions for Resource Management in Desakota Systems**: Identifying institutions that are capable of effectively managing and regulating ecosystems in the complex and chaotic desakota regions where existing institutional mechanisms, if present, may no longer be effective. Specific research issues under this theme include:
   a. Conceptually driven empirical investigations of new institutional models beyond community or government-based water and resource management and conflict resolution in the desakota transition zones. The new institutional landscape in desakota regions calls for re-evaluation of many development orthodoxies including concepts of community and community participation; and
   b. Empirically investigating the impact of institutional transitions underway in desakota areas, on the most vulnerable populations' access to resources and enjoyment of ecosystem services.

Research Entry Points

The complexity of interactions between social and natural ecosystems in desakota environments, and their implications for ecosystem services and poverty alleviation requires a complex set of responses. As mentioned at the outset, the research themes described are intricately connected, and there is no analytical basis for making any one more of a priority than another. Entry points for research support that cut across these themes and could provide a strong basis for programme

development do, however, exist. These entry points relate to core concepts, data, research at different scales, and methods. Explicit consideration must also be given to reaching target audiences that research on the relationship between ecosystems services and poverty seeks to influence. Strategies that recognize and build off these core common entry points will retain coherence and achieve impact despite the diversity and complexity of the phenomenon and the relevant research themes. More specifically core entry points are:

1. **Conceptual**: Unpacking and refining the conceptual frameworks in ways that more directly relate local perceptions of poverty to ecosystems services in desakota environments. Specifically, refining the conceptual basis for understanding the relationships between ecosystems dynamics, risk, poverty, technology and institutions in rapidly evolving and highly interlinked cross-scale systems contexts is of vital importance to generating new insights on any of the specific research themes.

2. **Data Metrics**: The fundamental role of economic diversification and other processes driving the desakota phenomena have remained hidden because the criteria for data collection are shaped by static distinctions between "rural" and "urban" areas. Developing indices and other metrics for data collection that transcend these definitions and allow delineation and social or geographical "mapping" of desakota systems is of fundamental importance to addressing any of the research themes identified above. The potentially central role of desakota contexts, based as they are on increased mobility, energy consumption and lifestyle changes, as a major source of greenhouse gas emissions, for example, cannot be determined in the absence of such metrics. Data are the foundation for scientific dialogue and evidence based decision-making. Data also must not only be accessible to different users, including vulnerable groups and local decision-makers, but also socially acceptable to them if policy prescriptions made on the basis of such data dependent analysis are to see effective implementation. Overall, developing the basic indices and metrics needed to characterize desakota phenomena represent an essential first entry point on which virtually all subsequent research results ultimately depend.

3. **Research, both interdisciplinary at and across different scales**: Water as well as the desakota phenomenon are inherently interdisciplinary in that they are the focal points where several disciplines, both of soft and hard sciences, intersect. While multi-disciplinary studies allow experts to slice out that part of the problem amenable to the application of their disciplinary tools, they still require integrating into a package of action by some means. Interdisciplinary research, on the other hand, begins with experts of one discipline examining the problem from the perspectives of another discipline (e.g. an engineer trying to think through the economics of a water problem). While most policy environments are inherently interdisciplinary, much of the academia is not, nor is such research academically rewarded. Interdisciplinary research that investigates these complex social-ecological interactions at local/micro, meso and regional levels, and across these different scales is required to craft effective and sustainable policy. Specific research questions are detailed in the above research themes. However, such research may be implemented in activities that include:
    a. Case studies of specific desakota contexts that document natural-social interactions and implications for ecosystem service and poverty interlinkages: Interdisciplinary research that investigates and documents drivers, impacts and both environmental management

and livelihood strategies are required. It is in these concrete cases that the interactions can best be explored and understood. This includes 'basic' and applied science to understand these interactions. Preliminary case studies were developed as part of this study, but these were an extremely small sample, completed on relatively small scales, and one of the findings was the lack of existing or credible data. Substantial additional case material is required to generate new evidence, understanding, and potential interventions and strategies. These cases could be along transects such as in the case of the majority of ones for this report, or also explore more distant relationships between ecosystems and people who rely on their services. It is likely that any case studies would need to consider the implications of factors at large scales that may influence social-natural ecosystem interactions.

b. Research at regional scales: This more macro scale of analysis may involve more basic and analytical research that may include, among others: 'tracking' of vulnerable desakota areas; transformative changes of watershed or catchment systems due to desakota development, including implications of climate-land cover-vegetation feedbacks and land use changes; and improved understanding of drivers.
c. Action-oriented research initiatives: Interdisciplinary efforts to develop, test, and evaluate technological, social and institutional innovations that may improve ecosystem management and poverty alleviation efforts. Select research initiatives should explore and learn from potential interventions that can lead to improved resource management and livelihoods. Such initiatives may include, for instance, trials of more resilient water infrastructure and management efforts that enhance provisioning and regulating services and alternative resource management institutions based on networks rather than geographic communities.

Such research initiatives may include cross-regional comparisons or joint studies that may enable explorations of common research problems, as well as highlight regional or sub-regional specificities and unique responses required.

4. **Methodologies and tools**: The desakota context is characterized by unprecedented interlinkages between human and natural systems across all scales of interaction from the individual to the global and, as emphasized above, this necessitates interdisciplinary research across scales. At present, however, most research and research tools are locked within disciplinary silos and often are incapable of addressing multiple scales of analysis. Core methods for systems analysis in ecologically or culturally unique settings may, however, apply across many disciplines and scales that don't currently "talk" to each other. Exploration of common methods across the spectrum from case study techniques to network analysis and complex system modelling represents a key research entry point that will cut across virtually all of the thematic research issue areas and scales of analysis. Furthermore, the evolution of common methods, tools and techniques is a critical entry point for true collaboration across disciplines. Common methods are far more likely to erode disciplinary silos than any more topic based attempt to encourage multi-disciplinary collaboration.

Audiences and Communication Strategies

Research on the above topics will provide critical insights to key actors across a range of scales from government decision makers and officers in international organizations to community, business, academic and NGO leaders. In many ways these are not different from the audiences most research seeks to inform. What is critical given the complex dynamic of rapidly changing desakota systems is recognition that conventional research reports and dissemination strategies, while important, are likely to prove insufficient.

Experiential learning strategies that directly expose key actors to issues inherent in managing the dynamics of change within desakota systems will be essential. Adaptive learning process based approaches that emphasize iterative forms of interaction between researchers and decision makers as new knowledge is gained and refined will be central to this. Processes are needed that rapidly cycle between the generation, dissemination, testing, application and re-evaluation of knowledge, in order to effectively inform policy and action to alleviate poverty and ecosystem services.

Introduction

In many parts of the world the relationship between ecosystems and livelihoods is changing in fundamental but poorly understood ways as economic systems diversify across the rural-urban spectrum creating what we call mixed-economic 'desakota' systems. Understanding these changes and their implications for vulnerable populations, particularly the poor, is essential to inform policy and action at all levels from the work of local NGOs up to global development and trade policies. More specifically, it is clear that over coming decades, two interacting forces will strongly influence the nature of ecosystems services and their role as a foundation for livelihood systems across developing countries:

- **Intensifying processes of technological and economic globalization**. These processes are intensifying and, in combination with demographic growth, are driving increased consumption and deepening the linkages between economic, environmental, food and other systems across scales, often shifting patterns of local dependency on ecosystems to more removed levels: and
- **Environmental change at all levels from local to global**. The impacts of climate change and environmental degradation at global to local levels will undermine the ability of coupled ecological and social systems to provide critical services.

These forces are playing out at the global level in the context of urbanization and political change, and are reshaping the livelihoods of vulnerable populations, particularly the poor who are often the most directly dependent on ecosystem services. They are also reshaping both the pressures on ecosystems and the nature and effectiveness of institutions for their management. Community-based management systems, for example, while adequate for maintaining forest and water resources within rural agricultural economic systems are often unable to cope with increases in demand and the pollution pressures that emerge with the establishment of manufacturing and industrial activities. The poor may both benefit from new job opportunities and suffer as the quality of ecosystems on which they depend decline.

The processes of change currently reshaping livelihoods and their relationship with ecosystem services are poorly understood. Such understanding is of fundamental practical importance to development policy in general and efforts toward poverty alleviation in particular. Most development policy is shaped by conceptual frameworks that characterize "rural" areas as dominated by agriculture and other natural resource based livelihoods while conceptualizing urban areas as the locus of the manufacturing and service economy. As transport, migration and economic diversification reshape the rural-urban continuum, this conceptual division is increasingly inadequate. As the current turmoil in global food markets illustrates, strategies that seek to improve the ability of local ecosystems to produce food and other products for local populations are insufficient in the context of an increasingly interlinked global food chain and

labour outmigration. The price of the basic staples on which the poor survive is influenced by factors as diverse as agricultural labour unavailability (with the young opting for cash income and city life), and conditions in distant ecosystems (groundwater decline or multi year droughts).

As a result, improved understanding is essential in order to identify practical entry points for poverty alleviation and the maintenance of basic ecosystem services as change processes, including those driven by global event such as climate change or large-scale migrations, intensify. In every relatively well-defined ecosystem, hundreds of households and many different social groupings are constantly making decisions that affect ecosystem services and the poor. As a consequence, this improved understanding needs to be coupled with effective mechanisms for interactive experiential learning in order to inform these diverse decision-makers and enable them to head towards responsive and effective development, environmental management and poverty alleviation strategies.

CHAPTER 2

About the study

2.1 Purpose and Objectives

The purpose of this study is to increase understanding of the relationships among patterns of global economic and demographic changes, the nature of ecosystems services, and the role of such services in increasingly interlinked urban/rural livelihood systems, particularly those of the poor. We seek to analyze key elements in the relationship among major change processes (i.e., economic globalization, urbanization and climate change); basic water resource systems and the wider ecosystem services they provide; and the changing role of ecosystems services in the livelihoods across the urban-rural continuum.

Our overall objective is to identify critical knowledge and experience gaps where research and related activities could catalyze new, more effective, strategies for poverty alleviation and environmental maintenance. More specifically, however, our purpose in undertaking the study is to inform DfID, NERC, ESRC and other actors regarding these gaps where a strategically targeted research program could have a major impact on the ability of society to address poverty through maintenance of ecosystems and the services they provide. Our analysis is being undertaken in preparation for the development of such a program. In this context our specific objectives are to produce:

- A coherent body of high quality information that identifies and analyses evidence of how urban-rural dynamics affect ecosystems services and environmental trends in each of the four regions, identifying commonalities and differences, as well as interlinkages between four study regions in Africa, Latin America, China and South Asia;
- A proposal as to how these challenges can best be addressed through research to provide poverty alleviation outcomes;
- Identification of innovative and effective dissemination strategies for research outputs to be aimed at a range of target audiences;
- Proof of the information and new knowledge required by developing country policy makers and international organisations to inform policy change and enable better ecosystem management; and
- Strategies for skills and knowledge exchanges to strengthen the capacity of developing country partners resulting in the development of a 'critical mass' of research expertise.

2.2 Methodology

This study focuses on water-based ecosystem services in regions facing the rapid growth of mixed/interlinked urban-rural economic and livelihood systems. The phenomenon—known as desakota—recognizes the increasingly blurred distinctions between rural and urban (McGee, 1991). The implications of this phenomenon for the poverty-ecosystem service relationship also are examined relative to the pressures now emerging as a consequence of global climate and other ecosystem change processes. The methodology used is two-pronged:

1. **Global and regional literature reviews** of formal peer-reviewed publications and of local grey literature. This work included extensive reviews of the impacts of environmental change at the global and regional scales on water resources, and the intensive interactions of social and ecological systems at the catchment level in illustrative desakota environments. A review of social science literature investigated global and regional trends influencing the desakota phenomenon, including growth of markets, demographic shifts including urbanization and mobility, and access to communications and other new technologies.
2. **Case studies**, both literature and field based, along desakota transects (i.e., across economically mixed regions that extend from urban centers outward toward regions that have traditionally been viewed as "rural") that illustrate the complexities of water-based ecosystem and poverty interactions. In field-based case studies, focus group discussions sought to capture these interactions as well as concerns of the marginalized that had not been formally researched and catalogued in international peer-reviewed publications.

This approach enables exploration of sociological and political research while trying to diminish the gap between scientific studies and the dynamic field conditions which policy and action must address. We contend that data often fail to reflect the dynamic change processes that continuously reshape society and its relationship with the natural environment. The standard statistical units for collection of census data in many countries, for example, only distinguish between urban and rural areas. Within these areas, they often focus on activities (such as "rural" agriculture) that are assumed to form a dominant part of the context. As a result, they often fail to capture dynamics such as diversification into non-farm livelihoods that emerge as change proceeds. Part of this is *sociological*: We all have pre-conceived notions and definitions (e.g. the distinction between "urban" and "rural") that shape our worldviews and the data we collect. As a result, change processes that do not fit our pre-conceived frameworks are often missed. By looking at ecosystem service and poverty issues through the desakota lens, we intend to catalyze new insights on familiar challenges. Part is *logistical*: Linear approaches to research and policy formulation are often not able to respond to emerging needs in dynamic and rapidly changing contexts. Finally, part is *political*: Understanding is often bounded by what we (and others) call the "sanctioned dialogue" – that is the established structure and entrenched politics of development debates. By combining formal literature reviews with field based "case studies" involving focus group discussions along desakota transects we introduce a wide set of voices that reflect dynamic changes emerging in local contexts and cut across the boundaries of the sanctioned dialogue.[1]

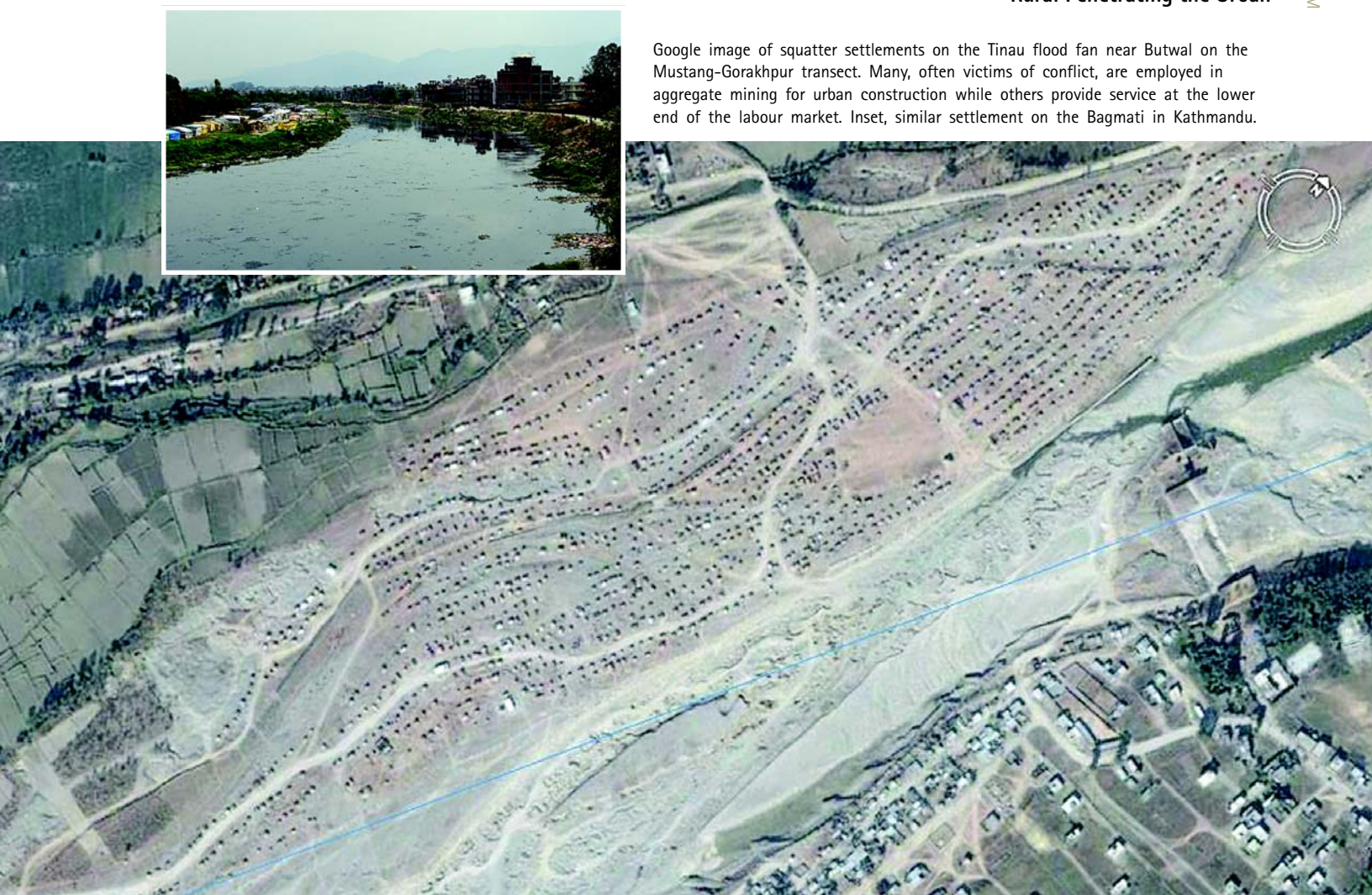
Entry points for catalyzing action to address major poverty or environmental problems can be identified only if they reflect the real opportunities and constraints people face and the ways in which power is exercised within society. The sociology, logistics and politics of data and research contribute substantially to the gaps among research, policy and action. Practical applied solutions will only emerge through methodologies that explicitly acknowledge and seek to bridge the gaps created by conventional approaches to acquiring data and their interpretation to formulate courses of action. As a result, policy research must have built-in within its framework an early engagement with different policy actors and a clear agenda of communicating such research (see Gyawali, Allan *et al*., 2006).

[1] For discussions on socio-political processes underlying the way science is conducted and framed, and related policy debates, see D. Sarewitz (1996)

2.3 Structure of the Report

This report is structured around two major sections. **Part I of the report**, the main strategy document, synthesizes core concepts and analysis as a basis for identifying strategic points of entry where research could make a catalytic contribution to ecosystem management and poverty alleviation. This document has six main chapters in addition to the executive summary and the first introductory chapter: (a) layingout the study and explaining its methodology; (b) a conceptual chapter on desakota systems and their dynamics; (c) a chapter on ecosystems and the basic scientific issues that must be understood in order to maintain the many key services on which livelihoods and the condition of vulnerable populations depend; (d) an integrating chapter that discusses and illustrates the nexus between poverty and ecosystem services in desakota contexts; (e) a chapter on critical research gaps and priorities; and (f) a final conclusion that highlights the gist emerging from the overall project. **Part II of the report** contains results of the core component studies used to formulate the main strategy document. This section of the report contains substantial background material that, while too extensive for decision makers and many practitioners, will be a critical resource for future researchers. We have included it in the reporting and intend to publish many elements of it in order to ensure future actors have access to the work we have done and can avoid "reinventing the wheel" in any future research program. It starts with a conceptual chapter and another examining desakota in the context of disaster. It then moves through chapters that contain results from the global and regional natural and social science literature reviews and case studies.

Figure 1:
Rural Penetrating the Urban



Google image of squatter settlements on the Tinau flood fan near Butwal on the Mustang-Gorakhpur transect. Many, often victims of conflict, are employed in aggregate mining for urban construction while others provide service at the lower end of the labour market. Inset, similar settlement on the Bagmati in Kathmandu.

CHAPTER 3

Desakota

3.1 The Concept

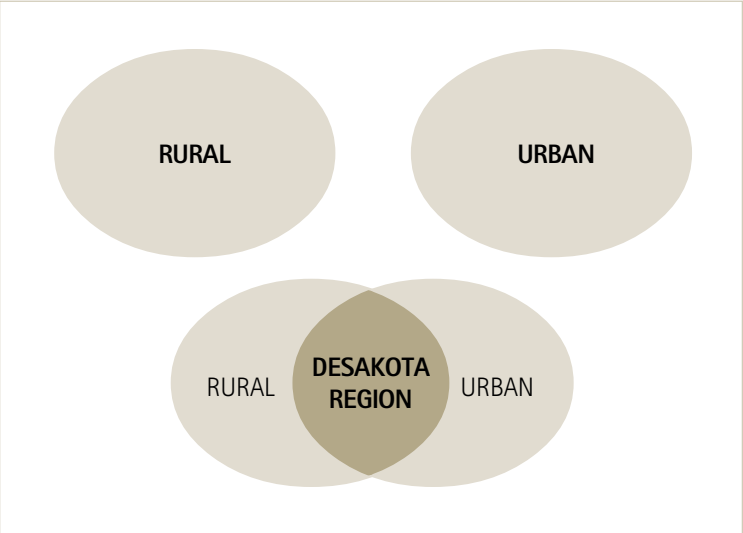
The environment is being stressed differentially across varied geographies by the socio-political processes that underlie recent economic and cultural globalization. These processes have brought about rapid social, institutional and livelihood transformation across broad areas. Migration and overall mobility have increased and market-centric livelihoods now dominate in many regions that were once dominated by rural agricultural or natural resource based socioeconomic systems. It is the mixed-economy region between "rural" and "urban," captured by the Bahasa Indonesia term desakota (meaning village-town) (McGee, 1991), where the trends in ecosystem stress can best be observed. These regions are linked to major urban centres by cheap transport axes where much more intense commercial agricultural and non-agricultural economic activities take place than in purely rural areas. The desakota phenomenon encompasses more than the term "peri-urban."[2] For the purposes of this situation analysis, desakota is conceptualized as the outcome of the interaction between rural and urban production and institutional systems. The rural is characterized by livelihood systems based on primary products production and support services, mostly strong informal institutions and technologies drawing upon local level human resources for their production and maintenance. The urban is characterized by secondary level production and tertiary level service sector based livelihoods integrated into national and global level economies, relatively more efficacious formal institutions of varying strength, and finally technologies drawing upon national and global level human resources.

The above does not imply that rural livelihood systems have informal institutions and urban systems formal institutions exclusively, but rather that formal systems are likely to be much more powerful in urban contexts and informal systems in rural contexts. In most of the global North, formal institutions are likely to be as powerful across the urban rural continuum, whereas in many countries of the global South informal institutions are likely to be as strong as in rural areas in certain segments of urban life, for example, in the shanty towns of Karachi, Mumbai, Dar-es-Salam or Lima and *vice versa* (e.g. see Hasan, 2002). Even in the global South where formal resource management institutions have deep penetration in rural livelihood systems, for example in the surface irrigation management system of the Indus basin, the actual day to day operations of those formal systems are likely to be inflected by the local power relationships and customary norms of resource management (Mustafa, 2002).

Figure 2 represents the desakota region that exists at the intersection of what have hitherto been conceptualised as predominantly separate urban and rural spaces. Interactions between rural and urban places has long been acknowledged, but recent changes in global political-economy and

2 A limited amount of literature on peri-urban issues is exploring the concepts espoused within the desakota phenomenon. See for example, McGranahan & Tacoli, 2006; McGranahan, 2004; Tacoli, 2002; Allen *et al.*, 2006; McGregor *et al.*, 2006.

Figure 2:
Desakota: the co-penetration of rural and urban systems.



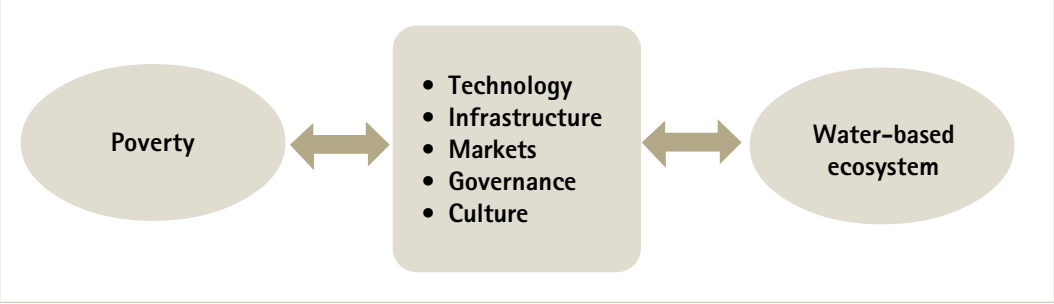
environmental systems as well as local dynamics mean that these interactions have led to a new rapidity and depth of rural transformation. But it is a transformation that is not complete, so that more and more socio-ecological systems can now best be described as variants of desakota rather than purely rural or urban.

The characteristics and determinants of desakota regions and consequences for ecosystem services vary widely geographically and over time. Key determinants include changes in technology, communications and transport infrastructure, market structure and the balance between formal and informal institutions of governance for ecosystem services. Figure 3 shows how these determinants are conceptualised as intervening processes that mediate in shaping the relationships between poverty and water-based ecosystems in any one social system.

The characteristics of the emergent mixed economy in desakota regions have fundamentally changed the proximate relationship between livelihoods, ecosystems services and methods of managing the environment. As impacts associated with the decline in rice production in Australia illustrate, where populations once depended on locally produced food, now prices reflect global markets and conditions in distant ecosystems (Bradsher, 2008). It is also the desakota phenomenon under which a woman living in the Mauritanian desert village of Maghleg is engaged in weaving textiles to support her family of three and is confronting globally driven 67 per cent higher wheat prices. Her solution is to switch to sorghum, skip breakfast and strictly ration food for other meals (Faiola, 2008).

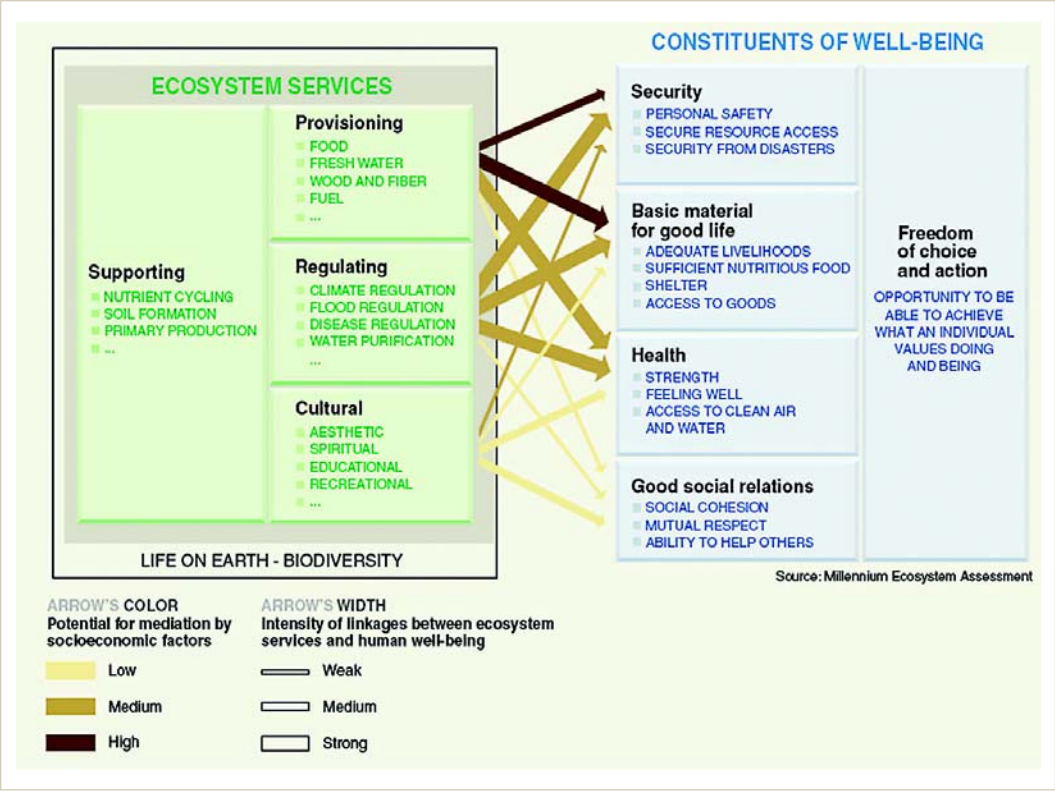
What kind of science is needed to understand the relationship between ecosystem stress and livelihoods in the desakota regions?

Figure 3:
Desakota: shapes intervening processes in socio-ecological systems



We begin with the definition provided by Millennium Ecosystem Assessment but try to move through that research and to deepen it. The Millenium Ecosystem Assessment (MEA, 2005) defined an *ecosystem* as 'a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit' and *ecosystem services* as 'the benefits people obtain from ecosystems, including provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits'. Changes in ecosystem services affect *human well-being* through impacts on security, the basic materials to support a good life, health, and social and cultural relations and such changes disproportionately affect the poor. Interlinkages between ecosystem services and human well-being were summarized in the MEA (Reid *et al*., 2005) by the diagram shown in Figure 4.

Figure 4:
Ecosystem Services and their links to Human Well-being (MEA, Reid *et al*., 2005)



Water is a crucial part of ecosystem services, not just as a resource but as a contributor to climate, chemical and biological systems. Complex spatial and temporal interactions within hydrological systems mean that pressures imposed at any one place or point in time can be propagated through the system and may have implications for future ecosystem function over varied spatial scales. We therefore use water as an entry point for studying the relationship between desakota development and ecosystem services.

In rural regions, the link between poverty and ecosystems services has generally been conceptualized in terms of access to resources (Borner *et al.*, 2007; Aggarwal, 2006; Cooper *et al.*, 2005). Access to forests or common lands, for example, entitles individuals to ecosystem products such as fuel, fodder, drinking water, and so on. These are direct economic inputs to household and community economies. If the condition of the ecosystem declines, then access to environmental services declines and poverty will logically increase. In desakota regions, however, the link between ecosystem services and poverty is very different – but perhaps more critical.

Take the example of water quality. Unplanned high density settlements in areas geologically unsuitable can mean fecal pollution of groundwater or surface water through poorly constructed pit latrines or irrigation of peri-urban agricultural plots with wastewater. The ability of upstream ecosystems to regulate water quality influences access to clean drinking water and thus the health status of recipient populations even in well established urban areas (Sajor and Ongaskul, 2007; Allen *et al.*, 2006; Drechsel *et al.*, 2007). Health, in turn, influences the ability to work, income levels and ultimately the distribution of poverty. Similarly, fisheries, which are important as a food source and in economic terms, depend upon the maintenance of the aquatic environment. If water quality declines to the extent that it threatens fisheries, this will increase poverty in the dependent communities. Overall, the growth of desakota characteristics may shift the well understood relationship between ecosystems services and poverty away from access to natural resources to much less well understood, more systemic, but equally important, impacts on health, disasters and so on.

Box 1: **Changing Resource Demands and Ecosystem Stress**

A key feature of desakota development is a change and more intensive use of ecosystem services. In many desakota areas, ecosystems have become increasingly stressed from the dual pressure from rural and urban demands, which has resulted in ecosystem degradation. For example, increases in water abstraction from an intensification of agriculture or from a shift from agriculture to industry, have reached unsustainable levels in many areas. In the Pakistan, India and China case studies, over-abstraction of groundwater has resulted in aquifer mining, which threatens future water supplies. Changes in land use associated with desakota development have also caused ecosystem stress, as natural vegetation has been cleared for agricultural and urban activity. In Tanzania, widespread deforestation, coupled with an increase in grazing pressure in the remaining areas of the forest, has contributed towards land degradation, resulting in severe soil erosion, siltation and loss of soil fertility (Olson *et al.*, 2001; Mandula, 2004). Such widespread changes in land cover have hydrological implications and may reduce the ability of the ecosystem to cope with climate changes.

In many desakota areas, water quality has declined from desakota pressures. For example, the water quality of Lake Victoria (Tanzania) has declined from increasing agriculture, industrial expansion and urban development associated with desakota. Small industries and mining have expanded in the region, releasing organic and inorganic suspended solids, dissolved nutrients, effluent and heavy metals into local watercourses. Similarly, inadequate waste disposal and lakeshore agriculture have caused phosphate and nitrate contamination, which has caused eutrophication problems (Ogutu-Ohwayo etal., 1997). Many of the case study areas, had very low water quality from the increase in pollution from desakota activity and in Nepal and India, this caused serious problems for human health.

Source: Part II Section C, F and G

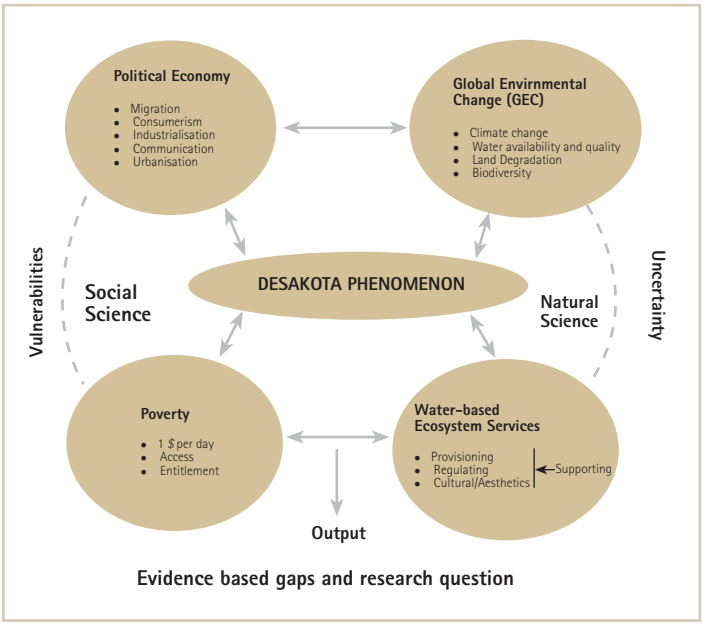
The growth of desakota regions also changes the nature of pressures on ecosystems and the incentive structures underlying management institutions. In these areas, the system of administration is primarily rural, but a political time-lag delays its re-adjustment to a more urban pattern as formal commercial and industrial activities increase (Brook and Davila, 2000; Fan, 2001; Farrington *et al.*, 2002). This time-lag allows for unexamined and not well understood developments, some benign and innovative, others rapacious in their search for legal loopholes and administrative vacuums. As the economic pull of urban centres reaches further into peri-urban and rural socio-ecological systems, ecosystems are increasingly stressed. Evidence suggests that ecosystems may be unable to cope with these stresses and will undergo fundamental, often irreversible, readjustments, which will have implications for the services that they provide (Box 1). Indeed these services are subject to interlinked—and often competing – urban and rural demands (for example over drinking versus irrigation water or fuelwood). Since labour now commands a market price, the degree of voluntary collective action that is required to maintain participatory resource management in the villages, whether of irrigation and drinking water systems or forest commons, in some cases is no longer readily available (e.g. see Mustafa and Qazi, 2007).

Changes in incentive structures for contributing to the management of common or joint resources may have far deeper social roots than change in the price for labour. Emergence of the desakota or more urbanized economy decreases and changes the nature of interdependency (Rodrigues, 2007). Forms of interdependency are now no longer defined by geographic location or as much by the scale of the family system. Instead they may become more network based—related to, for example, relationships within product or labour markets (Adger *et al.*, 2002; Start and Johnson, 2004; Tacoli, 1999). Communities in rural Nepal, for example, depend on labour markets that span the globe to generate the remittances on which many households depend for their survival. Such changes in interdependency affect institutions ranging from the joint family system (which has declined dramatically in South Asia) to institutions for resource management (Mustafa and Qazi, 2007, van Steenbergen, 1997).

The desakota phenomenon now dominates most of South Asia, China and many other parts of the less industrialized world. Recognition of this reality is essential to understanding the critical role ecosystems services will play over coming decades in livelihood systems, particularly those of the poor. Recognition is also central to understanding the changing incentives that underpin institutions for resource management. The desakota phenomenon brings to centre stage the desakota household whose income basket consists of flows from both the "rural" and "urban" ends of the spectrum and, thus, the new mix of dependencies on ecosystem services (McGranahan *et al.*, 2004; Stoian, 2005; Tacoli, 2002). Environmental services and stresses can no longer be understood in relation to historical notions of rural (agricultural) development or urban planning. Instead, the increasingly interlinked nature of "urban" and "rural" economic and other systems are already giving rise to new sets of socio-economic, institutional and environmental service issues in many developing countries.

We posit that macro level processes of political economy and global environmental change are directly influencing and enabling the desakota phenomenon. Similarly, as described above, strong interlinkages exist between the desakota phenomenon and ecosystem service management and delivery as well as poverty. However immense gaps in knowledge that elaborate on these linkages exist. While the Intergovernmental Panel on Climate Change (IPCC) conclusions of global climate change are fairly robust at the global macro scale, they become less so as they go down the scale. This is largely due to the complex feedbacks between geological, hydrological and ecological systems. This is best captured in the fact that the entire meso-scale Himalaya-Hindu Kush region is a 'scientific gap' in the IPCC. Similarly, within a social science perspective, understanding the systemic factors that encourage maintenance or destruction of ecosystems in desakota regions is a major gap. The dynamics of natural science/social science inter-linkages is captured in the following diagram (Figure 5).

Figure 5:
Conceptual Framework of Interlinkages in the Desakota Phenomenon



The meso scale desakota region, for the purpose of our study, can be conceived of as mediating the linkages between the macro level categories of the overall political economy characterized by migration, urbanization, consumerism, industrialization and communication and global environmental change, and the micro level categories of water-based ecosystem services and poverty in absolute as well as access and entitlement terms. The natural science/social science tasks lie in examining the desakota inflection to the linkage between the micro and macro level categories. It must be acknowledged here though that the desakota phenomena may itself be a significant driver of global environmental change, e.g., in terms of increased energy use for transportation and water abstraction among others, and global political economy as illustrated by the recent food crisis, than previously understood. We consider this potentially driving role of the desakota phenomena in global processes as a major research gap.

In the following sections, we attempt to elaborate on some of these linkages and, at the beginning of each of the following sections, a simplified conceptual framework indicates the linkages being discussed. We also identify where further knowledge is required to move towards strengthening delivery of ecosystem services for alleviating poverty. Drawing on global and regional based literature, we explore the top half of this diagram: macro political economic and global environmental change drivers, and how these differing processes in each of the regions lead to differing manifestations of the desakota phenomenon. Following this, based on literature and case material, we explore the bottom half of the diagram: the "meso level" relationship between ecosystem services and desakota, the institutions that manage ecosystem services, and the nexus between ecosystem services, poverty and desakota. But first, let us clarify in more detail what constitutes desakota.

3.2 Desakota Criteria

In order to determine the desakota characteristics of a region a few indicators need to be defined. In doing so, we draw from McGee's (1991) description of desakota as follows:

> *"Distinctive areas of agricultural and non-agricultural activity are emerging adjacent to and between urban cores, which are a direct response to pre-existing conditions, time-space collapse, economic change, technological developments, and labour force change occurring in a different manner and mix from the operation of these factors in the Western industrialized countries in the nineteenth and early twentieth centuries."*

Expanding and elaborating on these initial concepts, we tentatively identified the following indicators:

a) **Greater connectivity—physical, electronic, cultural**. This connectivity contributes to time-space collapse. It includes physical connections to major metropolitan centres by at least some transportation axes, which can support the movement of goods and people. This could be a dirt road plying some form of publicly accessible modern transport such as mini-buses or residents commuting using mechanized two wheelers. More "advanced" transport systems (e.g. air or rail links) can also play an important role in the desakota phenomena. This transport access can be recent or well established. In parts of Asia and Africa, transport axes and the inexpensive vehicles to utilize them have often come into place within the last 15 or

so years, i.e. within a generation, allowing for commuting to and from urban centres within a day (Thanh *et al.*, 2005). Such connectivity also includes improved access to information of the "outside" world (and hence knowledge of opportunities therein), not just through passive means such as newspapers, television (Johnson, 2000) and radio, but in the more active forms such as widely accessible cell phones (As illustrated by the rural woman entrepreneur in Figure 6) and in some locations the internet supported by technological development. Inter-local and international social and cultural networks also facilitates the movement of people and linkages across space.

Figure 6:
Daily Migrant Woman: selling strawberries in Lahore Pakistan

The juxtaposition of the mobile phone with exotic produce and traditional transport technology, set against the backdrop of high-voltage transmission towers and Moghul ruins, illustrates the desakota transition going on in South Asia. This phenomena was virtually unknown in South Asia fifteen years ago.

b) **Greater penetration of cash economy with remnants of reciprocity mechanisms on the decline**. Polanyi (1944) distinguishes between markets that are engaged in *exchange* (unregulated informal or regulated formal) with non- or weakly marketized societies engaged in *reciprocity* as a means of maintaining social harmony. With markets dominating society, monetized exchange becomes the norm. The need for state intervention arises with *re-distribution* through taxation and other means for society to function properly. Increasing market linkages are facilitating the predominance of a cash economy over reciprocity mechanisms, with much of it in the informal sector rather than the formal. This actually measures how far (or near) the region is to central government regulation through taxation and other means. The informal economy occupies a greater portion of the Southern urban economy than it does in the North, and deep rural hinterlands are sometimes wholly in the subsistence mode. However, a significant portion of the income basket of desakota households comes from informal rights over ecosystem services (e.g., obtaining fodder and

fuel from nearby forests rather than purchasing kerosene and Liquid Petroleum Gas from the market) that progressively declines as one moves towards the urban end of the spectrum (Gregory, 2005; Stoian, 2005; Twyman and Slater, 2005).

c) **Mixed livelihoods drawing upon local (as well as non-local) service and manufacturing opportunities**. Desakota regions consist primarily of households where working members are engaged in both rural agriculture as well as jobs, services, retail and manufacturing activities that have historically been seen as more "urban" occupations. As a result, income baskets contain a mix of rural and urban characteristics. This mix is supported by a daily labour market made available by transportation links that support daily or weekly commuting and short term seasonal migrations. In some places, this daily labour market provides women easier engagement in the labour economy due to the fact that they need not spend nights away from home.

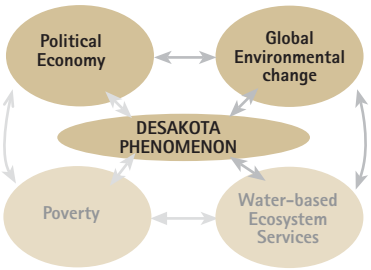
d) **Greater diffusion of modern production and resource extractive technologies**. Modern technologies (i.e. diesel or electric pump for accessing water rather than traditional muscle-powered wells; electrically-driven chaff cutters for fodder preparation rather than labour-intensive hand-cutting tools etc.) are gaining predominance over conventional and traditional means of resource harvesting or harnessing, with implications for demands and pressures on natural resources

e) **Tensions between formal and informal and traditional institutions for resource management**. Institutionally, desakota regions are often characterized by a poorly linked mix of formal institutions operating within defined enclaves (agricultural estates, corporate industrial estates, forest reserves, parks, etc...), declining or evolving traditional institutions and emergent informal institutions filling the gaps and often encroaching across enclave boundaries. This is frequently a source of tension and makes traditional and more formalized land tenure issues concerns of particularly sensitivity. In addition, traditional institutions and voluntary activities including those for forest, water or other natural resource management may be breaking down or under stress (Turner, 1999; Zoomer, 2006). It may be that people find less time to engage in non-market based activities or, because of changing technologies, new labour relationships or declines in interdependency, they have less incentive to contribute to institutions and functions that operate at a community level, which demand a high degree of enlightened self-interest volunteerism.

An additional concern is the degree of engagement or linkages between the global and local levels. Desakota regions straddle the rural-urban divide and necessarily mediate the transmission of global economic fluctuations, such as oil price shocks and major technological shifts, from both levels to rural and urban areas. For instance, the shock of global oil price hikes will be felt much sooner and more pervasively at the urban end of the spectrum than the rural. However, it is only a matter of time before rural areas too feel the impact when transporting necessities to the villages become much more expensive. As the Nepal case study (Part II F4) shows, a rural life maintained by a remittance economy finds it easier – and cheaper – to import rice from the Indian plains than to grow them in the irrigated terraces of the hills. There is, however, a limit to resilience: oil price shocks can happen with fatal disruptions to the supply chain quicker than rural areas can revert back to

growing food once the 'culture' of agriculture has been abandoned. This above statement however raises a criteria question: In the desakota region, given less infrastructure "locked-ness", can one expect the region to function as a shock absorber with livelihoods and economic activities shifting during such times towards the more rural or urban ends of the spectrum? Outlines of an answer can perhaps be discerned in Bangladesh's Khulna-Jessore desakota (Part II F2), which function as the first staging point before permanent outmigration.

3.3 The Drivers of Desakota Dynamics

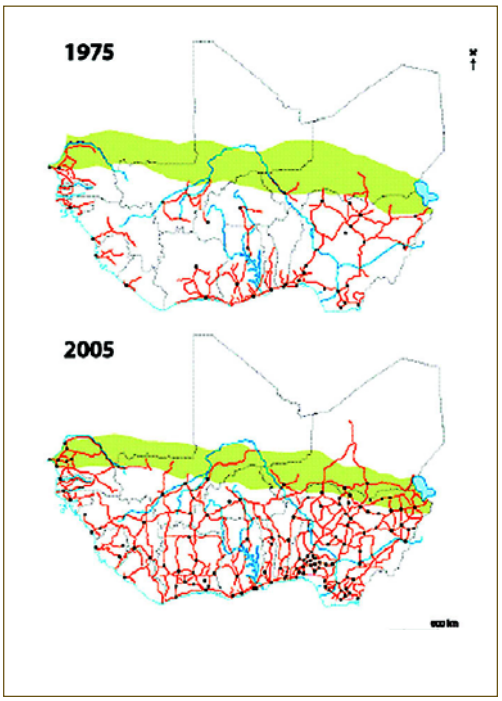


Global scale processes—the global political economy and global environmental change—are important sources of root causes behind desakota systems. Local pressures from human development as well as historical processes associated with water resources and related ecosystem services have accumulated over time (see Figure 5). This section outlines key pathways through which global pressures influence these accumulated pressures within the desakota. It is also recognised that the global political economy and global environmental change interact—for example through global regulatory mechanisms like the Kyoto Protocol. Conversely, desakota systems can collectively influence global processes—through the shaping of local socio-ecological relationships, human development status and even global initiatives (e.g., water resource demands, access distribution and the sustainability of resource management).

The 2008 global food crisis demonstrates the interconnectivity of water and development across scales between local and regional places and global processes. A combination of changes in local planting regimes (a shift from wheat and maize for consumption to bio-fuels), increasing demand (e.g., from China's rapidly expanding middle class), the failure of key regional harvests (e.g., the Australian rice harvest), and instability in the global financial systems (commodity speculation at a time of high carbon fuel price) have destabilised water-food systems resulting in increased hunger and malnutrition for the poorest with crises in 37 countries. At places this has fed back into the political system through violent protests in such diverse countries as Cameroon, Egypt, Haiti, Indonesia, Mexico, Morocco, Pakistan, Senegal and Yemen (FAO, 2008).

The extension of transportation and communication systems, access to energy and more affordable private and public transport have allowed penetration into previously remote areas at an increasing rate (see for example Part II E1, E3 and figure 7) facilitating space-time collapse. Enabling the movement of goods, people, information and finance between sites of production and consumption has strengthening linkages between product and labour markets in desakota systems. Communication systems, in particular cellular phones as well as the internet, have enabled improved access to information, particularly for areas that may be more remote. For

Figure 7:
The Expanding Road Network of West Africa



Source: West Africa's Road and Urban Network and
Source: OECD, 2007

example, in the case studies in Balochistan (Part II F3) and Nepal's Madan Pokhara (Part II F4) individuals use cell phones to call various towns to compare market prices. Communication and transport systems are drivers for more complex higher level organizational systems to emerge, such as social networks, banking systems and integrated commodity chains. The emergence of such organizational systems, in turn, has served as a core driver for migration, economic diversification, the growth of services and an overall intensification of economic activity and social change.

In addition to the purely enabling function of the above systems, increased access to communication systems and social networks serves to transmit images of wealth and opportunity as well as different cultural values, such as commodification, from distant areas to local communities. Younger populations, in particular, are utilising information communications technologies (Wagner *et al.*, 2005). Where poverty in rural communities was once largely defined by access to basic resources and social networks, new communications technology and services have helped to change perceptions of poverty. These same technologies have also provided real opportunities for livelihood development through providing up-to-date information on market prices and direct access to customers in agricultural zones that might previously have been described as remote. Research in Rwanda shows cultural and business information are often exchanged simultaneously (Donner, 2007).

An increasing density of transport infrastructure, and in growing economies the declining real costs of private and public transport, has led to more mobile populations. Between 1990 –2003 the number of road vehicles increased fourfold in Botswana and doubled in India and Ecuador (UN-HABITAT, 2007). Emerging desakota regions that are perceived to provide access to income from wages or business opportunities and access to services such as education and health care can quickly become a locus of opportunity drawing people in either as migrants or commuters. More mobile populations have made it possible for rapid transitions from dispersed rural to more concentrated desakota and potentially urban settlements through processes of population growth and interconnectedness (Simon, 1996). The result is a transition to high energy consumption socio-economic systems, the consequences of national mitigation and adaptation policy on these motors and subsequent desakota systems is unknown.

The systems enabling desakota style economic intensification have grown at the same time as "push" factors driving populations out from both rural areas and urban cores have intensified. Part of these factors stem from conflict and part from environmental degradation. Conflicts, whether the harsh day to day friction found in decaying urban cores and slums or the large wars and lower intensity conflicts that have spread over many rural areas, have been a major catalyst pushing people to migrate and seek opportunities elsewhere (McGregor *et al.*, 2006).

Where urban areas are not easily accessible, for infrastructural or political reasons, internally displaced people (IDP) or cross boarder refugees act as engines for rapid, localised urbanisation of the kind experienced under desakota. One of the principal aims of IDP and refugee camp management is to maintain them only as temporary sites and to facilitate return home as quickly as possible, where camps do exist they should be managed to minimise environmental impacts as stated in the internationally agreed Sphere Standards for humanitarian action (see http://www.sphereproject.org/). A number of recent armed conflicts have made this aim difficult to meet. Even temporary camps can have severe impacts on surrounding ecosystem services, for example

where demand for fuel and fodder leads to local deforestation and disruption of hydrological systems. UNEP described the environmental impact of human displacement to more than 20 camps in Liberia as leading to serious degradation of forest resources, soils and water courses up to the scale of watersheds (UNEP, 2006).

IDP and refugee camps are perhaps one of the most dramatic expressions of desakota, however the majority of migrants escaping armed conflict or environmental risk settle in marginal rural or urban locations including peripheral informal squatter settlements. The latter are a major engine for urbanisation, but are not a primary focus for this report. A small but solid base of literature on peripheral or peri-urbanisation exists including work on ecosystem services (e.g. Hardoy *et al.*, 2001; McGranahan *et al*., 2001) and could benefit from a reconsideration through a desakota lens. Marginal rural locations may be hazardous but offer access to land and livelihoods. This is predominantly through the informal sector so that both population change and behaviour remain largely undocumented by government and unassisted by formal state development policy.

In some cases, migration is catalyzed by signature flood, drought or storm events. In most cases, however, even such signature events reflect deeper processes of socio-environmental system change. In northern India, for example, flood risk grows despite half a century of structural river management. Increased hazardousness is in part associated with a failure to plan for watershed wide flood events when the embankments of individual rivers can act to block overland flow. This hazard turns to risk and loss in those places where formerly landless migrants have been attracted to settle close on land recently improved through embankment building. Time and again these populations are amongst the most impacted when embankments fail or are overtopped. In this way socio-economic inequality and river and flood management policy conspire through a multiplicity of individual migration choices to generate new populations of the vulnerable poor (Pelling, 2001).

Similar processes operate on both long and short time scales in other areas such as the Gangetic delta of Bangladesh. In India, for example, pulses of population movement often occur during droughts. These, however, often reflect longer-term processes of groundwater overdraft that have depleted aquifers and gradually eliminated drought buffers. In many cases, populations recognize these pressures far in advance of any signature drought or other event and are responding proactively. In Gujarat, India, rural populations often explicitly link investments in educating their children to the lack of any future for agriculture in areas affected by groundwater overdraft (Moench and Dixit, 2004). They are using the income from unsustainable agricultural practices as a transitional source of wealth that can be converted into new activities in the rapidly diversifying desakota economies.

Existing push factors are likely to be greatly exacerbated by climate change. Climate change predictions show that regions that are already water-stressed, such as South Asia and Africa, will suffer from further declines in precipitation levels, which will impact rural economies. For example, in Mwanza, Tanzania (Part II G1), the impacts of this have already been seen, as drought has driven pastoralists into the wetland areas, a trend that is likely to increase. One of the most consistent findings of global climate change predictions has been an increase in precipitation variability and extreme weather events, which is predicted in all of the regions (IPCC, 2007). This will have the most profound impacts on small farmers who lack sufficient assets to absorb frequent losses (UNFCCC, 2007; Brown and Lall, 2006; Vorosmarty *et al*., 2000), forcing them to seek alternative sources of livelihood.

Box 2: **Water Quality and Desakota in Bangladesh**

Bangladesh has the highest population density in the world, with large growth potential. The economy has been growing over 5.5 per cent per year during the past two decades. Despite this, high unemployment, a high proportion of labour working in agriculture and widespread poverty have dampened the positive effect of economic growth on human development.

The poor are increasingly becoming dependent on accessing a shrinking pool of free or informal access ecosystem services, e.g. fisheries and groundwater to meet basic needs or provide a resource base for development. Increasing competition has led to greater exclusion amongst the poor and given rise to widespread food impoverishment and malnutrition. This is exacerbated by deteriorating environmental conditions - often fuelled by localized industrial and urban pollution, frequently occurring extreme weather events and upstream withdrawal of water from international river courses - reducing availability of and access to resources for the poor.

The Southwestern region has suffered from salinization and water logging, which have undermined agricultural production and aggravated poverty. This process has been associated with a motor for desakota as local urban centres emerge formed by those migrating in search of economic opportunity. This has given rise to a distinct rural-urban continuum along Satkhira-Khulna-Jessore corridor in Bangladesh.

Source: Case Study Part II F1

Climate change will have profound hydrological and ecological impacts (Scheffer *et al*., 2005; Huntingdon, 2006), which will affect the provision of water-based ecosystem services. For example, changes in the hydrological regime will affect annual cycles of flooding and groundwater recharge, which will impact the dependent agricultural systems, such as those in central Amazonia and Pakistan. Changes in climate will also induce changes to the native vegetation cover and shift the limit of terrestrial biomes (e.g. Foley *et al*., 2000; Betts *et al*., 2004; Yu *et al*., 2006). This will impact some of the direct provisioning services that the natural vegetation provides, such as grazing, fodder and fuel, on which many rural economies depend.

Increased migration and reliance on economic diversification appear to be an almost inevitable consequence of climate change (Tacoli, 2007; Taylor, 2001). Both will contribute to the underlying dynamics driving growth of desakota economies. Improvements in irrigation systems or use of drought (or flood) resistant crops may offset part of this but with groundwater resources already under pressure in major agricultural regions, particularly India and China, and increasing demand for water supply to urban and other uses globally irrigation will not be able to offset increases in climatic variability. In addition to water availability and access, changes in water quality and disease vectors accompanying climate change (Ebi *et al.*, 2007; WHO, 2003) are also likely to act as push factors in the growth of desakota systems as isolated agricultural socio-economies become increasingly unable to meet basic nutritional, health and economic needs and development aspirations. Increases in disease that may accompany climate change may, as HIV already does in Africa, drive increasing demands for the health services found in desakota areas. Salinity and other water quality problems already limit the viability of agriculture in many regions and, as the accompanying box on Bangladesh illustrates, contribute to migration.

The array of push and pull factors driving the emergence of desakota economies are, as the above discussion illustrates, the outcome of complex interactions between systems that operate across scales from the local to the global. Understanding the linkages in such systems represents a major challenge. These linkages are, however, central to understanding and managing the relationship between ecosystems services and poverty in desakota economies. A starting point for recognizing these linkages lies in the regional differences observed in the nature of desakota type systems.

3.4 Desakota in the Regions

The desakota concept initially emerged in the context of Southeast Asia in the densely populated Javenese island of Indonesia (McGee, 1991), and has been explored explicitly in a limited fashion in a few countries in Asia (see, for example, Gyawali, Schwank *et al.*, 1993; Xie *et al*., 2005; Wang,

1997). However, concepts associated with desakota – greater connectivity through transport and communications that contribute to space-time collapse, technological developments, and change in economics and labour forces – are occurring in regions of South Asia, China, Sub-Saharan Africa, and Amazon-Andes. Table 1 presents a summary comparison of the four regions identifying the principle distinguishing driver for desakota and subsequent key characteristics as revealed by the case studies reviewed in Part II. The manifestations of these processes are regionally unique, contextualized within different histories, culture, and pace of globalization.

Table 1: **Matrix Comparison of Desakota Regions**

	South Asia	China	Sub-Saharan Africa	Amazon-Andes
Distinguishing determinant of desakota	Strong state and civil society, developmentalism, Population densities	Transition to market economy	Inequality and instability	Connection to global markets and government development policy
Urbanization trend	Moderate growth	Rapid growth	Rapid growth	Highly urbanized
Economic driver	Government sponsored modernization, industrialization and agricultural mechanization	Rural industrialisation	Uneven, enclave development	High value agriculture, service economy
Institutional context	Interdependent formal and informal systems	Shift from communal to private land management, State policy	Large informal sector	Parallel formal and informal systems
Social impacts	Communal resource management under stress. Widening income gap	Urban-rural income gap increasing	Households under stress	Gendered inequality in wages
Infrastructure driver	Road network, communications technology	Enclave industrialisation	Communications technology	Road network

The complexities of the desakota phenomenon in and within each of these regions cannot be adequately captured in a few paragraphs. However, the following discussion will present a snapshot of current regional trends impacting on the growth of desakota phenomenon[1]. These in turn will have significant considerations for the relationship between ecosystem services and poverty alleviation, as discussed in the following sections of this report.

South Asia has a long history of urbanization through the millennia. Even before independence the region had a well defined hierarchy of urban centres and market towns, even though the vast majority of South Asians lived in classic rural settlements. Since independence the pace of urbanization has accelerated to a high of 6.4% per annum in Nepal to a low of 0% in Sri Lanka, 2.9% in India and an intermediate rate of 3.5% in Pakistan and Bangladesh. Unlike mostly rural Sub-Saharan Africa, and mostly urban Latin America, South Asia has intermediate urbanization rates by developing world standards, e.g., Pakistan had the highest—35% urbanized population while, Sri Lanka had the lowest 15% urbanized population. India, the regional economic power house had a moderate 29% urban population (World Bank, 2007). Being that the sheer scale of populations involved in the South Asian context is so immense it is easy to forget that majority of South Asians live in rural or desakota type smaller towns outside of the physical limits of the mega cities. One of the key drivers of South Asian urbanization has been the modernizing development

trajectory promoted by the generally strong state apparatus in most South Asian countries—principally India and Pakistan and to a lesser extent Bangladesh and Sri Lanka (Bradnock and Williams, 2002). The active state promotion, for example of electric pump technology for groundwater extraction, agricultural mechanization and heavy industrialization promoted by the state sector have played a key role in transforming the traditionally rural economic and cultural landscape of South Asia.

An important and relatively well document aspect of the desakota phenomena in South Asia is the (often problematic) interaction between traditional informal resource management regimes and more modern, legally sanctioned resource management systems, e.g., for forestry see Agarwal (2001), Agrawal (2003), Rangan (1996); for irrigation water Mustafa and Qazi (2007), Mustafa (2002), Dixit *et. al.* (2006) and for fisheries see Kurien (2003). The literature documents the largely negative implications of resource access by the poor and the most vulnerable as their customary rights of access are being either monetized or altogether denied by more modern formal management regimes.

South Asia has seen a considerable expansion of its transportation infrastructure, particularly road and electronic communication infrastructure. In India for example there were upwards of 250 million cell phone connections, while in neighbouring Pakistan in 2006 23% of the population had access to cell phones, up from just 4.3% in 2003 (Sargana, 2006). This remarkable increase in connectivity is having little understood but admittedly transformative implications for resource management in the country. (Again see Figure 6).

In China, desakota conditions are similar to South Asia, although distinct political, historic and economic contexts have shaped the emergence of the desakota phenomenon. China's rapid economic growth has led to increases in urbanization which have been much more abrupt than other regions, beginning with economic reform in 1978. In 1975, China's urbanization level was 17.8 per cent, with a non-agricultural population of 15.4 per cent. In 2007, the urbanization level had risen to 45.4 per cent and non-agricultural population of 33.8 per cent (World Bank, 2007), and it is expected to reach 60 per cent by 2050. It is expected that peri-urban growth will increase substantially, with large manufacturing areas locating to these areas, attracting investment but also increasing demands on resources (Webster, 2002; Shen *et al*., 2005). Some scholars (Xie *et al*., 2005; Wang, 1997) have applied the concept of desakota to the Chinese context to describe the transformations taking place as rural populations become more urban without substantial movements to the cities. Xie *et al.* (2005) suggest that state polices have facilitated this process of desakota-ization with the transformation of decaying state-owned enterprises into private development initiatives, which are often based adjacent to large cities, with foreign investment, appearing in farming land like "flying intruders" (Wei, 2002). In addition, national policies of the Household Responsibility Systems and Township and Village Enterprises, appear to have facilitated the shift from communal policies for agriculture and land ownership to more individual/family unit production and privatization of local enterprise (Xie *et al*., 2005). These policies provided strong incentives for rural towns and villages to diversify and grow their economies by developing non-agricultural enterprises. However, development in desakota areas is driven both by large industrial projects such as coastal economic and technological development zones as well as bottom-up processes from the development of small

and medium sized enterprises, including Township and Village Enterprises that have survived the transition in market economies.

The sheer size of population in China and growth in desakota areas will have significant impacts on the environment and ecosystem services. The industrial development described above, along with strengthening transport and communication links, more relaxed registration status and less dependence on the state for essential goods (Liang, 2004), has led to an expansion of the floating population[2] ("liudong renkou") estimated in 2005 at 147.35 million of 1.306 billion people (Liang, 2004). By 2004, one-third of the labour force had moved into non-farm activities (Fleisher and Yang, 2003). There is a lack of gendered information on these statistics, although approximately a third of the migrant population are adolescents. However, the percentage of rural women who are becoming migrant workers in some areas is rising (Zhang, 2005), although their jobs are generally lower-paid, lower-skilled than men. Some women are vulnerable to trafficking (ADB, 2004), a similar problem emerging in South Asia. The income gap between urban and rural areas is increasing (Hu, 2002; McGranahan and Tacoli, 2006), although poverty in urban and peri-urban areas is also increasing (McGranahan and Tacoli, 2006).

Agriculture and industries are increasing demand for water extraction stressing the already water-scare north of the country, and are contaminating further the country's heavily polluted rivers (Amarsinghe *et al*., 2005). While government efforts are in place to control pollution, these are only of limited effectiveness. Overall, the impact of these demands and rapid land use changes in desakota regions has not been adequately explored.

In Sub-Saharan Africa, wide variability among countries and their diverse histories, politics and economies are influencing the rates and manifestations of the desakota phenomenon. Overall there are 400 million people living under $1 a day, with many of the poor facing constant struggles of accessing resources, exacerbated by the challenge of HIV/AIDS, malaria and other concerns. Political conflicts, corruption and vulnerability to external markets have limited development. The sub-continent has been slower than other regions to engage in the manufacturing sector, and engagement with global markets has been primarily for export of agricultural produce and minerals and import of primary products and commodities. Historically, economic growth, technological advancement, and transportation axes were aimed at developing industrial and mineral extraction sectors. Little investment was made in agriculture, a legacy that continues to limit current agricultural production.

Urbanization in Sub-Saharan Africa has occurred despite the lack of investment in manufacturing and industrialization as seen in Asia and Latin America. Access to markets, livelihood diversification and degradation of rural agricultural and pastoral lands are factors contributing to migration. Urban growth rates have far exceeded the growth of urban formal economies, and consequently governance and infrastructural development have not been able to keep up with the growing number of urban and peri-urban dwellers, resulting in urban decay (Beauchemin and Bocquier, 2004) and potentially an increase in dwellers in desakota areas. Almost half of the sub-continents urban population lives in small administrative centers and market towns (between 5,000 and 100,000 residents) (Sattherthwaite and Tacoli, 2003) playing an important role in urban-rural interlinkages, particularly for small-scale farmers and urban poor, where availability of

land, labour and informal markets is higher than around large urban agglomerations, and entry level barriers are lower. Little is known about gendered issues in desakota areas. However, it is recognized that women are particularly vulnerable to social and economic shocks, and in some cases may be left to manage households without tenure of land or water resources. In Tanzania, women heading households due to death or separation appear to be migrating to small towns to engage in wage labour, access resources and draw on existing social networks (cf Baker, 1995).

Recent changes in global and market linkages are leading to the development of manufacturing and service centres in some countries feeding into international markets (e.g. clothing from Lesotho, Mauritius and Madagascar; cut flowers from Kenya; and service call centres in Ghana and Senegal). These market linkages and efforts by the New Partnership for Africa's Development (NEPAD) to promote economic integration through the development of infrastructure in trade corridors likely will contribute to desakota phenomenon. Greater mobility and ease of transport not only facilitates the movement of people, goods and services, but also of information. Increased access to information (often from urban centres) and higher levels of education has supported innovation among farmers, as demonstrated in a study in Kenya (Evans, 1992). As in other regions, cell phone technologies and to a lesser degree, access to internet may support this flow of information.

In the Amazon-Andes region, the development of desakota regions has been significantly different, in part due to the high rates of urbanization much earlier than, for example, either Africa or South Asia. Currently, over 75 per cent of the population of Latin America lives in urban areas (Hyman *et al.*, 2005). Rural non-farm employment and income have grown substantially over the last several decades (Reardon and Berdegue, 2001), accompanied by a drop in the proportion of labour allocated to agriculture (Hyman *et al.*, 2005). Differing from the strong manufacturing growth in Asia, a large portion of economic development in the Amazon-Andean region has been on the growth of agro-industries and services, such as cut flowers, dairy production, and non-traditional agricultural exports. While the growth of high value agriculture has opened up employment opportunities, this has generally been tilted towards local elites rather than poorer wage earners. Where opportunities have emerged for women, this frequently has been in lower-paying, less skilled employment (Dolan and Sorby, 2003). Remittance economy is significant in Latin America, with over $US 40 billion in remittances in 2004, representing 27 per cent of all remittances to developing countries (Acosta *et al.*, 2008). However, it is not clear how much of this income is reinvested in household farms or the development of local businesses, although there is an increase in consumption of goods and construction of large houses, a phenomenon witnessed in Asia and SubSaharan Africa as well.

A main hindrance to economic growth in Latin America is the lack of transportation infrastructure (Calderon and Severn, 2003), which has focused on resource extraction rather than linking towns and population centres (Hoffman, 2006), similar to Sub-Saharan Africa. Only 145 of the 1.25 million miles of roads in the LAC region are paved (*ibid*). Significant investment is occurring in infrastructure improvement (Shirai, 2007), and increasing access to cheap forms of transportation is supporting movement of goods and people, particularly in frontier areas.

In the Amazon region, transportation axes to large cities and to more economically advanced regions are relatively poorly developed leaving the region more isolated and remote. Livelihoods

continue to be based on agriculture and extraction of natural resources. However, changes in global demand for biofuels and changing meat-based diets have put new pressures on the agricultural frontiers in Brazil and Bolivia to increase soybean production (Nepsted, 2007). These global processes, as well as beef and milk production increases are exacerbating deforestation in the Amazonian region (Hecht, 2005; Caviglia-Harris, 2004). This in turn is leading to increased expansion in the Amazonian region, in part supported by government policies. In Brazil, the Avanca Brazil policy aims to reduce urban pressures on southern cities by expanding urban agglomerates in the north, constructing a trans-Amazonian highway and improving/increasing the transportation networks throughout the region (Godfrey and Browder, 1996; Caviglia-Harris, 2004; Carvalho *et al.*, 2001).

The differing pace and manifestation of desakota development in and within each of the regions has significant implications for the role of ecosystem services within them, and associated environmental impacts and demands, which must be considered carefully in the development of any research program. In Latin America, for example, conditions may fall more at the urban end of the spectrum with the flooding and regulating services of ecosystems perhaps more of a role in comparison to provisioning services dominating more rural desakota regions of Africa. Furthermore, in the Amazon region, deforestation, soil depletion and degradation, major losses of biodiversity and emission of greenhouse gasses are key environmental consequences of development. Deforestation has global consequences of ecosystem services, as it affects the Amazon's roles as a carbon sink. SubSaharan Africa and parts of China and South Asia face extreme challenges of water scarcity to meet increasing urban, industrial and agricultural demands. Across all regions, domestic and industrial waste pollutes rivers and groundwater, to varying degrees and with differing attempts at regulation and management. Other parallels include the increasing role of informal institutions in provisioning of water resources. The role of informal water markets, for example, has been a sensitive issue in both Latin America and South Asia despite greatly differing levels of urbanization. Existing research on implications of desakota development, ecosystem services and poverty alleviation remains limited. However, we begin to explore these issues in the following sections. Regional differences will translate into important divergences in the applied research issues of relevance within different regions. However, comparisons may also lead to the identification of commonalities that can serve as a foundation for the development of strategies that respond to fundamental elements of social behaviour and ecosystem dynamics.

3.5 Thematic Lines of Enquiry

As conceived in this report, desakota brings together human development and ecosystem services concerns. This is valuable in opening a new conceptual lens on existing and emerging challenges for policy and research. Priority lines of enquiry include:

- Using a desakota focus to help understand and measure adaptation to climate change in dynamic socio-ecological systems.
- Examining the cross-scale linkages between global and local causes of (un)sustainability in socio-ecological systems.
- Examining desakota trends to explore opportunities and challenges for mainstreaming climate change mitigation and adaptation within development.

- Identifying how the desakota phenomena may be shifting the relationship between ecosystem services and poverty away from provisioning of resources to more systemic and equally important supporting services, e.g., exposure to environmental extremes, health, etc.
- The institutional transitions impacting resource management regimes in desakota areas, especially as they concern the most vulnerable population's access to resources and enjoyment of supporting ecosystem services.
- Critical linkages between technology, social and economic structures for example the roles basic physical and knowledge infrastructure systems play in enabling the emergence of mixed economic desakota systems.

Perhaps because much of desakota is driven by informal institutions it has fallen outside of formal state statistics and visions for development. Consequently, there is a lack of basic data. This corresponds to a paucity of basic demographic data to track urbanisation. Basic research is needed:

- Improved methods for measuring demographies and economies of desakota areas to address limitations of existing census and survey methods unable to capture patterns of migration and mobility;
- To track *deskota* and urbanisation globally and in detail for hotspot regions characterised by fragile natural environments and vulnerable social systems where crossing thresholds of sustainability can quickly tip socio-ecological systems into collapse.

Figure 8:
Transiting to High Value Vegetable Economy

© D Gyawali

Vegetables being packed in mid-hill Nepal for export .... to Bangladesh. Demand for high value crops-and the transport to facilitate meeting it-has seen conversion of poor rain-fed farmlands to drip irrigated commercial ventures where spring or stream sources can be harnessed.

© A Pokhrel

CHAPTER 4

The Ecosystem Context and Relationship to Desakota

Water plays numerous roles not just as a resource but also as a contributor to climate, chemical and biological processes and systems, and so it is a crucial part of numerous ecosystem services (Part II C section 2.2). However, the range and quality of water ecosystems are moderated in complex ways through the connectivity of the hydrological system across both time and space. Freshwater ecosystems are connected by flows of energy and matter (water, sediment, organisms). Any changes in the energy, quantity or quality of matter within or flowing through any part of the hydrological system can induce changes in other parts of the system. Such changes vary in space and time according to seasonal or longer term changes in climate (particularly precipitation and temperature), consumptive use by plants and animals including humans, and also human manipulations of the hydrological system. Pressures imposed at any place or point in time can be propagated through the system to yield responses that are often difficult to predict.

The processes driving the growth of desakota economic structures and those both contributing to and mitigating ecosystem degradation intersect in fundamental ways. Expanding desakota systems tend to concentrate pressures on ecosystems and the services they provide. Water-related ecosystems in many peri-urban or mixed economy areas are subject to severe pressure from a combination of agricultural, local non-farm and urban demands. This pressure stems from fundamental changes in land use, increasing demands for water and increasing pollution from all sectors. The combination of pressures often results, as the case studies demonstrate, in the creation of a highly polluted hydrological system. However, some positive pressures may also accrue from the economic structures that emerge. For example, populations having access to mixed livelihood baskets, resources and mobility can pull pressure off marginal lands enabling recovery of surface cover and thus better access to the ecosystem services on which livelihoods traditionally depended (e.g. forest products, clean water, etc...). That said, in most cases the combination of demands that range from continuation of "rural" agricultural water uses and waste/pollution to industrial and domestic impacts on water resources are generally severe (Allen *et al.*, 2006b; Bradford *et al.*, 2003; Douglas, 2004; McGranahan *et al.*, 2004) and can provide the perfect breeding ground for disease.

Beyond immediate impacts on water resources, the changing dynamics of desakota areas have major indirect implications for water-related ecosystems. Energy intensification is, for example, one such dynamic. An inherent feature of the growth of desakota economic systems is an increase in the mobility of the population, coupled with relatively energy intensive forms of agriculture or manufacturing production. Intensification of energy demands in desakota regions increase the use of both traditional and modern energy sources, which have clear implications for greenhouse gas emissions and climate change. In India, for example, expansion of groundwater irrigation, the foundation of much agricultural intensification, represents a huge increase in the energy intensity

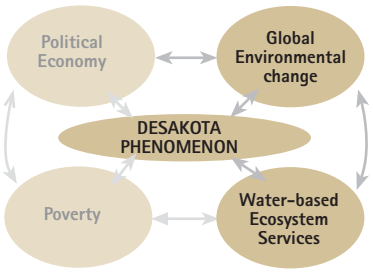
Table 2: **Linkages between State Changes in Water-related Ecosystems and Human Well-being (developed from Arthurton *et al.*, 2007)**

Pressures	State Changes	HUMAN WELL-BEING IMPACTS			
		Human health	Food security	Physical security	Socioeconomic
RIVERS, STREAMS, FLOODPLAINS					
• Changes to input from ↕ precipitation changes • Flow modification (damming, withdrawal) • Sediment budget modification • ↑ temperature • Eutrophication • Pollution (organic, microbial, heavy metals, persistent organic pollutants, solid waste) • Invasive species	• ↑ water residence time • ↑ ecosystem fragmentation • ↑ disconnection of river – floodplain connectivity • ↔ trophic structure • ↓ habitat • ↑ disruption of fish migration	• ↓ quantity of freshwater • ↓ natural purification processes, water quality • ↑ incidence of water-bourne diseases • ↑ malnutrition from ↑ drought • ↑ fish contamination	• ↓ fish stocks • ↑ flood damage • ↑ crop reduction from drought • ↕ crop reliability and change • ↔ species distribution from temperature change • ↑ salinisation • ↓ floodplain cultivation • ↓ livestock health	• ↓ flooding • ↑ drowning • ↑ community displacement	• ↓ tourism • ↓ fisheries • ↓ livelihoods • ↑ poverty • ↑ property damage • ↑ irrigated agriculture • ↑ allocation conflicts • ↓ water transport • ↑ cost of water treatment
LAKES, RESERVOIRS					
• Infilling, drainage • Eutrophication • Pollution • Overfishing • Invasive species • Temperature changes	• ↑ nutrients • ↔ trophic structure • ↓ habitat • ↑ algal blooms • ↑ anaerobic conditions • ↑ alien fish species • ↑ water hyacinth • ↓ storage capacity	• ↓ natural purification processes, water quality • ↑ fish contamination • ↑ chronic disease	• ↓ fish stocks • ↓ livestock health	• ↓ flood prevention	• ↓ tourism • ↓ fisheries • ↑ displacement of human communities • ↓ livelihoods • ↑ poverty
SEASONAL LAKES, ORGANIC WETLANDS AND OASES					
• Conversion, infilling, drainage • Change in flow regime • Water withdrawal • Change in fire regime • Overgrazing • Eutrophication • Pollution • Invasive species • If forested, conversion through tree felling	• ↓ habitat and species • ↓ flow and water quality • ↑ algal blooms • ↑ anaerobic conditions • ↑ threat to indigenous species • ↓ carbon storage • ↑ soil erosion • ↑ degradation of water resources	• ↓ water inflow and storage • ↓ natural purification processes, water quality • ↓ in available water quantity and quality		• ↑ flash flood frequency and magnitude • ↓ flood mitigation • ↓ drought mitigation	• ↓ buffering of flow extremes • ↓ livelihoods
GROUNDWATER					
• Water withdrawal • Pollution	• ↑ salinity • ↑ drying of shallow wells • ↑ surface water discharge • ↑ reverse groundwater flow	• ↓ available water quantity • ↓ quality from surface water	• ↓ agriculture extent and productivity • ↓ groundwater for irrigation	• ↑ conflicts and instability • ↑ competition for groundwater	• ↓ livelihoods • ↑ access costs • ↑ premature well abandonment • ↑ cost of water treatment
MANGROVE FORESTS AND ESTUARINE MARSHES					
• Reclamation • Pollution • Eutrophication	• ↓ decreased spatial extent • ↓ tree density, biomass, productivity	• ↑ malaria risk due to standing water	• ↓ coastal fish stocks	• ↓ coastal buffering capacity	• ↓ timber products • ↓ fisheries • ↓ tourism • ↓ livelihoods • ↑ displacement of communities

of agriculture and contributes directly to increases in GHG emissions. This example illustrates how the impacts of desakota development traverse spatial scales ranging from the local to the global. Therefore our assessment of desakota and ecosystems services considers trends and feedbacks at global, regional and local scales, to enable a holistic understanding of ecosystem changes. Global changes in temperature and precipitation are analysed and the hydrological and ecological impacts of this are considered at a regional scale alongside anthropogenic pressures from desakota development, such as land use change and intensification.

To understand the water ecosystem impacts of desakota development in specific areas, we have used a catchment-based approach because freshwater ecosystems are connected within catchments. We can only fully comprehend the impacts of direct changes to water-based ecosystems, such as water abstraction or pollution, and indirect changes, such as land use change, when the entire catchment is considered. Changes in land use, water quality and quantity that may be associated with desakota development in one part of a catchment can yield effects across the catchment and can be displaced in time. Such spatial and temporal displacements are particularly relevant for desakota, due to the patchy nature of its development and the locational disjuncture that is often seen between ecosystems and the services they provide. Table 2 summarises how pressures on water-based ecosystems typical of the complex effects of desakota, influence health, food security, physical security and socioeconomic aspects of human well-being. The linkages, impacts and feedbacks between desakota and water-related ecosystems across spatial scales are discussed further in section 4.1.

4.1 Ecosystems: Linkages Across Scales



Massive pressures on global hydrological systems are expressed in growing water scarcity and major declines in aquatic biodiversity (Part II C section 3). Management of both water quantity and quality has been so extensive, with widespread overuse, that anthropogenic impacts are clearly distinguishable across the entire global water cycle and the full range of water body types. These pressures are set to intensify under scenarios of climate change.

In this section, we investigate the impact of desakota within a landscape framework of terrestrial biomes (across space scales from global to regional) or a catchment framework (regional to meso-scales) – these are the 'natural' frameworks for water-related ecosystems science. Whilst accepting that 'desakota' is a multi-layered and extremely complex socio-economic phenomenon, in an ecosystem science context we consider it as a 'landscape treatment' or 'catchment treatment' of varying intensity that is controlled by: (i) increased population density and (ii) increased overall land use pressure, related to (iii) an increasingly patchy, complex and mixed mosaic of agricultural, industrial, commercial and urban land uses. In this way we are able to make the broadest use of the environmental sciences literature to assess potential desakota impacts on water-related ecosystems services within a context of climate change.

4.1.1 Vegetation and Land Cover Change

Interactions between atmosphere, land cover and land surface.

To date, enormous effort has been devoted to modelling climate and projecting climate change across the globe (Part II C section 3). Projections of climate change over the 21st century from multi-model comparisons are reasonably consistent in relation to temperature, indicating significant warming at the scale of the ESPA regions, but they are less consistent and more uncertain in relation to precipitation (Part II C section 4.2). Precipitation is projected to increase by 10% on average across China, with the largest increases in the north (+4 to +14%), especially in winter (+63%), and with smaller or no increases and a decline in winter precipitation (-36%) in the south. In India and the Hindu Kush, precipitation is projected to decrease during the dry season (-5%) and the monsoon is projected to intensify, bringing precipitation increases where the monsoon is currently strong and decreases where monsoon rain is weaker. In southern Africa, precipitation is projected to decrease in the south, particularly in summer, with little change or a small increase towards the equator and an increase in east Africa. In Amazonia, precipitation is projected to decrease towards the north and increase towards the south.

At a global scale, interactions between the atmosphere and biosphere result in the distribution of terrestrial biomes and ecoregions: 'relatively large units of land containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use change' (Olson *et al*., 2001, Part II C section 4.4). Changes in climate can lead to important adjustments within and between biomes, including large potential changes in physical structure (e.g. Dale *et al*., 2001) and biodiversity (e.g. Van Vuuren *et al*., 2006) as well as spatial extent. For example, very significant ecoregion shifts under projected climate changes are indicated by modelling studies in China (Yu *et al.*, 2006).

Such interactions and shifts are accentuated by human-induced changes in land and water use. Piao *et al*. (2007) argue that, despite important interactions between atmospheric CO_2 and vegetation that tend to decrease runoff under warming, land use change has had a larger influence on runoff than climate change over the last century, resulting in a notable increase. Deforestation, extension and intensification of agriculture, industrial development and the extension of road networks and buildings all increase runoff ratios and are typical of deskota development. Such human interference with vegetation cover has direct impacts on climate as well as indirect effects through changes in carbon storage and land degradation (e.g. Laurance, 2004), all of which may accentuate ecoregion or biome margin shifts as well as shifts in areas suitable to support agriculture (e.g. Ramankutty *et al.*, 2002) and other water-dependent activities. Since the desakota phenomenon is characterised by major changes in the nature, intensity and spatial pattern of land use, it has far-reaching implications for surface-atmosphere interactions that could significantly accentuate contribute to biome shifts and severely impact on water-related ecosystem services within and between biomes, and across spatial scales from entire ESPA regions to small catchments.

As a result of these interactions between surface cover and atmosphere, it is of crucial importance to have a dynamic, fully-coupled vegetation cover in global climate models (Foley *et al.*, 2000, 2003, Cramer *et al.*, 2001) that reflect changes in the physical properties of the land surface (albedo, roughness, leaf-area index, rooting depth, available moisture), and changes in associated

physical (fluxes of energy and momentum) and biophysical feedbacks (fluxes of matter, mainly carbon and water) (Foley *et al.*, 2000). Further refinement of the representation of vegetation / landcover feedbacks within climate models at a range of spatial scales could yield massive benefits in scenario-modelling of the consequences of land cover and land use intensity change and in advancing understanding of interactions between the desakota phenomenon and water–related ecosystem services in the context of climate change.

Scale-dependent interactions between vegetation and the water cycle: self-organised patchiness, catastrophic shifts in ecosystems and land use pressure.
Scheffer *et al*. (2005) and Rieterk *et al*. (2004) demonstrate hysteretic relationships between water-related variables (e.g. precipitation, soil moisture) and the cover of one or more vegetation types as threshold conditions for their survival are approached. Hysteresis may operate at different spatial scales. Thus vegetation can have large effects on regional climate, with this positive feedback leading to large-scale hysteresis between climate and vegetation change, and more locally certain plants, termed ecosystem engineers, can also control the availability of resources such as soil moisture and nutrients, until resource scarcity reaches a threshold and the system moves to a different, more homogenous state where the engineers are absent. For example, in arid areas, shrub vegetation patches shade the ground reducing surface evaporation and their root systems encourage water infiltration. These feedbacks, which maintain the local soil water resource, allow the shrub patches and associated understorey plants to persist once present. However, once critical environmental thresholds of moisture supply are crossed, the engineers and their moderating effects are also lost and, and as a result very substantial moisture inputs are needed to reverse the changes that have occurred.

Modification or removal of the vegetation cover, as is typically associated with the land use changes that accompany desakota development, disrupts these feedbacks accelerating changes in climate at larger spatial scales, and changes in soil moisture retention and thus land degradation at the local scale. Thus, Sternberg (2001) developed a simple dynamic model for savanna – forest landscapes in the tropics, that linked forest area to locally-produced (i.e. a function of land cover) dry season precipitation and feedbacks on forest establishment, illustrating that in marginal areas deforestation beyond a critical level caused a collapse of forest ecosystems and replacement by savannas. Laurance and Williamson (2001) also identified positive feedbacks between climate, deforestation and forest patch susceptibility to drought and wildfire damage, leading to what they described as a 'deforestation threshold' and Bucini and Hanan (2007), in a continental scale analysis of African savannas, concluded that a full understanding of savanna structure requires consideration of both resource limitation and disturbance dynamics. Analogies can be drawn between the patchy disturbances of forest and savanna landscapes described above and the emergence of complex, patchy, intensively-used landscapes in association with desakota. This implies a potential for the emergence of intense environmental thresholds in association with desakota development.

Extreme landscape pressures of land cover change are capable of causing rapid shifts in climate-landscape interactions, potentially leading to irreversible degradation with enormous implications for water-related ecosystem services, particularly where landscape sensitivity is high. A striking example of the impact of changing intensity of land use is found on the Tibetan plateau (Du *et al.*,

2004) where warming (0.04°C/yr) since 1978, particularly in winter (0.13°C/yr), has been associated with >200% increase in cattle numbers and 100% increase in sheep. The increase in livestock is believed to be a response to an increase in the spatial extent and productivity of plateau grasslands. However, grazing reduces vegetation biomass, which in turn reduces evapotranspiration and thus increases temperature, implying that the high temperature increases on the Tibetan Plateau may reflect not only global warming due to greenhouse gases but also overgrazing of vegetation due to increased livestock production, population increases and economic development. Whilst desakota areas offer more complex changes in land cover and land use intensity than this Tibetan example, the impacts of highly intensified land use under desakota, are likely to have similar environmental implications.

A major research need is to develop our understanding of interactions between land cover and climate under the pressures of desakota, including analyses of changes in the type, intensity, extent, distribution and patchiness of land cover types at different spatial scales, the sensitivity of different biome or ecoregion settings to such changes under current and projected climate conditions, and indicators (e.g. extent of high biomass land cover types, vegetation health / vigour, soil organic content) of systems approaching threshold conditions.

4.1.2 Land use, Water Stores, and Flow Regimes

Catchment land cover change

Along the gradient from biome to catchment, the relative importance of human influences on water-related ecosystem services changes from indirect impacts on climate to direct impacts on water quantity, quality and fluxes. Changes in land use that typify desakota development, such as clearance of forests (e.g. Costa *et al.*, 2003), extension of urban cover (e.g. Gurnell *et al.*, 2007) and intensification of grazing (e.g. Du *et al.*, 2004) or cultivation (e.g. Gordon *et al.*, 2008), transform catchment hydrological response and the relative importance of different hydrological pathways. Increases in the proportion of rainfall running off, decreases in infiltration/percolation to soil moisture and groundwater stores, and accompanying increases in soil erosion and sediment yields result from reduction of vegetation biomass, compaction or reduction of the fertility of soils, or the imposition of impervious surfaces. These changes impact on water stores, flow pathways, flow regimes and thus on all water-related ecosystem services

The hydrological impacts of land use change vary with spatial scale, pattern and intensity. As a result, it is not simply the aggregate changes across a catchment that affect water ecosystem services but their distribution and patchiness are crucial. Thus, Li *et al*. (2007) show, through numerical simulations of deforestation and overgrazing for the Niger and Lake Chad basins of West Africa, that there was no significant impact on water yield and river discharge of deforestation by thinning below 50% or patchy grazing below 70% for savanna and 80% for grassland areas, but water yield increased dramatically when land cover change exceeded these thresholds. Pandey and Devotta (2006), working on two Indian ecosystems, found that selective removal of trees (<25%) did not lead to significant hydrological alteration, but if a major block of forest was cleared, then spatio-temporal changes in the water balance were enormous. Patchy land use is typical of desakota landscapes. The above results indicate that if the patchiness can incorporate areas of semi-natural woodland or grassland, this can minimize adverse hydrological and ecological effects and sustains water-related ecosystem services far beyond aggregated but

proportionally similar land use. Interestingly, access to non-farm systems has pulled pressure off marginal lands in some desakota areas, enabling recovery of surface cover, particularly the extension of forests, and thus greater production of provisioning, regulating and aesthetic services.[5] For example, this has occurred in parts of the Himalayan region in India and Nepal.

Much remains to be learnt about how climate-driven land-cover modifications interact with direct land-use changes, amplifying them to induce even more dramatic changes (Lambin *et al.*, 2003) in hydrology and other resources at the catchment scale. Hydrological management through mixed and balanced land use approaches could be greatly aided by further fundamental research on hydrological trends and threshold conditions induced by particular mosaics of land uses and livelihoods that characterize desakota areas.

Water Quality: Buffers, Connectivity and Self-purification

The desakota phenomenon represents a spectrum from intensification of rural land uses, through land use supporting highly mixed 'rural-urban' economies to unplanned, often high-density 'urban' development around the fringes of cities. A key issue throughout desakota areas is access to 'clean' water and facilities for effective waste-water disposal. Thus, Merz *et al*. (2004) note increasing microbial and nutrient contamination of domestic water supply in rural areas of Nepal as a result of increasing settlement and intensification of agriculture; and Gupta and Deshpande (1999) describe mounting water resource pressures coupled with pollution of both surface and groundwater around expanding towns and cities in Gujurat, NW India (Box 3). Not only does increasing population density place pressure on water quantity and quality, but many people in desakota areas gain income from water-intensive activities, such as food production (e.g. Ellis and Sumberg, 1998) including animal husbandry and horticulture, brick and block making (e.g. Haack and Khatiwada, 2007), tanning and dyeing, and food vending. Household and industrial wastewater is rarely treated, and, when water resources are limited, farmers sometimes use untreated wastewater for irrigation (e.g. Rutowski *et al.*, 2007). These practices lead to massive deterioration in water quality (e.g. Kannel *et al.*, 2007) and high exposure of peri-urban dwellers to disease, particularly since many of the poorest people inhabit low-lying areas that are susceptible to flooding by contaminated water (Allen *et al.*, 2006). For example, in Tanzania, small industries and mining activity in desakota areas around Lake Victoria have caused severe water quality problems. High density and unplanned settlements around the slopes of Mwanza City, where shallow water table and steep gradients are ill equipped to deal with pit latrine systems, result in faecal waste increasingly entering ground water sources, or during times of floods, running into surface rivers and lakes (Part II G1). This has lead to an increase in the incidence of water-borne disease and increased nutrient run-off into the lake, damaging the already fragile ecosystem.

In the absence of water and waste-water treatment infrastructure, improved protection of water-related ecosystem services could be achieved by ensuring the provision of sufficient 'buffer' areas within the 'natural' drainage system to moderate hydrological connectivity to and from surface

5 Rudel *et al.* (2007) discuss this process of forest recovery that occurs when farmers abandon agriculture enterprises for better paying non-farm jobs as the "economic development path" to forest transition. They also point out that while forest transition may lessen local environmental impacts by people, the total impact of these people on forested lands may actually increase if they import substantial amounts of wood products and agricultural commodities from distant lands.

Box 3: Increased Industrialisation Causing Pollution Problems

Large parts of the Sabarmati river basin in Ahmedabad and Gandhinagar districts of Gujarat, India, comprise a major desakota zone that has witnessed rapid urbanisation and industrialisation catalysed by creation of industrial estates by the sate government. Eighty percent of the population in these districts is urban (Census of India, 2001). There are respectively 314 and 203 working factories in Ahmedabad and Gandhinagar districts (Centre for Monitoring of the Indian Economy, 2000-01) and the number of registered Small Scale Industry units in these two districts is 12776 (Centre for Monitoring of the Indian Economy, 2002-03). Especially in and around the desakota villages located across the Vadsar industrial zone, GIDC Vatva, Naroda, Gandhinagar, Himmatnagar, Narol, Aslali and Isanpur areas, these industries focus on food packaging, chemical and pharmaceuticals, cloth factories, and confectionary factories. In this area, high levels of pollution are present from disposal of partially or untreated industrial wastewater into groundwater and surface water systems. Part of the pollution problem can also be attributed to sewage disposal and open sanitation practices. This has aggravated existing water quality problems in this area caused by fluoride, salinity and other contaminants in the groundwater system. As a result, locally available water resources are unfit for drinking in most of the area and pose a serious threat to public health. They are, however, the only sources poor communities have access to. People from the area complain of fluorosis, joint pain, gallstones and stomach ailments. To meet the drinking water demand and also address the water quality problem, the Government of Gujarat has started supplying Narmada waters imported over long distance to the area. This, however, is only one step toward addressing the problems associated with pollution and water quality declines.

Source: Gujarat India Case Study Part II F2

and groundwater systems. Such buffer areas could be located at critical points within catchments, stimulating the retention and processing of wastes before they impact on downstream ecosystems. Research is needed to investigate small scale, low cost distributed measures to support self-purification of water within the drainage network. Such distributed measures could also improve the runoff regime, retain fine sediments and support aquatic and riparian ecosystem complexity and services.

Change and Manipulation of Water Storage

The major water stores in a catchment are groundwater, lakes and wetlands, snow and ice and the river flows that they regulate. Changing climate and human demand will greatly affect all of these water stores.

Approximately one-sixth of the Earth's population relies on glaciers and seasonal snow packs for a very significant component of their water supply (Barnett *et al.*, 2005; UNEP, 2007). In three of the ESPA regions (India and the Hindu Kush, China and, to a lesser extent, Amazonia) snow-ice storage is a major water store and river flow regulator. Over the last decade, glaciers have generally been shrinking and within the ESPA regions this has been particularly marked in Asia (Meier *et al*., 2003, Lemke *et al.*, 2007). Precipitation falling as snow is forecast to reduce dramatically (UNEP, 2007), implying further major shrinkage of glaciers and snowpacks. Loss of snow and ice storage will be a particular problem towards the western end of the Himalayas, since the monsoon weakens and summer precipitation declines from east to west. Rees and Collins (2006) estimate that under a uniform warming of $0.06^{\circ}C.yr^{-1}$, glaciers will disappear in 2086 and 2109, respectively, in the west and east. As a result of the arid conditions in the west, particularly at lower elevations, meltwater from snow and ice accumulations is the major component of runoff for great distances downstream and is crucial to regional water resources. For example, the population and economy of Pakistan are heavily dependent on an annual influx of about 180 billion cubic meters of water into the Indus river system, that comes largely from snow-melt in the Himalayas (World Bank, 2005). Snow and ice masses not only provide a reliable source of water to many river systems but also heavily influence their flow and temperature regime, for example delaying peak flows by several months. Loss of snow and ice storage will induce major shifts in the average annual flow regimes and year-to-year reliability of many major river systems, contributing significantly to an apparent intensification of the global water cycle (Huntington, 2006). Loss of snow and ice storage is an impact of climate change that will have enormous implications for many deskota areas in India and the Hindu Kush, forcing the development of new methods of water retention within affected catchments if the current populations are to be sustained.

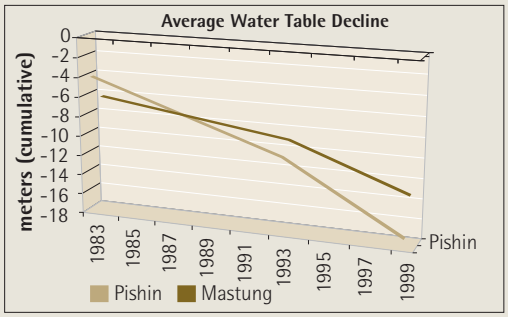
Direct human manipulations of groundwater and lakes, dam construction and water diversions are having enormous effects on water resources, river flow regimes the hydrological,

geomorphological and ecological functioning of catchments and, in aggregate, have very significant effects at the regional and global scales. For example, large dams currently store over 5000 km^3 water worldwide of which over 3000 km^3 are used in regulating river flows (Vörösmarty and Sahagian, 2000). Average aging of water passing through these large water stores is of the order of two to three months, strongly influencing the timing and magnitude of downstream river flows, and thus completely changing river ecosystem functioning and water-related ecosystem services.

'Aquifer mining' or overabstraction of groundwater stores is also having increasingly deleterious impacts on water resources, catchment hydrology and river networks. Whilst large dam development is too expensive to characterize deskota development, overabstraction of groundwater is particularly notable in association with deskota development in arid and semi-arid areas of south Asia and China. Groundwater pumping, usually for irrigation, is competing with traditional methods of groundwater management and usually greatly exceeds recharge rates. Furthermore, recharge from irrigated agriculture mobilizes salts accumulated in the unsaturated zone, resulting in widespread ground and surface water contamination. In many regions, increased groundwater exploitation associated with desakota development has resulted in declines in groundwater levels and water quality. For example, overexploitation of groundwater in northern China has induced the drying up of wells, land subsidence, pollution from waste-water contamination and seawater intrusion, and land salinisation (Han, 2003). In the Balochistan province of Pakistan, over exploitation of groundwater resources is causing rapid depletion of many aquifers and the disposal of untreated industrial, domestic, and municipal wastes into open water bodies and extensive use of insecticides, pesticides, herbicides, and chemical fertilizers on agricultural lands are polluting aquifers that are used for drinking water (Majeed, 2004, Box 4). Changes in the size and quality of the groundwater store have major implications for the quantity and quality of river flows (e.g. Smith *et al.*, 2008; Xu, 2001; Kang *et al.*, 2004; Ma *et al.*, 2005; Smith *et al.*, 2008).

Sustainable use of water resources, maintenance of the balance between land and water resources, and development of water-saving agriculture are required if desertification is to be arrested or reversed. In particular, development of smaller-scale distributed approaches to water management are needed, including water-retentive land use mosaics, infiltration basins and small surface storages, that are likely to be more sustainable and will avoid the adverse catchment-scale impacts on water quality, quantity and ecosystems that typify intensive surface and groundwater manipulations.

Box 4: **Water Mining in Balochistan**



Balochistan (Pakistan) is water scarce area with an average of 200mm of rain per year. Much of the traditional agriculture has depended on occasional rain fed or spate irrigation. In addition, community based *karez* system was a source of perennial water with an average discharge of around two cubic feet per second and was shared by up to 200 families. Deemed outdated in the 1970s there was policy shift towards using tube wells and much more water intensive cash crops like apples (Government of Balochistan and IUCN Pakistan, 2000). Although, it was an initial success, the water tables in the area started falling at alarming rates (Chaudhry, 2000).

While the tube wells are pumping water at least ten times the output of the *karez* the cutting of trees in the upland coniferous zones is possibly reducing ground water recharge (Olson *et al.*, 2001; Majeed, 2004). As a result many of the villages can no longer sustain any form of agriculture due to over-exploitation of the groundwater. The relatively richer households have managed to diversify livelihood by investing the windfall income into businesses and education. The poorest were, however, landless and dependent on daily labor in orchards and traditional rights to collect firewood and fodder. With dying of the orchards their entire source of incomes both in terms of cash and ecosystems services have suddenly disappeared

The catchment-wide effects of unplanned land use change and intensification, water resource exploitation, wastewater disposal, and water pollution impact particularly severely on river channel margins and wetlands through increases in flood frequency, low flows and water contamination. As a result, river channel margin areas that are naturally highly productive become severely degraded in desakota areas. The unplanned nature of desakota development often results in the poorest people inhabiting the low-lying degraded areas along river margins and as a result suffering severe consequences for their health and well-being.

(See Pakistan Case Study Part II F3)

Flow Regimes

Climate, land cover, and manipulation of water stores all ultimately govern river flow regimes (the annual pattern of monthly flows where the difference between high and low flows has both a timing and an amplitude, Harris *et al.*, 2000). A variety of flow regimes, characterised by their timing, amplitude and inter-annual variability, are found in different regions of the world (e.g. Dettinger and Diaz, 2000).

The river flow regime is thought to be the fundamental driver of both aquatic and riparian ecosystems (e.g. Junk, 1989; Petts, 1996; Poff *et al.*, 2003; Junk and Wantzen, 2004), acting as a transport and dispersal mechanism, habitat regulator, process modulator and disturbance (Doyle *et al.*, 2005), and so it is also a fundamental control on water-related ecosystem services. Research has focused upon quantifying properties of river flow regimes that might be of ecological importance (e.g. Olden and Poff, 2003) and on adverse impacts of changed flow regimes on aquatic and riparian ecosystems (Nilsson and Svedmark, 2002, Pinay *et al.*, 2002) and fisheries (e.g. Sultana and Thompson, 1997, Xenopoulos *et al.*, 2005) but much remains to be investigated, particularly in the context of complex, patchy, heavily human-impacted catchments that typify desakota.

Bunn and Arthington (2002) note that 'evidence about how rivers function in relation to flow regime and the flows that aquatic organisms need exists largely as a series of untested hypotheses' and so is a major research need. Since the flow regime is the culmination of all of the processes and projected changes discussed above; the cause of hazards such as floods and low flows, channel avulsion, bed incision or aggradation and bank erosion; and the driver of aquatic and riparian ecosystem services; desakota-impacted flow regimes demand close research attention. Such research needs to focus on flow regime characterization, controls and the development of approaches to distributed, small-scale water management to the benefit of both the flow regime and riparian – surface water – groundwater connectivity. Although not investigated in depth in our report, integrated research of this type could also focus on the dispersal of alien species, the multivariate triggers that cause such species to become invasive and possible control mechanisms.

4.1.3 Water-related Diseases

Water-related infectious diseases claim up to 3.2 million lives each year, approximately 6% of all deaths globally (MEA, 2005). Climate changes, coupled with increases in human pressure associated with desakota activity, are having major effects on the distribution, severity and changing patterns of water-related diseases (Part II C, section 4.6). Whilst the impacts of certain desakota-associated phenomenon on water-related diseases are well known, such as poor sanitation and contaminated drinking water, the impacts of more general land use pressure and change, particularly in conjunction with climate change remain controversial.

In relation to desakota, intensified encroachment on natural environments; reductions in biodiversity, particularly reductions in natural predators of vector organisms; increased, close proximity to particular livestock, crops, and production methods that support disease transmission; and direct pressures on water resources imposed by uncontrolled urbanization or urban sprawl have all been identified as contributors to the spread of water-related diseases (MEA, 2005). Under increasing population pressure and water demand, and as pre-existing water management institutions become stressed or fail under desakota change, naturally-occurring

water-quality problems can have severe health consequences that are independent of land use change (e.g. fluorosis and arsenicosis e.g. Chinoy *et al*., 1992, 1994, Dhiman and Keshari, 2006). Deforestation and associated changes in land use, irrigation, human settlement, industry and road construction, typical of desakota development, have been accompanied by an increase or emergence of malaria, and schistosomiasis in some areas of Africa and Latin America (Patz, 2001). Although malaria is endemic in the Amazon region, Takken *et al*. (2005) describe a dramatic increase in malaria cases, which peaked at over 500 000 cases per year in the 1990s. They argue that deforestation has favoured the main malaria vector *Anopheles darlingi* by creating numerous sunlit larval habitats and also bringing many potential blood hosts (workers in forestry, agriculture and animal husbandry), into close contact with mosquitoes. Vittor *et al*. (2006) confirm that in Peru *A. darlingi* demonstrates significantly higher human-biting intensities in areas that have undergone deforestation and road development. Takken *et al*. (2005) note that although malaria clinics and control programmes are now reducing the number of malaria cases in Amazonia, risks remain high in rural and peri-urban (i.e. desakota) areas where humans and mosquitoes are in close contact and where health surveillance and primary health care infrastructure and institutions are increasingly out to step with risk. Desakota is not necessarily negative – new transport and information exchange flows can open opportunities for learning and action to mitigate new risks but this requires a strong co-ordinating system.

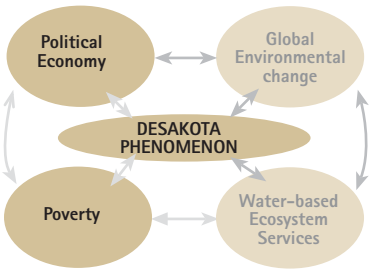
Climate extremes and changes can (i) affect health directly (e.g. temperature- related morbidity and mortality, health effects of extreme weather events, floods, air-pollution), (ii) aggravate pre-existing health conditions (e.g. effect of heatwaves on people suffering cardiovascular or respiratory illnesses), and (iii) increase exposure to infectious diseases by supporting their transmission (Martens *et al.*, 1999, Patz *et al.*, 2005), and extending their spatial and seasonal ranges. It is in area (iii) that climate impacts are particularly complex and, in some cases controversial. Thus, Magadza (2000) suggests that the latitudinal and altitudinal range of malaria and schistosomiasis are likely to increase as stream flows are reduced to a series of pools, which reduce mosquito larvae mortality for much longer periods than at present, and that onchocerciasis (river blindness) could establish further south within Africa. The prevalence of waterborne disease agents, such as *Giardia* and *Crypposporidium* cysts have been correlated with rainfall, and malaria epidemics have been correlated with El Niño-related extreme weather conditions (Patz, 2001). Also Lama *et al*. (2004) and Olago *et al*. (2007) have associated environmental temperature, particularly in relation to El Nino, and the incidence and extent of cholera. However, Patz *et al*. (2005) note that there is still uncertainty in directly attributing the intensification or reappearance of water-related diseases to climate change because of the lack of long-term, high-quality data sets and the variable influence of confounding factors such as socio-economic and immunity / drug resistance changes.

Uncertainty and scientific controversy are particularly notable in relation to associations between climate trends and the occurrence of malaria. For example, there are conflicting results in relation to increases in the incidence of malaria in the East African Highlands, where it has become a serious health problem. Whilst some studies have shown little association between climate and malaria (Bouma, 2003; Hay *et al*., 2002), Pascual *et al*. (2006) showed strong linkages between malaria and temperature increase and Zhou *et al*. (2004) suggested that climate variability may be also be influential.

Research connecting climate change, desakota and catchment and river functioning is needed to identify and develop catchment and river management interventions between water ecosystem processes and water-related diseases

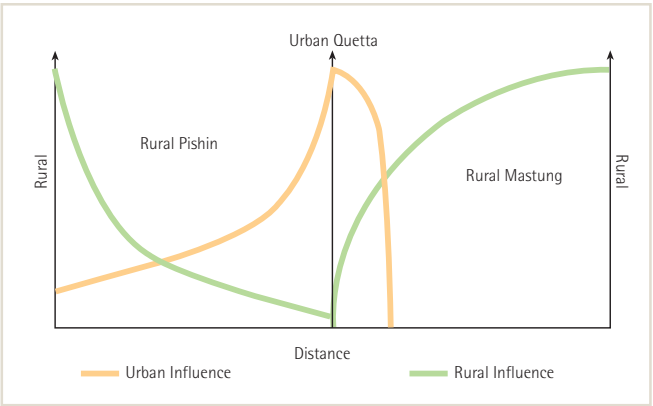
Desakota regions, as argued throughout this report, are regions where existing institutional management approaches have come under severe stress from a range of social and environmental pressures. As described in the above sections, these environmental changes are complex and have interlinkages across scales. Furthermore, the rate of adaptation of institutions often falls behind those of biophysical changes occurring in ecosystems. This institutional lag is due to poor understanding of the scope and nature of these environmental stresses, and is exacerbated by inertia inherent in social organizations. The ecosystem challenges summarized above and described in detail in Part II C, need to be examined against the institutional context within which they manifest themselves.

4.2 Institutions and Desakota



As transitional environments, the concepts that underpin most approaches to the development of institutions for ecosystem management may be less applicable in the desakota region. Community-based approaches, one of the centrepieces of development strategies in most rural regions, are heavily challenged when communities are no longer strongly interdependent and geographically defined. Mobility, the diversification of livelihood and income options, changing social relationships—all these factors raise major questions regarding the viability of community-based approaches. More urban approaches to the development of institutions for ecosystems management are less applicable in the desakota context. Formal management organizations (such as municipal authorities, water districts, forest and park departments, utilities) are generally either weakly established or function as "enclave" institutions—structures that function in physical or social isolation from the realities of daily life for the populations living in the desakota region. Instead, desakota environments are characterized by highly mobile informal institutions—such as informal water markets—that focus on provisioning services but less often on management of the ecosystem or resource base itself. Notionally the schematic diagram in Figure 9 in the context of the Pishin Mastung case study in Balochistan illustrates the trajectory of influence of formal urban and rural informal and customary institutions across the rural urban spaces. (For details please see appendix F, Pishing-Quetta-Mastung corridor case study.)

Figure 9:
Pishin-Quetta-Mastung Corridor: schematic representation of the reach of urban formal and rural informal/customary institutions.



The low intersection of urban and rural influences in case of Pishin illustrates a relative institutional vacuum in the Pishin area, which has higher desakota type influences than Mastung.

The institutional challenge for ecosystem management illustrated above is complicated further by the locational disjuncture between the "ecosystem" itself and the services it provides. In some cases this takes the classic upstream-downstream set of relationships (hill areas supplying water that downstream *desokota* regions depend on), as illustrated in the Andes case study (Part II G3). However, services in the other direction also occur. The transmission of pollutants from desakota regions to downstream rural or urban areas may be regulated by riverine ecosystems that decompose or sequester contaminants. Also, the nature of ecosystem services often changes as desakota characteristics grow. For example, forests in rural areas forests may provide provisioning services such as food, fuel, fodder, and lumber for local use. As the desakota characteristics of a region increase, however, the benefits (and the demands) from forests may shift. Provisioning services may change from fodder to fuel, or services may move away from provisioning toward regulating, such as ensuring a continuous base flow, filtering of pollutants, temperature mitigation, or cultural (aesthetic) values. In addition, provisioning services may shift from meeting local demand to more distant areas, such as with the global flow of food and biofuels. Or, as in the case of the Amazon forests, ecosystem services may include the global regulating function of carbon sequestration. Such shifts have major implications for the relationship between ecosystems services and poverty. They also have very major implications for the incentives different groups may (or may not) face to manage ecosystems or to pay for ecosystems services. As a result, the whole question of institutions for ecosystem management becomes conceptually and practically complicated in desakota environments.

On a conceptual level, many development models for the management of forests, water resources and other ecosystem elements begin by assuming some form of direct connection between users and the resource base. This is, for example, the core assumption underlying frameworks of the "commons" and community-based natural resource management (Ostrom, 1990, 2002; Agrawal, 2001; Baland and Platteau, 1999; Ribot, 2002). These frameworks lead to institutional models for resource management through spatially delimited local communities, assuming that those benefiting from the resource have a stake in its management and in its sustainability. They also often assume some level of interdependency between users; none of the individuals involved may be able to function economically or even survive unless they contribute to group management and maintenance of the system or resource. The "operational" model that follows involves the creation or building of management institutions that formally link input to management with benefits from management. In the desakota and rapidly urbanizing regions, the linkages between management and benefit are often several steps removed. Furthermore, many residents with diverse basket of livelihoods may not be as directly dependent as they once were on water resource based activities, such as agriculture, and therefore may not be as committed to maintaining communal infrastructure, such as that for irrigation.

Changes in the tank systems of South India with the spread of mechanized pumping technologies illustrate the manner in which changes in interdependency affect institutions. Much of South India was traditionally irrigated through interlinked tank (pond) systems that were constructed, operated and maintained at the community level. The introduction and rapid spread of mechanized pumping technologies fundamentally changed incentives for maintenance of tanks and the irrigation systems they supported (Janakarajan, 1994; Janakarajan, 1999; Janakarajan and Moench, 2002). With a well and pump, individual farmers were able to access water at the time

Figure 10:
Diesel Imperialism

A traditional water wheel in Rajasthan lies in ruins, displaced by a diesel pump. Subsequent overpumping led to groundwater overdraft rendering the diesel pump irrelevant. In Nepal's Gandak irrigation command, non-functioning government-managed gravity-flow tertiary distribution prompts a farmer to assure his field's irrigation by .... a diesel pump!

and in the amount they required without having to wait for their share of canal deliveries. Furthermore, once the well and pump were in place, individual farmers had little incentive to contribute to joint maintenance of the tank system. In theory the tanks contribute to groundwater recharge in ways that ultimately benefit well owners. But the link is far from direct and often difficult to prove even through detailed scientific studies (COMMAN, 2004). Now, in many parts of South India the "rural" economy has diversified and the incentives to contribute to the management of tank systems have further declined. A similar transition is documented in the case of the karez system in Balochistan as described in Box 5 below.

Box 5: Technological and Institutional Transitions: water resources under desakota conditions in Balochistan province of Pakistan

Karez is the traditional technology for passive tapping of groundwater in Balochistan province. In addition to Balochistan, the technique is also widely practiced in the arid regions of Afghanistan, Central Asia, West Asia, North Africa and even as far as Peru. *Karez* constitutes an aqueduct for tapping water table and involves intense social organization for its construction and maintenance. The social capital around *Karez* is characterized by secure water rights for the share-holders, active water markets, and well articulated systems of reciprocal exchange and customary rights of access to water for domestic use (Mustafa, 2007). As part of the modernist social and technological transformation, individually owned tubewells are gradually replacing the *karez* system in the province. The excessive pumping of ground water has substantially lowered the water table in the province bringing the *karez* system to the brink of extinction. This technological transformation has profound, cultural and institutional implications, particularly since those changes limit poor people's access to water in addition to straining *karez* centered social capital. Local voices illustrate this well:

With the unlimited growth of tubewells, the karezes *have gone dry which hurts the smaller shareholders, the* bazgars *[tenants], and the poor. The larger shareholders have of course benefited, because they could install personal or shared tubewells.* (Zangeen Khan, Kunghar).

In these modern times people are abandoning the ancient and traditional irrigation, and trying to maximize cropped area. Ever since the tubewells have arrived, a competitive trend has emerged amongst the people and farmers. The installation of tubewells for modern irrigation succeeded in increasing agricultural productivity, but it also gravely damaged the ancient Karez system. Karezes were a great source of social and communal life for us village folks. People would sit on their sides and discuss their issues and find solutions to their problems. But modern times, new technologies, and tubewells have dried out the karezes and their resurrection is no longer possible, nor is there any future for the existing ones (Ghaus Bux, Kunghar).

Source: Pakistan Case Study Part II C3

In much of the industrialized world, society attempts to deal with management needs such as those above through formal management institutions. Replication of this model in many developing country contexts has resulted in the creation of "enclave" institutions. Such enclave institutions often exist in direct competition and conflict with remnant "traditional" and other community-based resource management institutions and with the informal (often market) institutions that have emerged to meet water supply or similar needs. They generally serve the interests and respond to the perspectives of wealthy sections of the society, often to the detriment of the poor. Forest reserves designed to protect sources for piped water supply systems, for example, often exclude the poor from access to basic fuel and other resources. At the same time, the poor are far less likely than wealthy sections of the population to receive supplies from the piped water systems.

It should be noted that governments have made efforts to address this disjuncture between formal and informal management institutions, and resulting inequities. For example, in the

Box 6: Tanzania: changing notions of community management

The attempts by the Tanzanian government to introduce participatory ecosystem management initiatives in previously rural wards of the Mwanza District on the shores of Lake Victoria provide a good example of how traditional conceptions of ethnically and culturally homogenous, bounded communities are not only redundant in the desakota context, but can exacerbate tensions and further aggravate ecosystem pressures. In Kabangaja village, the community based natural resource management system introduced to manage lake side ecosystem concerns in the form of Beach Management Teams, did not take into account the large population of immigrant Ha fishermen living in the village, nor the presence of an Italian fish processing plant. Their attempt to manage the beaches in a community based, participatory fashion, caused tensions between the local Sukuma farmers and the immigrant fishermen—both of whom felt they should represent 'community' concerns. It also caused tensions between both of these groups and the Italian fish processing plant, as the regulations were biased towards Perch fishing, which was the basis of the fish processing plant's economic activity, but not of the local fishermen, who focused on catching the indigenous *dagaa* fish. The failure of the government to take into account existing ethnic tensions, and the highly diverse nature of the community and its natural resource use practices, led to ethnic tensions flaring up, and vigilante groups forming in an attempt to counteract the actions of the Beach Management Teams. This is a prime example of how redundant notions of rural 'communities' were not only ineffective in managing the ecosystem services at hand, but created serious conflict amongst local resource users and had adverse effects on the attempts to regulate the harvesting of lake resources.

Source: Case Study Part II G1

Andean irrigation sector, research has posited that local and indigenous water rights and rules in the Andean region have been neglected and discriminated against (Cremers *et al.*, 2005). The Government of Ecuador requested research to propose institutional reform to strengthen the national irrigation sector, and examined institutional viability, political democracy, equity and water rights security. Results stressed the complementary role of central governments, local governments and water user organizations in enabling policy frameworks, and to translate constitutional recognition of local and indigenous rights and common property systems into practical procedures and institutional structures (Cremers *et al.*, 2005). However, in desakota contexts, where notions of "traditional" and "local" are undergoing rapid change, and "local" may include a wider range of actors, including migrant populations, approaches to "community management" and "local associations" may be problematic. As Box 6 illustrates, the disjuncture between institutions and the interests of different groups can create tensions that spill over into active or passive forms of conflict.

Traditional gender-based roles in the processes of harnessing ecosystem services also have been changing under desakota influence. For example, women in Bangladesh used to manage a healthy stock of seeds for future use. With the advent of desakota phenomenon, such institutional roles have become redundant. International imports of high yielding seeds (often provided by multinational companies), improved communication and media interferences (advertisements) are particularly focused on males, the public decision-makers in much Bangladeshi society. This has reduced the role women once had in deciding on which varieties of seeds to store and use. Decisions are now taken within the much more public sphere created by markets.

Markets are probably the most common and robust forms of institutions in desakota regions. As markets grow networks of buyers and sellers involved in the production, transport and marketing of goods emerge. In some cases these relationships exist as formal associations such as dairy cooperatives, mother's groups, vegetable grower associations, and business groups. In others, people are linked through the daily interactions necessary to support their livelihoods and they may not even be aware of the chain of relationships within which they exist. Whether formally structured or not, vertically linked networks are often the main entities directly delivering the produce (firewood, water, food, etc.) harvested from ecosystems. In some cases, as with local water markets, the ecosystems involved are proximate. In other cases, as with the delivery of wheat from the northern hemisphere to Africa or soybean from Brazil to Asia for biofuels and livestock, the ecosystems are distant and the markets create virtual flows of ecosystems services between regions.

Models for payment of ecosystem services (PES) are an additional market-based approach that facilitates compensation from end users/beneficiaries of services to those who are responsible for managing the resource. Conventional water-based payment for ecosystem models take place within the context of a watershed and generally have involved downstream users in, for example urban areas, paying upstream habitants to protect forest areas as a way of maintaining river flows and water quality (Rosa *et al*., 2003; Swallow *et al.*, 2007). PES models have been viewed by policy and development actors as tools to compensate those, often more poor, in rural upland areas, for investing time and energy in the management of the ecosystem, even if they are not the immediate beneficiaries of the provisioning and regulating services these provide. Critics of this model have raised concerns that financial payments may not reach the poor in these areas. Some have advocated from a movement away from a conceptual framing of financial "payment" to one that considers mechanisms for "compensation and rewards" which may evoke a wider range of compensation measures (Rosa *et al*., 2003; Swallow *et al.,* 2007). In conditions where there are global flows of ecosystem services, such as forests sequestering carbon to mitigate emissions of global greenhouse gas emissions, PES models are also emerging such as REDD (Reducing Emissions through Degradation and Deforestation).

REDD models are vehicles for national countries (UNFCCC, 2007) to provide payment to developing countries to enhance forest cover and limit forest clearing, and limit other degradation processes. While REDD agreements are currently under development, there are some questions about how payment may reach the poor, and whether or not there may also be further repercussions of preventing access of the poor to forest areas. For example, with the delineation of park or forest reserves, this may directly affect their access to the fuel, food, medicines, or NTFPs and other provisioning services on which they depend for their daily livelihood or income needs. Trade of food is another example of a global flow of ecosystem services, in essence the virtual flow of water from producing regions to consumers. Under the payment for ecosystem services model, the cost of maintaining distant systems would be incorporated in the cost of products, in the case food. This would see a flow from consumers to land and water managers in producing regions. With the poor already paying large portions of income for food, and with price escalations, this could exacerbate poverty conditions. As such, payments for ecosystem maintenance would fall on those who could least afford the cost.

Overall, as a result, the institutional challenge in desakota regions can be seen as emerging from the following:

1. The decline of geographically defined and geographically dependent communities and, accompanying this, the decline of traditional resource management institutions based on notions of reciprocity: people, activities and products are increasingly mobile and separated from the condition of local ecosystems;
2. The growth of informal and formal, market-based, institutions of exchange for delivering ecosystem products such as water, food, fuel and fodder. These institutions generally lack the organizational structure necessary to engage in ecosystem management as well as product delivery;
3. The separation of formal institutions (private agricultural or industrial estates, areas managed by forest or park departments, town and city municipal corporations) into functional enclaves where little or no incentive exists to maintain the flow of ecosystem services to the poor. In the absence, or weak presence, of institutions for formal regulation, desakota regions see poor

redistribution of ecosystem service benefits, thus contributing to conflictual situations among various social entities therein; and

4. The limitations of payment for ecosystem models to reach the poor with challenges in extrapolating models as one moves from more local to global flow of ecosystem services.

In some locations, institutions for resource and ecosystem management have emerged in desakota context that attempt to respond to the above challenges. For example:

- In Tamil Nadu, farmer groups have been working with representatives from the tannery industry to identify viable mechanisms for reducing pollution (Moench *et al.*, 2002);
- In Yemen, an "association of local projects" financed through remittances in the Tai'iz area (Al Hima) provides an array of water services that include attempts to regulate groundwater extraction (Mohieldeen, 1999; Ubels and Wevers, 1996); and
- In Nepal, community forest management activities begun in the mid-1980s, and more recently, community water supply as well as electricity, continue to expand despite the last decade of war and extensive out migration of the youth, particularly young men.

These examples, a very small selection among many that could be found, suggest that institutions for ecosystem management can be formed or encouraged to emerge despite the major changes occurring as economies diversify and communities become increasingly defined on the basis of social networks and less on the basis of geography or physical proximity. Understanding how, where and why such institutions for management might emerge and contribute to the maintenance of ecosystems and ecosystem services represents a major social and natural science challenge in desakota regions.

The development of effective institutions for managing resources in desakota regions is particularly intense with regard to water and water-based ecosystems. Challenges in the forestry sector illustrate contrasts with water resources. For example, the successful expansion of community forestry across areas of Nepal despite heavy migration and the growth of desakota type economic systems illustrates some form of effective management. With forests, management areas can be clearly delineated and the effects of management can be directly observed. With water resources, however, this is often not the case. Groundwater overdraft, for example, often results from competitive deepening of wells in desakota areas as conflicting interests seek to maintain access to limited water supplies. In addition to increasing the scarcity of water, this often has impacts on surface ecosystems. The volume of water available, the boundaries of the resource base and the impacts on ecosystems, however, often are not clear to users. In comparison to the forestry case, delineating the resource base and the interconnections between water use and ecosystem impacts often requires far higher levels of natural science research. At the same time, without understanding the dynamics of the system it is often impossible to identify the points of leverage for management around which institutions could be created. The social and natural science challenges facing the development of effective institutions are, thus, intimately interlinked.

Unless they are properly addressed, the absence of effective institutions for managing the resource base and mediating competing demands can spill over into conflict[6]. The example from China in Box 7 serves as a particular illustration of the issues that can emerge in desakota contexts.

[6] The Pacific Institute maintains a database and bibliography of conflict incidents involving water. See http://www.pacinst.org/resources

In many cases, despite well-intentioned efforts, formal regulations are ineffective for maintaining ecosystems and mediating conflict in desakota regions. The institutional reach of formal regulatory structures often is extremely limited in the dynamic and rapidly changing desakota contexts. In China, for example, the government prepared the 'Bo Hai Blue Sea Action Plan' and the 'Water Pollution Prevention Program of Hai River Basin' and executed it through the State Environmental Protection Administration (SEPA). These programs concentrated pollution prevention in the large urban centres of Beijing, Tianjin and Shijiazhuang and pollution from these large point sources decreased. However, the water quality has continued to decline from much smaller scale urban centres and industries, which have been estimated to contribute to 50% of the pollution in the Hai river basin (Global Environment Facility; Schweers *et al.*, 2008). This type of dynamic is common. While such formal regulatory measures are important, they tend to be more successful at regulating pollution from large point sources but lack the capacity to do this from the diverse array of much smaller users that characteristically emerge in the "informal world" that characterizes desakota contexts. Understanding this "informal world" is, as a result, essential.

Box 7: **Governance, Management and Institutions in Miyun Basin, China**

© W. Schweers

Managing the city's water crisis and dealing with various cross-jurisdictional and cross-sectoral conflicts have become some of the most demanding tasks of the Beijing government. The two main water conflicts stemming from Beijing's growing thirst include: (1) regional conflicts over water distribution and quality, and (2) Beijing municipality limiting Miyun county's development aspirations. Particularly under dispute are Miyun's control of mining and intensive fish farming and programs for restructuring the agricultural sector (Peisert and Sternfeld, 2005). The disparities between the urban population benefiting from ecosystem services and the rural population requested to provide them, is an example of the conflict in desakota region between rich and poor and competing interests between provisioning ecosystem services (farmers) and regulating services (urban residents) along the desakota scale.

Source Case Study Part II G2

4.3 The Informal World

The desakota region is characterized by a mix of formal and informal economic activities (Aberra and King, 2005; Tacoli, 2002; Thanh *et al.*, 2005), with implications for the understanding of poverty as well as the management of natural resources. Too often, the conceptual debates around poverty alleviation have concentrated on "economic growth" assuring its actualization. While it is undoubtedly true that economic growth is necessary to generate and sustain the flow of resources necessary for poverty alleviation (Cooper *et al.*, 2005), it alone, without the requisite institutional vehicles, will not assure that the well-meaning measures will even reach the poor. As the cases from Sub-Saharan Africa, Latin America and South Asia indicate, gains from economic growth in pockets can be completely swamped by other social demerits such as uncontrolled in-migration or population growth. On the positive side, in the Nepal-India case study transect, income from remittances (from mostly informal migration) is orders of magnitude greater than foreign aid or direct investments. The role of the state, which work along the formal system, as well as other institutional instruments, such as self-help groups and clan networks, that rely on more informal arrangements are crucial to the understanding how actual economies work in the clumsy space called desakota. Focusing only on the formal can mean bypassing the poor who often have to make do in their everyday living within the informal system.

The informal economy, it is argued, is the socio-political response of the poor to their economic vulnerability in the face of national and global pressures over which they have little say (Chen, 2007; HLCLEP, 2006; Larsson, 2006). The informal sector is one that produces goods and services, some of which are marketed, but which for various reasons escape enumeration, regulation, or other type of public monitoring or auditing (Smith, 1989; Thomas, 1992). This may involve small scale, often self-employed, producers in commerce, transport and cottage industry. It also includes household sector activities, often by women, which involve no market transaction and are excluded from national accounting. It may also include more illegal activities related to trafficking of illicit drugs and of people. Some speculate that the informal sector is much larger than the formal economy, maybe even as high as 90% of the total economic activity in a predominantly rural country like Nepal. It is, however, not just a rural phenomenon. Much of the economic activity in desakota regions and in large urban areas throughout Africa, Latin America, Asia and even parts of Europe and North America occurs in the informal sector "below the radar screen" of governments (de Soto, 1989, 2000).

What recognition of the informal economy does is to re-define the boundary of our understanding of economic activities to include the vast reality of coping with everyday living that the majority of the population in many regions indulges in, but which have yet to see academic insights, policy foresights or legal hindsights. In resource management, a good example of the formal forgetting the informal reality to the detriment of both is the irrigation sector in Nepal.

Of the total cultivated area in Nepal, 52% is non-irrigable, and of what remains, in the hills, most of the irrigable area is already under some form of irrigation developed by farmers through the ages (Gyawali, 2003). Only a very small portion has resulted from decades of government intervention. The former are generally referred to as "farmer managed irrigation systems (FMIS)" and the latter "agency managed schemes" through central government interventions. These FMIS are basically in the informal system, despite attempts by the state to bring them under classification and registration. One difficulty in estimating how much irrigation there is in Nepal lies with its definition. There has been a tendency to count as irrigation only that which has been under some form of formal agency intervention using modern cement technology. The small FMIS irrigation systems often employ simple but effective "brush wood" dams on small streams which are economic enough to build and fall within the farmer's capacity to rebuild after they are washed away by floods, while the state-constructed massive concrete structures are not, given the extreme and violent nature of Himalayan hydro-geology. Such irrigation systems have not been properly inventoried and the state is only dimly aware of their existence.

The above example illustrates the transfer of risk resilience capacity from village to state that has been the hallmark of much of state-led development intervention in the field of irrigation, and the transition from the informal to the formal. It has a direct bearing on the understanding of poverty and its alleviation. The poor often depend on the informal sector but only activities occurring within the formal sector are recognized as "legitimate" by governments. This does not, however, imply that bringing informal institutions into the formal sector will assist the poor. The Institute for Liberty and Democracy conducted an experiment that demonstrated how the formal sector may limit opportunities for the poor. In this case, officially registering a small business, whose workshop consisted of nothing more than two sewing machines, took 289 working days, the equivalent of 32

months' income at the minimal wage. Such high transaction costs of operating in the formal sector are at the root of a dynamics of marginalization and vulnerability of the poor (de Soto, 2000). As Box 8 from Tanzania illustrates, part of this may reflect the underlying incentives governments have for regulation. These incentives often have little to do with actually managing resources or benefiting the poor. Across much of the world systems based on some form of tax collection often represent a central element in attempts to bring the informal sector into the formal sector. This often leads to a bias in management policy towards those resource users that are either able to pay taxes or generate revenue for the government through export.

Box 8: Marginalizing the Informal Sector in Tanzania

In Tanzania, revenues generated by formal sector fishing and mining companies have biased legislation to favour these industries, at a direct cost to informal sector fishermen and miners, and without any particular benefit to the ecosystems concerned. Fishing legislation, for example, is based on regulations tailored to protecting the Nile Perch's breeding grounds, and annual cycles. While this benefits industries based on perch fishing, local, informal sector fishing activities usually target smaller, indigenous species of fish such as the dagaa and the haplochlomines. Perch based regulations are not always in sync with the management of these other species and the legislation disadvantages local fishermen's ability to manage their catch and maintain a decent livelihood. The perch is an invasive, predatory fish that has been blamed for the extinction of 200 out of the 400 endemic haplochlomine species, and is thus a serious threat to the health of the Lakes ecosystem. In this instance, regulations based on ecosystem health and poverty concerns would be far more mutually beneficial to people and ecosystems than those based on the ability to generate tax based revenues.

Source: Tanzania Case Study Part II G1

The case of Tanzania illustrates how the competition between the formal and informal sectors, while key to livelihoods, poverty in desakota areas, also has implications for changing production systems and ecosystem demands. In the Tanzania case, pressures on the ecosystem are emerging as a consequence of an expanding formal sector. As the case of millet-alcohol production in Nepal that is outlined in Box 9 illustrates, pressures can also emerge as traditional activities expand in desakota contexts.

Box 9: *Kodonomics*

In many hill villages of the corridor, the area under finger millet (*kodo* in Nepali) cultivation and its yield per hectare has declined. However, in Baglung district, the area under millet increased remarkably from 4,000 in 1990 to 20,000 hectares in 2003. Millet is not a cereal that is consumed as a regular portion of the diet. In most areas, even those who traditionally consumed millet have shifted to eating rice, wheat and maize. So where is this increased production used? Millet is used for making alcohol and is bought and sold widely in all the villages and roadside settlements, even though the activity borders on the illegal. A large but less-expensive millet-alcohol (*kodo ko rakshi*) market exists. Even a small hamlet called Bayantari of 150 households in Syangja District imports 200 liters of millet-alcohol in a day.

There are several reasons for expansion of millet-alcohol production. First, reduced summer rain in the area has affected yield of maize grown between March and September. Millet is a relay crop after maize and uses both rain and soil moisture of late August and September. Declining productivity of maize had encouraged people to grow millet using soil moisture. Second, in the late 1990s a new highway connected Pokhara with Baglung. The opening of the highway made export of millet-alcohol to major metropolitan areas like Pokhara and beyond possible. Millet became a reliable source of cash income to a large number of households which otherwise could not afford to send their family members to work outside the country. Brewing millet alcohol requires low investments, and a readily available market assures quick cash income.

Turning cereals into alcohol is illegal even though it has been a very traditional drink, often required in some religious rituals; but millet-alcohol business operates informally providing significant income to rural households. It might perhaps be the largest informal economy account in the overall national production budget. Though millet brewing provides income to the most marginalized households, it has serious implication on sustainability of forests. Brewing millet requires a large quantity of firewood, which is so far unrecorded in studies on ecosystem.

Ubiquitous Cottage Industry: Brewing *kodo ko rakshi* in Pokhara

Source: Nepal Case Study Part II F4

At the root of desakota lies social resilience in adapting to new circumstances. It is often forgotten that both formal and informal institutions in these areas are under the stress of change, and the decisions that are daily taken within them are often an expression of underlying political relationships that involve hedging bets and making compromises. The degree of decentralization (the reach of central decisions) is reflected in the capacity of political manoeuvrability of the local political institutions. The market driven, decision-making processes of the informal economy are enmeshed in these socio-political processes.

The large role played by the informal economy and informal institutions in desakota systems has major implications for the ability to manage ecosystems in ways that maintain key services. Within desakota contexts, many of the institutions on which resource management systems are founded in both rural areas and more urban zones have a limited reach. The reach and influence of traditional rural resource management institutions decline as one gets further away from the rural heartlands towards the metropolitan areas. Similarly the reach of formal markets as well as central governmental institutions largely situated in urban power centres (aside from those that create and operate within enclaves) diminish as one heads towards the rural hinterlands and distances from, generally urban, power centers increase. The fuzzy region in the center where the hegemony of both is at a minimum is the desakota region. Traditional fora for governance, such as the farmer organization for managing irrigation systems, have generally decayed, but have not been replaced by strong formal institutions. The "reach" of municipal corporations or similar "strong" urban institutions that often engage in resource management extends only to municipal borders or to enclaves of particular importance to the urban area (such as the location of a dam for water supply). At the same time, traditional fora may continue to exist, but inequities in resource allocation or negative consequences from intensification of traditional activities are often common (Allen *et al.,* 2006; Brook and Davila, 2000), as described in the case of water management in the Andes (See Part II E3).

Overall, desakota regions are characterized by an institutional "clumsiness." Traditional informal, emergent market and weak formal institutions all often exist in parallel. Sometimes the preexisting institutional landscape determines the pattern of the diffusion of desakota influences. Hierarchical tribal institutions versus more egalitarian village committee structures may, for example, facilitate or inhibit the diffusion of conflict resolution mechanisms. The strongest institutions in desakota regions are probably the market and banking networks that allow goods and finances to flow in and out of regions. Such network institutions have historically not been viewed as playing a key role in the management of ecosystems or access to ecosystem services. The potential for a greater role may, however, exist. Activity-based associations (such as dairy or market cooperatives) often do emerge in desakota environments and can play a role in resource management and the mediation of water-conflicts. In Tamil Nadu, for example, associations of farmers have been negotiating with industrial water users to reduce pollution. From the emergence of dairy cooperatives in India to associations of actors in water markets, limited examples do exist of market actors in informal settings creating institutions that then take an active role in managing water resources and mediating conflict.

4.4 Thematic Lines of Enquiry

Desakota dynamics place particular pressures both on ecosystems and the institutions for their management. As a result, research must address both core scientific and institutional management issues. Key lines of enquiry in each of these arenas are bulleted out below.

4.4.1 Environmental Science Research Needs:

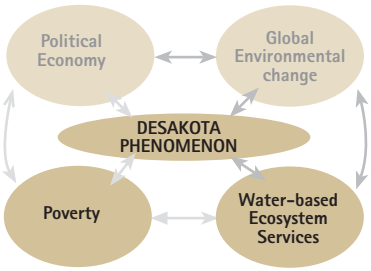
- Further refine the representation of vegetation / landcover feedbacks within climate models at a range of spatial scales
- Develop understanding of interactions between land cover and climate under the pressures of desakota, including analyses of changes in the type, intensity, extent, distribution and patchiness of land cover types at different spatial scales, the sensitivity of different biome or ecoregion settings to such changes under current and projected climate conditions, and indicators (e.g. extent of high biomass land cover types, vegetation health / vigour, soil organic content) of systems approaching threshold conditions.
- Develop understanding of how climate-driven land-cover modifications interact with direct land-use changes at the catchment scale. In particular undertake research on hydrological trends and threshold conditions induced by particular mosaics of land uses and livelihoods.
- Investigate small scale, low cost distributed measures to support self-purification of water within the catchment drainage network, which could also improve the runoff regime and support aquatic and riparian ecosystem complexity and services.
- Investigate smaller-scale distributed approaches to water resource development within catchments that avoid the adverse regional impacts water quality, quantity and ecosystems that typify large surface and groundwater manipulations.
- Undertake research on river flow regimes that focuses on their characterization, their controls, and the development of approaches to their distributed, local management which incorporate issues of riparian – surface water – groundwater connectivity. Although not investigated in depth in our report, integrated research of this type could also focus on the dispersal of alien species, the multivariate triggers that cause such species to become invasive and possible control mechanisms.
- Develop research that connects climate change, desakota and catchment and river functioning to identify and develop interventions between water ecosystem processes and water-related diseases.

4.4.2 Institutions Managing Ecosystems Research Needs:

- The development of strategies, institutions and incentives for mediating conflicting demands ond pressures on the resource base, and for moderating pollution and maintaining flow and water quality regimes for basic water services in desakota environments;
- The institutional transitions impacting resource management regimes in desakota areas, such as community based natural resource management, especially as they concern the most vulnerable population's access to resources and enjoyment of ecosystem services.
- Identifying alternative mechanisms that support governance of ecosystem services such as organizations based on existing networked patterns of association.
- Approaches for reflecting the value of ecosystems services in day-to-day life that go beyond the payment for ecosystems services model or polluter-pays principles. This will require close interaction between those understanding the basic science of ecosystems within landscape mosaics and those seeking to value the services generated;

Desakota, Poverty and Ecosystems Services

5.1 Rethinking Poverty



Defining poverty is a complex task. In development circles, most international agencies have conceptually incorporated into their programs the definition of poverty as deprivation of well-being due to lack of material assets or income, low levels of health provision, poor or no education, and food insecurity (e.g. UNESC, 2001, UNDP, 2007). However, in practice, this broad definition is usually reduced to a simple economic measure of a $1 per day threshold, below which a household hits abject absolute poverty after it is unable to meet the minimum levels of food, energy, and shelter needed for basic bodily survival (World Bank, 2007). Such an indicator certainly has value in quantifying and assessing progress towards increasing incomes, addressing one aspect of poverty. However, the ubiquitous validity given to this simplified economic indicator as the sole concrete measure of poverty is extremely problematic, not only because of the fluctuations in exchange rates and varying inflation rates, but also because of its inability to capture the diversity of experiences of deprivation by the victims of poverty. Within this school of thought, the limitations of the $1 per day measure in addressing regional and local contexts has led to the creation of additional threshold of $2 per day to differentiate the severity of poverty (Turner and Fisher, 2008).

Economic measures such as the $1 per day, and now $2 per day, standards do not capture the multiple factors contributing to poverty including access to education, health, food and nutritional security, access to natural resources, and social marginalization. Most importantly, these measures do not consider whether or not people see themselves as "poor", how they may define their poverty, or how they envision ways out of it. In the series, *Voices of the Poor*, Narayan *et al.* (2000) attempted to do just this, and perhaps not so surprisingly, the poor in the study did not define poverty within the context of income but within the context of asset management: "....managing assets—physical, human, social, and environmental—as a way to cope with their vulnerability..." (p. 7). Douglas and Ney (1998), arguing from the perspectives of anthropology and political science respectively, critique the over-riding presence of Homo Economicus in defining the poor, which fails to account for the social differences between needs, wants and actualization of individual capabilities. Poverty is not only materially but also socially defined, and social considerations determine how poverty is perceived and strategies for its alleviation pursued. Definitions of, approaches to, and measurements of poverty need to appropriately consider the broader range of factors that contribute to poverty and the experience of it, and perhaps even more importantly, the factors that enable or constrain the ability of individuals and households to move out of poverty.

The desakota context forces changes in perceptions of who is considered "poor". The case studies explored how communities, in defining poverty, emphasize how people see themselves and others. Why people are viewed or view themselves as "poor" can often be tangibly related to specific causes that may range from household structure to education or access to common lands or common institutions. Box 10 below describes changing perceptions of poverty in the Nepal case study:

Box 10: Changing Perception of Poverty along the Mustang-Gorakhpur Corridor in Nepal

The social system is undergoing changes as telephone, mobile phones and visual media are making inroads, changing aspirations, expectations, and education. In the villages along the mid-Nepal transect north to south from Mustang in the trans-Himalaya to Gorakhpur in the Indo-Gangatic plains, people perceive poverty differently even while large sections live in absolute poverty. Poverty has caste and gender dimensions. The changing perception of who is poor in this case study is as follows:

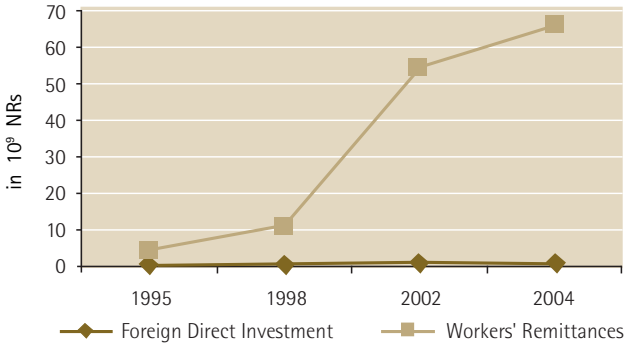
Locations	Who are considered poor?
Ghandruk, Kaski	Subsistence agricultural farmers, occupational – traditionally marginalized castes – such as tailors and agricultural tool makers; those without 'hotels' or tea shops along the trekking routes; and those not working abroad (USA, UK, Japan, Malaysia, Europe, Korea, Gulf)
Putali Bazaar, Syangja	Those who do not own bus/truck or micro-bus capable of transporting necessities between roadheads and villages, and whose sons/daughters are not in government services or other forms of pensionable employment. Those with large land holdings (old category of wealth) but much of it lying fallow because of lack of agriculture labour.
Madan Pokhara, Palpa	Those without cash generating farming (vegetables, coffee) and not involved in micro household business, such as weaving or other artisan skills. Those without higher education, beyond high school.
Dudhraksha, Rupandehi	Household with a drunkard male (usually head of family) who spends majority of earnings on liquor and quarrels with family members and neighbours.
Shankar Nagar Rupandehi	Unemployed even though with bachelors level education. Those with property but with much of it lying idle or abandoned because of the outmigration of skilled family members to Europe or Australia.
Marchawar Rupandehi	Those without quality-education (not necessarily just a formal school-leaving certificate) who are not able to take advantage of what NGOs and government agencies have to offer because of the absence of effective education. A degree is not enough to get employment. Education must be relevant to helping people gain employment in the highly competitive market.

This example demonstrates the importance given by communities in Nepal to access to opportunities arising through desakota conditions as a means of alleviating poverty, such as education, that may facilitate gainful employment. Agricultural land, conventionally considered an asset, are of less importance in the context of labour shortages limiting its productivity and therefore economic value, while capital or services that facilitate access to cash income may be seen as key elements to a successful livelihood strategy. Such a broadening of perspective on poverty is essential to identify more effective avenues for poverty alleviation that, while partially related to increases in income *per se*, needs to encompass a more relevant set of definitions suited to local social and environmental contexts. Central to this is an approach that considers enabling conditions that the poor themselves understand and in many cases may already be taking advantage of (such as outmigration for jobs to cities nationally or internationally), which may facilitate people to move out of poverty. The "stages-of-progress" methodology for measuring poverty (Krishna, 2004; Krishna, 2007) may be one promising framework. Instead of assessing the income, consumption and assets of people, the methodology focuses on the reasons people either

fall into or escape poverty. By targeting the reasons that people become more or less poor, not their income level, the method can be used to point to actions and policies that may alleviate poverty. An example of this may be development of diversified and non-farm livelihood sources – key indicators of desakota conditions – as a poverty exit pathway. This is but one new approach that remains relatively unexplored. There is a need for development of robust methods and tools to adequately capture the complexities of factors contributing to poverty, particularly in changing desakota contexts.

At first glance the phenomenon of desakota appears to offer opportunities for moving out of poverty. The movement towards diversified livelihoods and non-farm employment can improve sources of income; increased transportation and access to markets may improve sale of agricultural (or other) goods and products; and improved communication and knowledge (of market prices, technologies) may improve production and economic returns.[7] Even increasing value of land in desakota areas may benefit those with land-holdings: they often sell or lease their land for industrial purposes or to the rich in cities looking for weekend refuge from the urban jungle. For individual households, remittances – built on the social capital found in extended families – are becoming an important source of income and a driver of cultural transformation. The capacity for households to gain an income through remittances is increased through telecommunications and transport access that can enable economic migration and the ability to send money or goods home. Figure 11 shows the rapid increase in the percentage of households receiving remittances in the Central Himalayan corridor. This is indicative of the dynamism that characterizes desakota, especially when compared to the minimal levels of direct foreign investment which might be associated more with corporate capital enterprises found in cities or industrial agriculture. While remittance economies are contributing to alleviation of poverty, the implications of this global trend for local demand for ecosystem services and their management are not well known.

Figure 11:
Contribution of Remittances to Household Income (x109 NRs)



Source: Part II F3 Mustang-Gorakhpur Corridor Case Study

However, the relationship between desakota and poverty alleviation is not so straight forward; desakota conditions may also exacerbate poverty and inequities. Not all have access to opportunities that emerge within desakota conditions; and the poor with limited access to skills and education may have less of a chance to avail themselves of these prospects, as was indicated above in the changing perceptions of poverty from the case in Nepal. If they even have the social and economic resources to migrate or commute for employment, this is often as low paying, low skilled labourers, frequently in poor working and living conditions. Increasing access to technologies may expand agricultural production, such as the case of mechanized milking in the dairy sector in Columbia; but it has also led to unemployment of women in the work force, who

[7] See Table 3: Comparative Matrix of Conditions in Case Studies Areas further below, which lists impacts of desakota on poverty in the case studies.

were predominantly manual labourers. The increasing value of land in desakota areas has also led to tenure insecurity of the poor who have limited political voice or power to retain their usufruct rights to land, and are forced to look elsewhere for shelter. Existing research has not been able to capture the implications of desakota phenomenon on poverty alleviation, and new approaches are needed to consider these complex relationships. They need to be attentive to the issues of who 'wins' and who 'loses' in the desakota context, with an eye towards identifying interventions which address underlying factors that may enable or constrain the poor's ability to take advantage of opportunities, and to find pathways out of poverty. In the discussion of poverty issues in desakota areas, it is critical to consider more closely the interlinkages between ecosystem services and poverty.

5.2 Themes in the Ecosystem Services and Poverty Nexus

Up to this point, the report has analyzed drivers of desakota change, implications of the desakota phenomenon on water-based ecosystem services and the institutions that manage them, and has looked at both opportunities and negative impacts of desakota on poverty. It is worthwhile here to explore more concretely interlinkages between water-based ecosystem services and poverty in desakota contexts. Both the social science literature reviews (cf Part II D, E and G) as well as the case studies (cf Table 3) give concrete examples of how these interconnections have manifested themselves in specific transects and localities. In several of these desakota contexts, widespread processes of industrial intensification and of demographic concentration are leading to intensifying demands on and decreasing quality of water- and forest-based ecosystems. This is affecting the quality of provisioning and regulating ecosystem services. In part, due to this decreasing quality of services and increased mobility, people are no longer reliant only on ecosystems that are immediately proximate but are increasingly dependent also on regional and even global ecosystems. Existing resource management institutions are less effective in these dynamic environments, and a rise of market economies for provisioning of ecosystem products is emerging.

Figure 12 presents an extreme case of ecosystem services conversion following changes in market demand coupled with the absence of strong institutions for land categorization and management as well as environmental protection. The image is of a brick factory in Nepal, a locally important driver for soil loss in Kathmandu Valley. As prime agricultural land is converted into a commodity for brick production and exported out to meet construction demand in Kathmandu, it is not clear if such land could be rehabilitated after the removal of the top layers of soil. This process of re-defining a rural ecosystem service (fertile soil) as a resource having a different value in the proximate market (bricks) was preceded by another similar desakota phenomenon. The Kodku river at the bottom of the valley fed the irrigation channels of the terraced fields from farmer-managed brushwood intakes further upstream. In the 1990s, the government pushed a scheme, currently on hold, of using the river waters to augment urban Kathmandu's water supply. Perhaps the response of the villagers subsequently in converting farm soil to bricks (instead of irrigated rice) was triggered by the uncertainties induced by state policy and market pressures. This case also flags the tendency under desakota for previously rural productive assets to be transformed and exported out of the region to meet external demand within the set of complex constraints faced by decision-making households.

Figure 12:

The Transformation of Ecosystem Services: farm soil being baked into bricks for export to urban development in Kathmandu, Nepal

Source: PART II D Social Science Global Literature Review

Box 11: **Bangladesh Fixed Income Poor**

In Desakota regions the emergence of markets as mechanisms for distributing service access and the increasing reliance of the inhabitants of desakota regions on imported goods (and services) has already inflicted economic hardship amongst the poor and lower income groups, especially those who rely mostly on fixed income. Neither do they have any control over price fluctuations, nor can they fall back on ancestral, informal access and use resource rights during difficult times in a bid to support their consumption behaviour. In cases of occasional crop loss due to extreme weather events driven by climate variability and change, reliance on international sources for food items escalates local prices and exposes local markets to global supply levels and price fluctualtion . Speculatory and market middle-men can extract a valuable windfall profit under these circumstances , often at the cost of fixed income middle-class and poor inhabitants of desakota regions. In the aftermath of cyclone induced crop loss in 2007, Bangladeshis found it difficult to cope with sky-rocketing food prices. This then turned into dissent over low wage rates, which eventually culminated into conflicts and reduction of overall productivity in industries where large number of migrant labours had been working.

Source: Bangladesh Case Study Part II F1

What are the implications of these trends for the relationship between poverty and ecosystem services? This area remains relatively unexplored, and more research is required to better understand these dynamic interconnections. However, based on our analysis to date, we can begin to identify direct implications for poverty, particularly related to: 1) decreasing access to provisioning services, and 2) increased exposure to health and disaster risks. In desakota environments, perhaps more so than in rural areas, increasing market intermediary institutions and lack of moderating political organization may exacerbate vulnerabilities. However, while all poor are vulnerable, not all the vulnerable are poor. Increasing reach of markets as part of desakota and changes in formal and informal resource management institutions is shaping vulnerability to poverty and environmental risk, not only of the poor, but also the middle class and the more wealthy.

5.2.1 Decreasing access to provisioning services:

a) Decreasing direct access to ecosystem provisioning services to meet livelihood security needs.

Development approaches tend to focus on the role that common land, forests, and water resources pay in directly meeting basic livelihood needs of the poor for food, medicines, fodder, fiber, and fuel (MEA, 2005). These resources, and derived products, are also critical sources of income, for example, as natural products such as medicinal plants, or for agriculture and livestock based products dependent on these inputs. This direct dependency is evident particularly in rural areas, but also in more urbanized ones (Lewis, 2007; Vedeld *et al.*, 2004). In desakota environments, degrading ecosystems and decreasing quality and quantity of water-based ecosystems are having direct impacts on the lives of the poor and severely affecting their ability to access quality provisioning services. More distant actors with available capital and high resource needs are also adding increased pressures on local provisioning products, such as the case of China's demand for timber from Mozambique (Section II E1). This impacts not only of deforestation but also on local fuelwood supply, and access by the poor. Women and girls, often responsible for collection of water, fodder, fuel, and minor forest products are particularly affected as time and energy required to obtain these essential products increase and working conditions deteriorate. Limited access is exacerbated by lack of secure tenure by the poor, at times with extreme implications.

For example, as described in the Pakistan case study (Part II F3), intensification of demand for and extraction of water resources, decreasing supply due to climatic variability, and movement towards more individual access through tubewells rather than collective access through the *karez* system has directly negated access by the poor to water resources. In the Indian case study (Part II F2) agricultural intensification and industrialization has led to over-extraction of groundwater resources and pollution of accessible water sources by chemical fertilizers and inadequate disposal of industrial effluents. This has directly impacted the poor who rely on such water sources for

drinking or to water their animals, thus exacerbating health problems such as fluorosis. This dependency on provisioning ecosystem services is mediated by the diverse "clumsy" mix of traditional, formal and emergent institutions in desakota regions, which generally do not consider issues of equity or access by the poor. In addition, while predominant views are that improving the ecosystem condition and access to these resources will particularly benefit the poor, more recent analyses suggest that the relationship between common-pool resources and income is more complex. In some cases, relatively more wealthy households have increased reliance on common-pool resources (Narain *et al.*2005).

b) Increasing reliance on market institutions provisioning of ecosystem services

Perhaps one of the most distinct changes in desakota regions is that to some degree, the direct primary linkages between people's needs and ecosystem services are reduced. With decreasing access to ecosystem services, increasing mobility of goods and services, and an increase in a cash economy, there is a rise of intermediary market institutions to deliver such services. This increase in market economies creating fixed prices for water and food may even further reduce access by the poor to provisioning ecosystem services to meet their daily and livelihood needs. However, research has only sparsely investigated the role and accessibility of intermediary institutions in desakota regions.

Research in the peri-urban water supply sector that has explored the delivery of services through markets and formal institutions such as utilities may inform this rising phenomenon. In these cases the poor, who are unable to access public delivery systems, will pay up to 100 fold more for water services than the rich, often for poorer quality water (Hardoy *et al*., 2001). This case is largely a function of economic scale with the poor generally unable to purchase bulk supplies – the per liter cost of a full 6000-12000 liter tanker load of water is generally a fraction of the amount charged when water is purchased in 1-10 liter increments. For the less poor, the commodification of basic resources, such as water or fodder, that takes places within desakota can provide gains through extended choice as well as the benefits of scale. However, when combined with the negative circuits of commodification and poverty described above this can result in increased inequality as well as poverty in desakota regions.

Figure 13:
More Expensive by the Liter for the Poor

Secondary or tertiary market institutions appear to be growing as chains of resource access and distribution expand from local to global in their reach. This generates a resulting mix of reliance on water markets, and imported food, fuel, and fodder, where production depends on ecosystems that may be relatively proximate (local) or quite distant (up to global) but where most users do not have day to day resource

access. Issues of equitable and affordable access by the poor to provisioning institutions are central. Relative deprivation adds implications for governance and social stability as well as for addressing the basic resource needs of the poor. Increasing dependence on markets for food and resulting negative impact on poor in desakota areas emerge strongly in the case studies in Nepal as well as in Bangladesh, the latter described in Box 11. Diversity in production chains can add resilience but as the distance between producer and consumer increases so do points of vulnerability that can lead to scarcity and price increases.

5.2.2 Increasing exposure to health and disaster risks

Desakota development also is influencing regulating water-based ecosystem services, such as flood control, disease regulation, and filtering of pollutants. As a result, desakota induced environmental degradation in desakota areas is increasing health problems and exposure to disaster risks[8]. Poor water and sanitation practices and poor water quality resulting from urban and industrial waste, such as those described in the Tanzanian (Part II G1) and Indian (Part II F2) cases, all directly impact the health of human populations, as well as livestock and aquatic resources in the food chain. These may include more common water-borne diseases such as cholera, typhoid and dysentery, but with the extent of agricultural and industrial pollution, health impacts may be even more severe. The poor may be most affected with lower immune systems due to poor nutrition; lack of access to health services; and lack of access to alternative (accessible, affordable) water sources as discussed in the previous section.

Decreases in the quality of ecosystem services such as flood control will affect directly those living in flood plains – frequently poor populations living in environmental marginal lands. Flood zones of the Indo-Gangetic Plain and Mozambique, as well as wetlands in Bangladesh and Tanzania are good examples of areas at risk. In addition, these areas are selected frequently as the site for municipal, industrial and other waste disposal. This increases both water pollution and flood hazards resulting in a double health and disaster risk impact on local communities. Furthermore, flooding conditions may exacerbate the presence of disease vectors, potentially increasing the extent of malaria, dengue, diarrhoeal related conditions and other disease.

The intensity of desakota development places increasing pressure on ecosystems to provide regulating services for drainage, purification of water, disease control. And, as mentioned earlier, while the poor still depend on access to provisioning services, this is changing in contexts where these are no longer directly available, and there is increasing reliance on external markets to provide those goods (food, fodder, water) from more distant ecosystems. It is possible, though this line of thinking needs more investigation, that in desakota areas there is a shift occurring from a more predominant focus and reliance of the poor from provisioning to regulating ecosystem services.

Increasing vulnerabilities

Additional factors are contributing to vulnerabilities of poor, and even the more relatively wealthy, to manage disaster and health risks. HIV/AIDS is a key problem affecting vulnerability, exacerbating negative health conditions, limiting access to resources, and decreasing adaptive

[8] Exposure to water-related disease and pollution has been discussed substantially in sections 4.1.3 and 4.1.5

capacity and abilities to manage environmental or economic shocks. The prevalence of HIV/AIDS in SubSaharan Africa is particularly destructive, with systematic impacts disrupting all aspects of rural livelihoods and their ability to meet basic daily needs (Haddad and Gillespie, 2001; de Waal and Tumushabe, 2003; Drimie, 2004). This not only includes reduced immunity to diseases, but also decreased ability to work and to obtain food, nutrition and other needed resources not only by the person directly affected but by those who must devote time as care givers, who are often women. A study in Ngamiland, Botswana (Ngwenya & Kgathi, 2006) discusses how HIV/AIDS not only affected families' ability to collect and gather water, but also how it impacted water supply and delivery. That is, the sheer numbers of cases of illnesses and deaths affected government departments ability to ensure water supply. The potential increase of HIV/AIDS in desakota environments where there is increasing mobility and flow of people is of concern—not only in SubSaharan Africa, but also in South Asia, China and elsewhere— and potentially may exacerbate vulnerabilities of poor women, men and children.

In desakota environments, lack of secure land tenure and increasing market value of land is marginalizing the poor further, forcing them to shift to more hazardous geographical locations. For example, where flooding is an issue, houses and assets of the wealthy tend to be clustered in high locations—raised villages or in major urban centres, such as Dhaka, Bangladesh, in upper story apartments. This is often the case in conditions of high air and water pollution where the wealthy buy assets in less polluted locations. The poor, for economic or political reasons, are forced to locations of higher biophysical vulnerability and fragile conditions. In some cases, they may be forcibly removed from land of increasing value, as occurred in cases of China and Tanzania.

Lack of political power or organization may also further exacerbate vulnerabilities of the poor to these health and disaster risks. For example, they may lack political strength to prevent disposal of toxic substances, waste, and industrial pollutants in the areas where they live. Or, as in the case of Guyana described in Box 12 below, inequitable power relationships and weak management institutions may limit adaptation and disaster mitigation strategies that may benefit the poor.

In desakota contexts, poverty is dominant but not deterministic to exposure to disaster risk, and vulnerabilities may increase across categories of wealth. The high death toll among wealthy European tourists, often in tourist enclaves, during the Asian Tsunami of 2004

Box 12: **Vulnerability, Poverty, and Disaster Risk in Desakota Areas**

Vulnerability to disaster risk is determined by the exposure to physical risks, hazards, shocks and stress, and the capability of social response to anticipate, resist and recover from the impact of a natural hazard or disaster (i.e. adaptive capacity). While poverty is one factor that contributes to a person's or household's vulnerability, other factors include physical and material assets such as access to infrastructure; social/power relations; and psychological attitudes (Ahmed and Mustafa, 2007). In desakota regions, changes in socio-ecological relationships result in shifts in the geographical and social distribution of risk and vulnerability. Rights and entitlements of poor and vulnerable populations to ecosystem services may become more threatened, and these populations may then be marginalized to high risk, hazard prone areas such as flood plains.

Power relations and ineffective institutions also affect vulnerability to such hazards, as illustrated by the case of coastal Guyana, in a desakota region located 16 km east of the capital, Georgetown, an area at high risk from fluvial, pluvial and coastal flooding (Pelling, 2003a, 2003b). Vulnerability to flooding in this region is rooted in historical causes of risk traced to Guyana's colonial experience and post-colonial modernisation projects which transformed the coastal environment, clearing and replacing coastal mangrove stands with a landscape of sea-walls, irrigation canals, plantations and human settlement. In addition, deeper structures of political patronage and information asymmetries continue to influence the distribution of resources between and within communities, thus affecting the production and social and spatial distribution of vulnerability to flood hazard (Pelling, 1998). In this example, within formally recognised community organisations, vulnerable individuals (low-income householders, renters, petty-agriculturalists, female headed households, the young and old) were excluded from decision-making, which was the domain of house owning businessmen with relatively high socio-economic status. As a result, activities to strengthen adaptive capacity and mediate risk from flooding focused on household centred adaptation (raising yards or modifying dwellings) rather than communal action (drain cleaning, garbage collection) which would benefit the poor.

Source: Part II B

demonstrates this well. Evidence of this also can be found in response to droughts in India and Nepal where research identified that it was more the lower middle class farmers than the poor who faced the most negative impacts (Moench and Dixit, 2004). Despite having sizeable land holdings, they were entirely dependent on water for often high value cash crop production with no other livelihood alternatives in place, whereas the poorest segments of the populations were relatively less affected from these events, having already diversified their livelihood base.

Research is required to better understand factors contributing to vulnerabilities of different social, gender and income groups to decreasing water quality and quantity, increasing pollution and increasing exposure to health and disaster risks. Such knowledge may also contribute to understanding how and why people move into and out of poverty. In addition, research is required to better understand the role and function of intermediate market institutions for provisioning of water, food and fodder, and how to ensure accessibility by the poor. Development research also needs to consider mechanisms to strengthen secure tenure to resources along side political organization and representation by the poor to negotiate or lobby for rights and access to quality ecosystem services. This latter point is critical. As the case of Guyana above illustrates, lack of voice leads to further impoverishment, lack of access to resources, and increased vulnerabilities. The ability to organize has had immense impacts in Gujarat, India, where a strong activist movement has emerged against industrial polluters of water sources. Strategies and actions that can enhance opportunities and support mechanisms for the poor to organize – whether to take advantage of desakota opportunities or to ensure that their voices are represented in new and emerging institutions governing access to resources are essential. With collective action, the poor may enhance their bargaining positions in negotiations with more powerful stakeholders – be they businesses, industry, or the elite – for their rights and entitlements to quality ecosystem services.

5.3 Translation on the Ground – Field Cases

A key element of this study is to use case studies to allow for better salience through literature review and field observations of issues often buried in literature, to alert ourselves to new emerging surprises that research efforts have perhaps not adequately flagged, and to test if the desakota concept does help in bringing forth in sharper focus the complex dynamics between water-related ecosystem services and poverty. To this end, eight case studies were conducted, four in South Asia, two in Latin America and one each in China and Sub-Saharan Africa (see Part II F and G). The results have been summarized in the following matrix (Table 3).

What emerges is that, while there are regional specificities, desakota regions around the world do exhibit some common features where households enjoy incomes from rural as well as urban sectors of the economy. Because these regions have better transport and communication linkages, ideas, people and goods exhibit wider geographical mobility than what conventional beliefs about the rural countryside lead us to expect. In countries such as India and China as well as frontier areas of the Amazon, undergoing rapid economic growth, the selected desakota regions also exhibit strong in-migration from poorer regions. Such mobility provides better income opportunities but is also prone to more disruptions due to far-off events not under the control or even purview of local management systems. Within the mixed nature of the household income, not an insignificant proportion stems from traditional access to ecosystem services outside of

Table 3: **Comparative Matrix of Conditions in Case Areas**

Case	Water-based Ecosystem Services	Poverty	Regional Specificity
Mustang-Gorakhpur Corridor (Nepal-India)	• Greater connectivity has enabled greater market-led pressure on water resources • Increased local pollution of water bodies from increased economic activities and domestic sources • Decline of traditional water and forest management institutions: state-promoted quasi-formal institutions such as water users' associations still weak • Modern resource extraction technologies (i.e. pumps) lead to decline of traditional water allocation authorities • Emergence of unregulated markets to supply water to new settlements	• New technology and markets benefit those capable of taking advantage from them, primarily urban areas and the rich, not the poor • Industrial manufactures displace traditional occupation castes • Communication improvement encourages migration • New institutional initiatives have promoted pro-poor environment for development	• External migration intense, making the region dependent on remittance economy
Pishin-Quetta-Mastung Corridor (Balochistan, Pakistan)	• Non-local marketing opportunities in the cash economy of water intensive crops like apples leading to a strain on groundwater resources • Traditional karez water management system in physical decline due to groundwater pumps • Hierarchial karez-based management system for conflict resolution weakening but still strong	• Communication improvement generates potential for labour market and remittances but they are unevenly taken advantage of by different communities • Access to modern technologies such as pumps and chemical fertilizers, but capacity to take advantage differs and depends on local historical relationship patterns • Talibanization perhaps related to rate of change	• Strong "local" difference within transect between ethnic communities capable of taking advantage of technology (Pishin) and cross-border trade and those unable to (Mashtun), in part due to cultural differences
Ahmedabad-Gandhinagar Region (Gujarat, India)	• Greater connectivity has increased diversified economic activities and increased demand for water, promoting not just more extraction of groundwater but also tanker-supplied water • In-migration for jobs has increased adding to resource pressure • Discharged of industrial and domestic pollution has increased with poor regulatory oversight • Bias in policy has led to subsidized electricity and chemical fertilizers that have led to overpumping • Traditional institutions have lost power while central authorities have been unable to regulate the market	• Greater access to employment, health and education opportunities • More opportunities for women to find work but pressure on them increases with double burden of housework as well • Penetration of cash economy means fodder etc available previously free of cost to the poor is no longer so • A shift to payment for food in cash makes poor more vulnerable • With no other sources of water, poor forced to drink heavily polluted sources, resulting in long-term severe health problems as well as fluorosis, dysentery. • Poor get poorer if they cannot afford tubewells but have to buy more expensive water	• Significant difference in pollution, water abstraction to meet industrial demand, outmigration between heavily industrializing regions such as Gujarat (India) and Hai River Basin (China) and poorly industrialized regions such as the Nepal, Pakistan case studies • Communication leading in-migration (as opposed to outmigration) when economic activities provide opportunities for jobs

Satkhira-Khulna-Jessore Corridor (Bangladesh)	• Non-local marketing opportunities (e.g. apples, shrimps) put pressure on local use of freshwater • Industrial growth corners increasing share of water leading to more pollution • Weak informal institutions are not so capable to check/curb degradation of aquatic environment	• Rate of expansion of local labour market outpaced by rate of increase in poverty due to loss of livelihoods • Considerably diverse household economies between agriculture, service, labour and manufacturing jobs locally and nationally • Weakening of local collective voice, poor local participation in governance process • Poor marginalized from services from modern production and processing technologies • Tension is mounting with increased ecosystem service demands from the poor and degrading quality of services
Miyun Reservoir Watershed -Hai Basin Region (China)	• Increased demand for urban water supply, industrial development, and drought leading to drawdown of reservoir • Hai River: Non-point sources and urban waste polluting 80% of reaches; 50% groundwater unsuitable for drinking • Increased access have allowed more pressure on reservoirs (illegal dumping, fishing) but also enabled better monitoring • Cash economy is dominating farmer-to-farmer and farmer-to-resource relationship, state interventions try to limit ecological damage by closing down enterprises and converting agricultural land to forest or grassland, giving compensation to farmers • Water-related conflicts between jurisdictions as well as between regulating authorities and traditional ecosystem users	• Improved communications have meant that the poor benefit from migrant labour opportunities, local tourism employment or marketing products near main cities • Significant differences between disadvantaged poor who cannot benefit because they are cash-starved and those who have migrant family members that send cash back • Strong government action to control pollution (shutting down 21 enterprises) result in local job loss affecting the poor and traditional water rights are withdrawn by new regulations • Closing off of grazing areas to limit ecosystem degradation led to sharp reduction of herd sizes and loss of shepherd's income

Mwanza-Lake Victoria Region (Tanzania)	• Nucleated settlements lead to better market access but result in more ecosystem stress in and around settlements • Better market opportunities lead to inmigration of inland agro-pastoralists • External policies (i.e. structural adjustment) result in increased resource extraction and generally result in detrimental impact on ecosystem services	• Nucleated settlements lead to insecurity of land tenure and resulting food insecurity • Introduction of alien species leads to decline of local fishery and availability of protein for the poor • Increasing penetration of globalization leads to increased vulnerabilities due to over dependence on external economy and decrease in regulatory capacity of the state • Domination of cash-based economy has damaged social institutions based on reciprocity, affecting mostly the poor and vulnerable	• Communication leading in-migration (as opposed to outmigration) when economic activities provide opportunities for jobs
Fuquene Watershed-Andes Region (Colombia)	• Decreased lake volume from in-fill due to dairy intensification has reduced flood regulation, habitat for wildlife and downstream flow. • Increasing market linkages and technological innovations has intensified agricultural production and use of chemical fertilizers, leading to non-point source pollution	• Expansion of Non-Farm Rural Employment (NFRE) in dairy and mining have provided income earning opportunities • Technological innovations in dairy industry led to unemployment of women who previously provided manual labour • Filling of lake by elite for increased dairy production limiting local access and downstream flow • Inadequate formal or informal institutions to mediate conflicting demands on water resource and ensure access by poor	
Central Peruvian Amazon	• Increases in global demand for biofuels and changing meat-based diets driving land use change of clearing forests, soybean production, and establishment of pastures • More limited transportation links, but current policies promote opening up of frontier through new road development and Trans-Amazon Highway will facilitate extraction of forest resources and agricultural products • Deforestation in Amazon leading to green house gas emissions and decreasing carbon sequestration potential, with implications for mediating climatic changes at global scale	• Opening of agricultural frontier has lead to in-migration • In areas where frontiers have closed, agricultural intensification and dairy production has expanded, but extent of market not differentiated along corridor • Growth predominantly favours local elites • Areas of closed frontier deforested over fifty years previous, demonstrate higher degrees of social capital and farmer organization than areas deforested in later periods	• Transport links, government policies and global markets leading to in-migration • Global character of ecosystem services provided or affected: through provisioning of biofuels and food products, and deforestation contributing to GHG emissions and affecting Amazon's role as a global carbon sink

formal management or market mechanisms. Degradation of these resources through capture by more powerful entities, pollution and over-extraction have had a detrimental impact on the overall endowment of the poor who are least capable of articulating their grievances in a collective manner.

5.4 Thematic Lines of Enquiry

Key research priorities emerge from re-thinking poverty, water-related ecosystem services and the linkages between them:

- Identifying how the desakota phenomena may be shifting the relationship between ecosystem services and poverty away from provisioning of resources to more systemic and equally important regulating services, e.g., exposure to environmental extremes, health risks, etc.;
- Improving understanding of factors contributing to changing patterns of vulnerability for the poor in desakota regions such as those associated with decreasing water quality and quantity, increasing pollution and increasing exposure to disaster risks;
- Increasing understanding of the role and function of secondary and tertiary intermediary (market) institutions for provisioning of water, food and fodder in desakota type transitional contexts;
- Documenting through case studies the opportunities, constraints and vulnerabilities for the poor in desakota environments. Identify actions and policies to address inequities in access to opportunities, such as skills, education, and training allowing the poor to take advantage of new economic opportunities in the cash economy;
- Exploring the significant remittance incomes in these regions in relation to the constraints faced as well as the potential for investment of household savings into environmentally sustainable production rather than consumption, especially in the formal economy;
- Developing understanding of the implications of desakota dynamics for specific vulnerable and poorly understood socio-ecological systems, such as those found in many highly mobile pastoralist societies, fishing communities and high-mountain regions;
- Developing new and refined methods and indicators (at local and regional scales) to capture region and culture specific definitions of poverty that include income with other material and social assets, education, health and access to services in desakota environments;
- Exploring the underlying reasons people move into and out of poverty: case studies at the micro and regional scale in desakota contexts could help improve understanding of this question;
- Documenting, through commissioned case studies as well as re-visiting primarily 'grey literature', strategies of collective action by the poor – and the conditions that enable such democratic processes – that may have enhanced their access to quality ecosystems services in desakota contexts. Regional and inter-regional comparisons need to be made to help generalize policy conclusions; and
- Since much of the innovative activities within desakota contexts occur within the informal economy, undertaking policy focused research to tap into this adaptive mechanism.

CHAPTER 6

Critical Research Gaps and Priorities

Where do insights from the ground realities of the case studies and the review of literature for understanding desakota systems and the linkages between poverty and ecosystem services within them lead? It is clear that the desakota phenomenon, and related economic intensification, demographic concentration and mobility are leading to unprecedented dynamic interactions across scales between human and natural systems with major impacts on water-based ecosystems, livelihoods and sources of vulnerability. Existing research has not yet adequately tackled the complexity of challenges in ecosystem services and poverty arising from these dynamic interactions. This is in part due to the focus on conventionally defined "rural" and "urban" regions and the accompanying lack of recognition for more mixed economy, desakota, areas; the absence of tools to evaluate development problems in such areas; the challenge of investigating complex interactions across scales; and the rapidly intensifying interactions within interlinked local to global systems. The core motivation for this study is to identify mechanisms or practical points of entry for alleviating poverty and maintaining the basic ecosystems that supply key services on which livelihoods either directly or indirectly depend by addressing these gaps. The lines of enquiry identified below address that objective. They are followed by more specific points of entry that could serve as basis for a cohesive program.

6.1 Lines of Enquiry

This review points to eight lines of enquiry where research is needed to catalyze change and address the complex interlinkages between ecosystem services and poverty in desakota environments. The first of these relates to understanding and identifying critical threshold conditions in interlinked social and ecological systems that may lead to transformative changes. The second places due attention on the intense stress on natural systems, especially water-based systems, due to intensification of economic and human activity coupled with changes in landuse patterns. Economics of ecosystem management is a critical third area for enquiry with particular emphasis on the implications of desakota phenomena for strategies founded on payment for ecosystem services. Exploration of social and ecological conditions and management processes in desakota areas requires a fourth area of focus on knowledge systems that bridge divides between scientific lines of enquiry and local decision-making processes. The fifth theme places emphasis on the need to identify key drivers and linkages that create or expand the desakota phenomenon. A sixth main area of research leads to an improved understanding of impacts and vulnerabilities arising in desakota regions which may extend from local to global scales with emerging flows of ecosystem services that move beyond conventional understanding. The seventh theme explicitly considers desakota and poverty relationships and research required to address inequities in equitable access of the poor to income, resources, and services. Finally, there is a need to re-imagine institutions that are capable of effectively managing and regulating ecosystems in the

complex and dynamic desakota regions where existing institutional mechanisms are no longer effective. Important concerns that crosscut these themes include health, conflict and learning strategies. These research themes are not mutually exclusive, nor should they be considered in isolation. In order to effectively challenge the complexities of ecosystem services and poverty linkages, any research program must address multiple themes. This said, as discussed in section 6.2 following the individual research themes, there are strong common points of entry for research related to concepts, data, interdisciplinary research across scales, and methodologies. These common points of entry could provide a strong platform for focused research that addresses multiple issue areas.

6.1.1 Critical Thresholds in Interlinked Socio-ecological Systems

Desakota regions are critical zones where intensification of human activity can cross thresholds that trigger transformative change in social and ecological systems. Such changes are often destructive in that they can precipitate the decline of regionally important ecosystems and the services they provide. However, changes can be more positive, if they, for example, improve gender-based access to resources or relieve consumptive pressure on forests for fuel. In both cases, however, understanding the critical threshold conditions likely to trigger transformative change is of fundamental importance for developing country policy makers and international organizations. Unless key thresholds and the cascade of changes they catalyze when crossed are understood, it will be impossible to manage ecosystems and ensure maintenance of the services they provide to the poor and other sections of society.

Recent research on ecosystem dynamics highlights the importance of land-use and vegetative mosaics in relation to temperature, precipitation, water quantity and water quality (Feddema *et al.*, 2005; Pielke *et al.*, 2007; Gordon *et al.*, 2008). Land-use mosaics across scales from the micro to the regional are also important factors in controlling runoff dynamics, groundwater recharge, sediment dynamics, water quality and ecosystem function within river systems. As a result they are central to everything from drought to floods to river channel and wetland dynamics. In order to maintain ecosystem services in desakota areas, there is a need for improving environment-specific understanding of land-use land-cover change; the early warnings of tipping points given by vegetation condition (including plant disease, decline in productivity, species disappearance, patchiness); and the implications of land cover patchiness and crossing of tipping points for local climate and water resources, hydrological and water quality regime changes. It is necessary to update and extend science-based knowledge on water systems dynamics and tipping points at meso and local scales along with their relation to other drivers of ecosystem services including *climate, ecology, agriculture, forestry, fisheries, wetlands and other systems.*

Research on thresholds in ecosystems should be intimately linked with similar research on tipping points in social and institutional systems. Desakota regions are focal points for intensification of economic activity and social change. As mobility, migration, and the flow of information, goods and services increase, the community-based social institutions that have historically managed ecosystems or delivered ecosystem services to vulnerable populations often collapse. In a manner similar to ecosystems, institutional systems can reach critical thresholds that trigger transformative change. Irrigation systems, for example as in the case of spate, and to some extent karez irrigation in Pakistan, can collapse when migration or the pull of other economic activities

undermines the availability of labor for maintenance. This can reshape water flows and the landuse mosaic within a region. It can also change access to water for vulnerable populations as the institutions that once enabled access decline. A similar story can repeat itself in other resource regimes such as pastures, communally managed forests or fisheries, as illustrated by the Africa case study.

Overall, desakota regions appear to be critical zones where thresholds in interlinked socio-ecological systems can easily be passed. Understanding the nature of thresholds and how systems can be managed is central to maintaining access to ecosystem services, particularly for women, the poor and other groups. Within this overall theme, the following specific research themes could help inform practical interventions for poverty alleviation:

1. Define and monitor thresholds where changes in land cover mosaics can lead to abrupt but sometimes delayed transformative changes in hydrological and ecological system dynamics and water quality. Identify ecosystem indicators that provide warning of proximity to particular thresholds. Such changes are usually difficult to reverse and have implications for moisture retention, floods, droughts and the productivity of woodland, pasture, cultivated land, fisheries and other ecosystems on which the poor depend;
2. Commission and review case studies which may help to understand and theorize potential thresholds where desakota type changes affect the viability of formal and/or informal institutions for sustainable water and other natural resource management. This would require integrated social and natural science methodologies;
3. Using multi-disciplinary research techniques, investigate how regional or large watershed scale environmental systems may undergo transformative change because of economic intensification within more localized desakota areas;
4. Track desakota type transitional regions in sub-Saharan Africa, South Asia, and China (where the desakota type transition seems to be most intense) for evidence of vulnerable socio-ecological systems susceptible to the collapse of vital ecosystem services. Such tracking could be achieved through multi-disciplinary case studies and monitoring key surface and groundwater quality data. It could also involve the development of clear sets of indicators to track and possibly map desakota processes globally and in detail for high vulnerability regions; and
5. Investigate the role desakota dynamics may be playing as a locus of the greenhouse gas emissions that contribute to global climate change. In addition to pre-existing natural-resource based livelihoods, intensification of commercial, industrial, service and other economic activities coupled with increased mobility and transport specifically in desakota regions may be a significant factor contributing to the growth of greenhouse gas emissions. This may contribute to the potential for crossing tipping points or thresholds in global climate systems that have direct implications for poverty. Climate is a key arena where the ecosystems services on which local populations depend are affected by growing interlinkages between local and global systems.

Research on these topics would provide critical insights to key actors across a range of scales. At a local level it would provide NGO and local government practitioners with key insights central to landuse planning, disaster risk reduction and the viability of community-based and other institutions for environmental management. At higher policy levels, understanding the implications of thresholds in interlinked systems will be central to structuring of insurance systems along with trade and production policies in key fields such as food and agriculture. Results from

research may be of particular importance as part of global attempts to address climate change. Understanding the degree to which growing GHG emissions associated with desakota contexts contribute to overall emissions at a global level, and thus the potential for crossing tipping points in global climate systems, could form the basis for targeted programs to reduce emissions that target the dynamics driving the desakota phenomena.

Given that the critical insights from such research will relate to the dynamics and thresholds in rapidly changing complex systems, conventional research reports and dissemination strategies, while important, are likely to prove insufficient. Experiential strategies that directly expose key actors to issues inherent in managing the dynamics of such systems will be essential. Adaptive learning process based approaches that emphasize iterative forms of interaction between researchers and decision makers as new knowledge is gained and refined are essential. Scenario modelling and gaming techniques that directly involve key actors at every level from national policy to local villages combined with direct exposure to field realities may also contribute to forms of understanding that are poorly conveyed by publications or reports. To achieve this, modelling and analytical techniques need to move out of the realm of experts into more accessible and interactive formats where informed but non-expert actors can directly interact and "play" with models so that they gain a "feel" for the dynamics of interacting systems and can compare that "feel" to their own more directly grounded experiences. This is a critical arena for experimentation and capacity development. Tools, such as the WEAP water modelling system of the Stockholm Environment Institute represent an initial step in this direction. Development of similar accessible tools in a variety of other arenas and improved strategies for integrating them with social dialogue and adaptive learning techniques are important.

6.1.2 Natural Systems under Stress in Desakota Regions

Within desakota regions the overall intensification of economic and human activity coupled with changes in land use systems feedback into climate change and place intense direct stress on natural systems in general and water based ecosystems in particular (Sharma and Shakya, 2006). Such stresses emerge as pollution and water demands from commercial, industrial and service industries coupled with similar pressures from agricultural intensification. They also emerge as the land use mosaic changes—particularly as vulnerable populations settle on river margins, wetlands, hillslopes and other ecologically sensitive land areas.

Solutions to such pressures depend, not just on understanding of the thresholds mentioned elsewhere as a focal area for potential research, but also on more broad based understanding of key natural systems and the processes that sustain them. In particular, research is needed on understanding and managing surface and groundwater flow regimes and improving the functioning and productivity of river margins and aquatic systems within desakota areas. Where basic science is concerned research on interlinked vegetative and hydrologic systems that focus on inundation-connectivity dynamics, sediment-fertility relationships, surface-groundwater interactions, water quality, habitat-landforms and land use mosaics is of particular importance. This has major implications for changes in sediment, water quality, temperature regimes and river flows – i.e. the determinants of the aquatic and riparian habitats that are of central importance for fisheries and the spread/survival of alien and native organisms and water-related diseases. It also has implications for surface and ground water resource conditions (and the degree of exploitation they will support) under changing climate and desakota pressures.

Key areas exist where research on natural systems under stress in desakota regions could lead to practical strategies range across a variety of scales. At the macro level, changes in climate system dynamics associated with the monsoon or El Nino could catalyze major more localized changes in vegetation and hydrologic systems with direct implications for the strategies needed to maintain ecosystem services. Hydrological change may, in turn, affect agricultural production, flood and drought risk, and water supply at local levels. The ecohydrological (and geomorphological) functioning of riparian and littoral habitats and how they are impacted by climatic and anthropogenic change is important as many communities are directly dependent upon the ecosystem services that these habitats provide in addition to the protection they can afford against environmental extremes and water quality deterioration. Hydrological change may also affect groundwater sources, pathways and relationships with surface water and precipitation. *An increased understanding of groundwater is particularly important* because groundwater is less sensitive than surface sources to short term variations in precipitation and the manner in which groundwater is managed directly affects the sustainability of water supplies for domestic, agricultural and industrial use as well as ecosystems. Water resource condition changes are also important because of the major role they play in water quality with direct implications for human and ecosystem health.

Critical points of entry on stressed natural systems could be summarized as needing to focus on fundamental scientific research on stresses on natural water-based ecosystems due to intensification of economic and human activity coupled with changes in landuse patterns. Particular emphasis should be given to landscape mosaic – ecosystem service interactions in desakota regions. Starting at the local level and moving upward to regional and more modeling based approaches. Specific research issues under this theme include:

1. Develop understanding of interactions between land cover and climate under the pressures of desakota, including analyses of changes in
   (i) the type, intensity, extent, distribution and patchiness of land cover types at different spatial scales,
   (ii) the sensitivity of different biome or eco-region settings to such changes under current and projected climate conditions, and
   (iii) establish indicators of desakota-affected systems approaching threshold conditions (e.g. extent of high biomass land cover types, vegetation health/vigour, soil organic content);
2. Undertake research on river flow regimes that focuses on their characterization, their controls, and the development of approaches to their distributed, local management which incorporate issues of riparian – surface water – groundwater connectivity;
   (i) investigate small scale, low cost distributed measures to support self-purification of water within the catchment drainage network, which could also improve the runoff regime and support aquatic and riparian ecosystem complexity and services;
   (ii) investigate smaller-scale distributed approaches to water resource development within catchments that avoid the adverse regional impacts on water quality, quantity and ecosystems that typify large-scale manipulation of surface and groundwater systems;
3. Intensified modelling based research at the local scale on the hydrology, geomorphology and ecology of ecosystems under conditions of increased uncertainty about future precipitation and temperature trends;
4. Develop research that connects climate change and desakota with catchment and river functioning to identify and develop interventions between water ecosystem processes and water-related diseases; and

5. Refine the representation of vegetation/landcover feedbacks within climate models at a range of spatial scales.

As with the issue of thresholds in desakota systems, results from such basic scientific research are of critical importance to inform the activities of key actors across a range of scales – in this case from local watersheds up to major trans-boundary river basins. Where basic ecosystems science is concerned, many of the key actors will be in communities, local governments and the sector-specific organizations charged with managing forest, water and other resources. These actors are central to the day-to-day decisions that influence whether or not an area of buffer vegetation is maintained, how water control structures are designed and whether or not sources of pollution are identified and controlled. As a result, their actions will have a particularly direct impact on the maintenance of ecosystems and whether or not vulnerable populations have access to the services such systems provide.

6.1.3 Economics of Ecosystems and Poverty

The complex interconnected dynamics of ecological and livelihood systems in desakota contexts pose complex challenges for approaches to valuing ecosystems services and developing systems that communicate such values to users. Economic approaches to ecosystems management have emphasized valuation of the public goods they produce as a justification and mechanism for guiding public investment. They have also emphasized more direct mechanisms for compensating those protecting ecosystems for the value of the services such systems produce – the so-called "payment for ecosystems services" model.

Such approaches may have both particular strengths and weaknesses in desakota contexts. Strategies for maintaining landscape mosaics, for example, would benefit from evaluations that quantify the economic value of reduced flood or other disaster losses, improved water quality and habitat "values." Such economic evaluations could provide a clear justification for public investment in open space and vegetative buffers around streams. They could also be used to create specific flows of funding from those who benefit from ecosystems services to those involved in the protection of ecosystems. It is important to recognize, however, that the payment for ecosystem services models will in many cases place the largest burden of payment on the poor.

Idealized conceptions regarding payment for ecosystems services have typically been framed in relation to wealthy (often urban) beneficiaries compensating poor (generally rural) communities for maintaining key ecosystems. This is the case, for example, with strategies for forest protection in poor upland areas as a way of maintaining river flows and water quality for downstream municipalities. It is important to recognize, however, that the increasingly interlinked nature of desakota systems and growing dependency of the poor on services produced in distant ecosystem will in many cases reverse payment flows. In the case of food production systems, for example, sustainable production depends heavily on maintenance of soil and water systems in major grain producing regions such as Australia. Trade in food represents, in essence, a virtual flow of water and other ecosystems services from producing regions to consumers. Under the payment for ecosystems services model, the cost of maintaining such distant systems should logically be incorporated in the cost of products, in this case food. Doing this would result in a flow of resources from consumers to land and water managers in producing regions. With the poor

already paying a large portion of their income for food, this could easily become a major catalyst for increases in poverty. It would, in essence, place the largest burden of payment for ecosystem maintenance on those who can least afford the cost.

Overall, the dynamic nature of desakota systems and the complex often geographically disconnected linkages they create between the production and consumption of ecosystems services create major challenges for both valuation of such services and for approaches to reflecting that value in market transactions. Economic valuation of ecosystem services is, however, a key factor influencing the logic of both public and private investment in their protection. It is also a key entry point for dialogue with decision makers in finance ministries. Finally, where such values can be reflected in transactions they can both create incentives and generate the resources necessary for management. As a result, this is a critical area for research in desakota contexts that can address the links between poverty and ecosystem services. A key need is to value ecosystem services in the desakota context in ways that move beyond models for payment for ecosystem services. Specific research issues include:

1. Development of improved approaches to estimating the benefits of water-related ecosystem services including, where existing climate information permits, probabilistic benefits such as those associated with flood and other disaster risk reduction; and
2. Innovative approaches for reflecting the value of ecosystems services in day-to-day life, particularly for the poor, that go beyond the payment for ecosystems services model or polluter-pays principles. This will require close interaction between those understanding the basic science of ecosystems within landscape mosaics and those seeking to value the services generated.

Key users of results from this type of research will include decision makers in finance ministries and others charged with allocation of funds to development activities. Private sector actors in businesses such as insurance may also utilize such research results.

6.1.4 Knowledge Systems

In the complex task of managing ecosystem services and serving the most vulnerable amidst our communities, there exists a wide disjuncture between the knowledge systems (and the primary sources of information that form the basis of such knowledge systems) used by the decision-makers at the global and the local levels. At the upper end, "high" science with advanced technologies such as space observations or sub-atomic physics dominates the discourse, especially when related to such global concerns as climate change. Higher level debates on response strategies are also fed by estimates of global water availability, national population growth rates or similar macro-aggregated data. Decision-making at the village level is often unaware of these data and tools, and is based on cultural memory and every day experience of interactions with the ecosystems.

This disjuncture has particularly severe implications as the dynamics of desakota systems strengthen and deepen the linkage between global and local livelihoods, risks and change processes. If global attempts to address climate impacts or poverty are to make any headway, "high" science must make stronger links with local level actors. This includes not only physical collection of more local level data but also strengthening capacity of local decision-making to use the analysis that emerges from such exercises. "High" science has to recognize the legitimacy and implications of knowledge generated at

local levels through processes that may not follow conventional scientific techniques. To achieve this there has to be a two-way communication between the "scientific" communities both at the local and the national and international scale. This calls for a communications strategy for research dissemination to the local levels managing ecosystems as well as to glean local concerns upwards in time to address emerging ecological and social desakota hotspots.

In the social sciences, the disjuncture is of a different nature. Where rapidly changing social patterns of desakota undermine the applicability of standard 'rural' and 'urban' concepts, the conventional methods of conducting decadal census based on such categories will not lead to a proper assessment of the ground realities. In the field of economics, the dominance of the informal economy means that economic opportunities that contribute to the household income baskets will have poorly understood social behavioural patterns, and indeed, the economic opportunities themselves (e.g. the sand mining of river beds, water markets, fisheries collapse etc.) will not have been rightly analysed to help the poor achieve better incomes. Concepts of poverty, particularly those limited to economic criteria of $1/day or $2/day income, need to be broadened to include understanding poverty from other disciplines such as social-anthropology, and to include local definitions, which are moulded by not just local culture and political economy as illustrated by the case studies of Nepal and Pakistan, but also by the broader market and its advertising media power.

In managing water-dependent ecosystem services as climate change proceeds, the statistical assumptions on which disciplines ranging from engineering hydrology to insurance are based is evaporating. Attempts to project future conditions from historical probabilities are now inappropriate. As a result, the knowledge systems on which water resource and climate related disciplines are based need, in many places, to be re-evaluated. New approaches that emphasize and incorporate higher levels of uncertainty need to be developed.

The challenge, however, goes beyond the technical and statistical foundations of knowledge systems. Where disciplines are concerned, the overall domination of engineering, and sometimes economics, has meant that the contribution of other science disciplines to the decision-making process has been insufficient. New institutional modalities of "data democratization", for example through the involvement of schools in the collection of basic hydrological, ecological and other data as part of the education curriculum, have to be contemplated and implemented. Similarly, the traditional knowledge base has to be more thoroughly pursued to mine the wisdom therein to understand the impact of new challenges, from natural causes such as climate change and social causes such as mass migration, in the rapidly changing desakota zones.

Entry points for research and experimentation on knowledge systems that could have very practical implications for the management of ecosystems services and the well-being of vulnerable populations in desakota contexts require exploration of social and ecological conditions and management processes. In desakota areas this requires a focus on knowledge systems that bridge divides between scientific and local lines of enquiry and decision-making processes. While this theme is very broad, tangible research issues include:

1. Developing improved methods for measuring demographies and economies of desakota areas to address limitations of existing census and survey methods;

2. Exploring changes in the underlying principles on which stochastic approaches to hydrology and civil engineering are based to identify new approaches to the design of water infrastructure and institutions in desakota regions that are resilient under uncertainty. Given the rapid pace of change in climate and landscape mosaics, the scientific basis for probabilistic analysis of hydrologic systems may no longer be justified because future probabilities cannot be predicted based on the historical period of record. This may necessitate basic changes in the scientific and engineering knowledge systems on which infrastructure and institutional designs are founded;
3. Collecting data on critical ecosystem characteristics and the services they produce through innovative techniques while also developing mechanisms to make the data (and the analyses based on them) accessible and useful to vulnerable groups; and
4. Exploring avenues for incorporating systems dynamics and uncertainty in primary to higher educational curricula to prepare future environment and water managers for careers in a world where static categories and linear forms of analysis will be of limited value.

Research and exploration of strategies for catalyzing change in knowledge systems would be of direct relevance to key decision making audiences within specific sectors, such as urban and regional planning, engineering and hydrology. More importantly, however, strategies that focus on building the capacity of communities within desakota contexts to generate and use different forms of scientific "information" could fundamentally alter the decision-making terrain. Data and information are sources of power. Increasing the penetration of locally generated knowledge into higher level processes while also increasing the ability of local communities to access and use information from other sources will increase their ability to influence decision making processes at all levels. This strategy is also consistent with the adaptive learning processes recommended in other areas.

6.1.5 Drivers of Desakota

A key feature of the desakota lens lies in the linkages between ecosystem services and globalisation trends that are particularly evident within the political, economic, demographic, transportation, and information sectors. The social and physical drivers inducing rapid change and greater connectivity in these areas produce a phenomenon of rich innovative possibilities coupled with severe dangers of ecosystem degradation. The drivers are also focal points where different knowledge streams infuse, highlighting the shortcomings of existing tools for collecting and analyzing data and interpreting interdisciplinary inter-relationships. While some information on specific drivers exists, what is poorly understood are the synergistic interlinkages between them and how they may be influencing or expanding the desokota phenomenon, and, as a consequence, the impact on ecosystem services and poverty.

A prime mover within the desakota is **transportation** and the improved access it provides for market related needs as well as other social services such as health and education. Linked with enhanced capacity for physical transportation of goods and people is that of information **communication**. Communication infrastructure systems also include access to the global languages that enable or constrain access to both information and work opportunities. Changing **demography** is another driver, where the region sees extensive in-migration from rural areas and out-migration keeping social relations (ethnic, religious and linguistic) in a state of permanent flux. The desakota region and the dynamic volatility within it has been the background against which severe **conflict** has emerged as the inducer of a range of changes, from political to demographic and economic.

It is against this dynamic background that the most global of all changes, **climate change**, has emerged as a driver of major significance for the ecosystem and the social order dependent upon it. Mobility and flexibility, both of which are enabled by transport, communication and flexible water administration systems, are central to the ability of populations to adapt to climate change, settle in low hazard risk areas, build institutions, and diversify/intensify livelihood activities. Achieving this without exacerbating climate change and other ecosystem concerns depends, at least in part, on access to and penetration of low impact technologies. Identifying and understanding the impact of these drivers and their externalized costs is an important research initiative that needs to be undertaken.

Critical research issues on the drivers of desakota systems and their impacts on poverty and ecosystem services include:

1. Investigating the role of improved communication, transport, banking, knowledge and other systems in enabling economic diversification and the development of desakota dynamics under different demographic, institutional and cultural contexts; and
2. Exploring factors that underlie the development and reach of technologies and systems that enable the penetration of desakota dynamics into more rural areas. This could lead toward strategies for encouraging the use of "environmentally benign" energy, transport and water management systems and green technologies. This may represent a key entry point for both alleviating poverty and reducing negative impacts on climate, water and ecosystems and the services they provide in increasingly important desakota regions. The diversification and flexibility inherent in desakota environments may provide opportunities to enhance the ability to adapt to climate change while also reducing greenhouse gas emissions. Research that explores synergies between adaptation to climate change and reduction of greenhouse gas emissions in desakota environments may be particularly rewarding.

Research in these areas would be of critical use to key actors involved in development planning. It could, for example, highlight tradeoffs between investment in basic transportation and communication infrastructure (the "rails" on which mobility and flows of information run) and targeted sector specific development projects. Research and projects that seek to develop and incubate innovative water management, transport, energy and institutional technologies would also be of potential direct interest to private sector actors. Iterative adaptive learning processes that seek to engage diverse communities represent a key mechanism for both engaging actual decision makers and disseminating results in such contexts.

6.1.6 Understanding Cross-scale Impacts, Vulnerabilities and Opportunities

The desakota phenomenon has major implications for ecosystem services at a global as well as local scale. Globally, urban areas are widely recognized as centers of intense energy, water and other resource use as well as major sources of pollution. We believe the dynamic intensification of economic and other forms of human activity in desakota regions may be of greater importance. These dynamics and the pathways for mediating them have not been explored because, unlike the conventional distinctions between "rural" and "urban," desakota regions have not been recognized as distinct entities and, as a result, statistics, research and information on them are lacking.

Figure 14:
Fuelling Desakota Transportation

Portering daily necessities: with desakota transformations underway, diesel powered "iron buffaloes" have taken over the task from humans as tractor tracks on the river bed (which is being mined for construction aggregates) indicate.

Conceptually, the rapid increase in transportation, construction, industrial and other forms of economic activity in desakota regions can be seen as a major driver of energy intensification, water and air pollution and competition over water and other natural resources. This intensification is likely to be a major factor contributing to the growth in greenhouse gas emissions and other pollutants. It may also be a driver at multiple scales of competition over access to basic resources (water, energy, etc...) that are already points of conflict at both local and global scales. Competition over water, for example, is widely recognized as a critical source of conflict in some local conditions while a similar dynamic is occurring at global levels as competition over fossil fuels intensifies. This competition is often intensified by pollution of available ground and surface water supplies as industrial effluents are added to those from agricultural and domestic uses. Similarly, the desakota phenomenon has major implications for access to resources for agro-pastoralists and other extensive livelihood systems that often support culturally distinct groups. Research that explores the linkages between ecosystem services, (particularly those related to water) social capital and poverty and their implication for civil conflicts is of clear relevance in relation to desakota phenomenon.

In addition to competition and conflict, desakota dynamics also involve forms of intensification that can be conducive to the incubation of disease vectors. Bird flu, for example, has emerged in the intensive poultry industries that concentrate in desakota regions. Many disease vectors, such as malaria, dengue and many bacterial pathogens, are water-borne.water-bourne. Such water bornebourne vectors can affect both humans and the production systems such as agriculture or aquiculture (fish and shrimp farming) on which they depend. Technological and institutional interventions that address issues of water treatment and sanitation can directly address ubiquitous challenges of poverty and health. This is also the case with the intensified energy use associated with transportation, housing, commercial and industrial activities in desakota regions.

Figure 15:
Stinky Weed
neelgandhey

Desakota dyanmics, including more intensive and extensive transport networks and environmental instability can also enable the spread of invasive species. Water hyacinth, for example, while purposefully introduced into specific locations has become widespread in adjacent managed and unmanaged water systems. Opening opportunities for the dispersal and colonisation of invasive species adds additional dynamism and uncertainty to water services management, including the potential for cross-border movement of species and management disputes.

© D Gyawali

Ageratum Houstonianum: A migrating invasive species which is toxic to animals in the hills. Farmers of Lamjung, Nepal say this species has appeared in the last five years.

Another implication of impacts of the desakota phenomenon on global ecosystem services relates to the flow of food, water and other products that depend on ecosystem services in other regions on which populations in desakota areas depend. Virtual flows of water, rather than water use in local agriculture, now represent the main “stream”

of ecosystem services meeting the food needs of local populations. (Allan, 2003). As a result, food security may now depend on a combination of global as well as regional conditions where the sources of resilience and vulnerability are poorly understood. In some locations, the poor may become marginalized and forced to depend on high risk or exploitative .livelihoods, e.g. mining or brick kiln work in Balochistan and Nepal. In other conditions, however, the intensification of activity in desakota regions is clearly creating new livelihoods and enabling access to services (such as education) that directly benefit vulnerable populations. Research on this could be critical to everything from food security to social and economic mobility for poor, women and other vulnerable populations. Similarly, identifying mechanisms for maintaining the water-based ecosystem services that provide key resources for the poor when those ecosystems are separated from the beneficiaries by distance and/or function is a major conceptual and research challenge. As identified above in the section on economic issues, models based on payment for ecosystem services are a starting point but they are clearly inadequate when applied, for example, to global grain markets – the main source of virtual water flows between regions. Moving from the tangible to the conceptual, specific research issues within this theme include:

1. Identifying increasing dependencies within desakota livelihood systems on geographically distant ecosystem services (e.g. food production or water supply from distant regions), and through a combination of dynamic modelling, field cases and other research techniques improve understanding how rather than increasing flexibility and diversification, this may introduce new sources of risk. Exploration of economic and other mechanisms for managing such globally interlinked systems is required;
2. Identification and management of disease vectors in desakota regions as industrialization increases, particularly in China and South Asia. In specific, studies that focus on disease vectors associated with land and water use intensification and climate change represent a critical avenue for reducing the health impacts that create poverty in such contexts; and
3. Identifying the factors that encourage dispersal and colonisation of invasive species, measuring the economic, cultural and health costs and benefits as well as ecological impact of colonisation, and identifying mechanisms to control colonisation in desakota contexts.

Research on these themes would be of particular relevance to actors engaged in global change policy, including that related to climate change and specific sectors such as health. Dissemination strategies that are capable of gaining legitimacy required in such sectors are, as a result, particularly relevant, e.g., publication in peer-reviewed journals (the fundamental requirement for achieving recognition in processes such as the IPCC on climate change and medical debates). Engagement processes for working with key actors engaged in climate adaptation (such as Adaptation fund board members) and trade and economic policy are also important. Although the audiences for results are specific to individual research themes, strategies for disseminating results should also emphasize the iterative adaptive learning processes identified before.

6.1.7 Desakota and Poverty

The desakota phenomenon appears to be offering pathways out of poverty. Improved transport systems, mobility, communications and connections with markets may facilitate opportunities for livelihood diversification, improved incomes, or even access to health and education services. However, as demonstrated in the cases and literature reviews, the desakota phenomenon may also result in increasing inequities. Those with less education, skills and services are least able to take advantage of

such opportunities. In South Asia, women particularly are marginalized due to lack of access to training, limited language skills, and cultural norms limiting mobility. In addition, technological innovations may draw further lines of inequity. In Colombia, for example, mechanization of the dairy industry marginalized women's employment, and where women were able to access new income opportunities in expanding global and regional industries, these were low-paying jobs.

In desakota envronments, the scale of increasing pressures on quantity and quality of water resources, forests, and communal grazing land directly impacts the poorest groups who rely on water, fuelwood, fodder and non-timber forest products directly to meet their daily livelihood needs. Increasing value and conversion of land for industry or real estate has forced poor from resources on which they live and depend. Desakota development, in part due to negative impacts on water-based regulating services such as flood control and filtering pollutants, are exacerbating health problems and disaster risks to the poor. Increased exposure to polluted sources, such as the brick kilns in Balochistan or industries in Gujarat polluting water sources, aggravates poor health conditions, which are compounded by lack of access to effective health services and exposure to disaster risks. The poor often live in more hazardous areas such as marginal flood plains that may also be sites of industrial and other waste disposal. Increasing market dependencies, lack of secure land tenure, and lack of political organization are increasing vulnerabilities of the poor, at times forcing them to shift to more hazardous geographical locations.

Research is required to identify the "poor" in desakota areas, using comprehensive and relevant definitions of poverty that include lack of access to resources and services, and to understand how the poor have been adapting and coping with loss of access to ecosystem services. One crucial piece is the role of the informal economy as a critical source of livelihoods for the poor, which also has implications both for increasing pressures on ecosystems, such as brick-making or construction in South Asia, (Figure 12), as well as managing ecosystems such as the case of solid waste management in China. As quantity and quality of water resources become more limited in pockets of intensified economic activities in South Asia for example, water increasingly is supplied through informal markets. The escalating reliance of secondary and tertiary market institutions for provisioning of water, food, fodder may further marginalize poor who are unable to affordably and equitably access such services.

Development research and interventions have tended to avoid the informal sector because of the difficulties in understanding its complexities and unbounded nature, and in establishing effective regulations and enforcement. Efforts must be made to better understand and work with and within the informal sector—not to attempt to 'formalize' it—but to improve standards, norms, social protection and flexible institutions that can support working conditions for the poor and enable their access to water-based ecosystem services. Research is also required that addresses the inequities in accessing opportunities made available by the desakota phenomenon, through improving access to skills, education and training of the poorest groups. It also includes improved access to and benefits from markets through enhancing institutional arrangements such as co-operatives, complemented with a larger systemic approach to strengthening pro-poor market conditions, including infrastructure, strengthening business planning, and competitive integration. Research also needs to adress vulnerabilities of the poor that may inhibit access to ecosystem services or increase risk and reduce adaptive capacities to disaster and health hazards. Moving

from impacts to potential responses, specific research issues on poverty include:

1. Identifying how the desakota phenomena may be shifting the relationship between ecosystem services and poverty away from provisioning of resources to more systemic and equally important regulating services, e.g., exposure to environmental extremes, health risks, etc.;
2. Improving understanding of factors contributing to changing patterns of vulnerability for the poor, particularly women, children and other social groups that face exclusion, in desakota regions such as those associated with decreasing water quality and quantity, increasing pollution and increasing exposure to disaster risks;
3. Increasing understanding of the role and function of secondary and tertiary intermediary (market) institutions for provisioning of water, food and fodder in desakota type transitional contexts;
4. Documenting through case studies the opportunities, constraints and vulnerabilities for the women, children and the poor in desakota environments. Identify actions and policies to address inequities in access to opportunities, such as skills, education, and training allowing the poor to take advantage of new economic opportunities in the cash economy;
5. Exploring the significant remittance incomes in these regions in relation to the constraints faced as well as the potential for investment of household savings into environmentally sustainable production rather than consumption, especially in the formal economy;
6. Developing understanding of the implications of desakota dynamics for specific vulnerable and poorly understood socio-ecological systems, such as those found in many highly mobile pastoralist societies, fishing communities and high-mountain regions;
7. Developing new and refined methods and indicators (at local and regional scales) to capture region, culture and gender specific definitions of poverty that include income with other material and social assets, education, health and access to services in desakota environments;
8. Exploring the underlying reasons people move into and out of poverty: case studies at the micro and regional scale in desakota contexts could help improve understanding of this question;
9. Documenting, through commissioned case studies as well as re-visiting primarily 'grey literature', strategies of collective action by the poor – and the conditions that enable such democratic processes – that may have enhanced their access to quality ecosystems services in desakota contexts. Regional and inter-regional comparisons need to be made to help generalize policy conclusions; and
10. Since much of the innovative activities within desakota contexts occur within the informal economy, undertaking policy focused research to tap into this adaptive mechanism.

Research of the above type could inform decision-making by key actors across a spectrum from national and global development organizations to local governments and NGOs. Where national level actors are concerned, improved understanding of poverty and the role of the informal sector in mediating access to and use of ecosystem services could inform national poverty reduction and other planned development strategies. A key contribution of this theme could be rearticulating the environmental agenda in the global South away from its perceived Western political genus towards a question of livelihoods, justice and poverty alleviation. Within local regions, research on the informal sector could be of particular use to sector specific organizations, such as water utilities, that often operate in a manner that is distinctly disconnected from the informal systems delivering key products such as water.

To be effective in reaching both national and regional audiences, interactive and experiential learning process based approaches are essential in relation to this as well as many other of the research themes we have identified. Strategies for working with or regulating the informal sector to improve maintenance of ecosystems and equitable delivery of the services they provide will, for example, be inherently experimental. Learning and the development of effective strategies can only emerge as experience is gained. Adaptive learning processes will, however, be insufficient as the sole mechanism for disseminating knowledge generated. Key research results, such as improved understanding of the nature of poverty in desakota regions are of direct relevance to the global academic and professional audiences that shape international development policies. Influencing these audiences often requires formal peer reviewed publications and more conventional modes of dissemination in addition to experiential adaptive learning modes.

6.1.8 Governance and Institutions

In the desakota regions that have been explored in this study, traditional systems of ecosystems management as well as those assuring social justice and harmony are breaking down but formal ones have not yet been firmly established. The region sees a complex mix of old village practices coexisting with urban (at times even global) ones, and the melange presents a vibrant potential for re-imagining institutions. This mix has within it the potential for evolving effective new governance that is simultaneously environment-friendly and pro-poor, but also contains the possibility of institutional collapse that is detrimental to both. The design of response mechanisms that are capable of effectively addressing social-ecological impacts in desakota regions must at its core deliberately concentrate on the development of capable and equitable institutions.

Where old regulating institutions of the village level community-based natural resource management have faded, and governmental management regimes have not taken a firm hold, increased means of communications have allowed aggressive market penetration into the rural hinterlands. Often this regulatory vacuum has resulted in the introduction of new technologies (e.g. diesel pumps for extracting groundwater as well as overdrawing from small streams) that, while providing labour-saving and other amenities, have exploited natural resources to the point of irreversible insult or at least severe stress. Maintaining the regulating functions of key ecosystems in desakota regions by encouraging a mosaic of protective institutions around critical ecosystem areas becomes crucial for buffer zones. This requires developing strategies, institutions such as local governance organizations, and incentives for moderating pollution and maintaining the flow and water quality regimes that provide basic water services.

Such re-imagined institutions have to be capable of addressing varied policy options that range from coercive means (laws, regulations and the courts), persuasive means (incentives and other market mechanisms), and “options limiting” ethical means (that appeal to higher values of conservation, intergenerational goodwill or even religious concerns with purity or taboo that intrinsically prohibit their votaries from engaging in inappropriate behaviour) (Lukes, 2005). An important point to realize is that not all these functions can or should be expected to be performed by one institution: check and balance between different powers are essential if unpleasant surprises in decision-making are to be minimized in a context of high scientific and social uncertainties.

Figure 16:
Technological Innovation

Iron buffaloes and bullocks of the desakota: Technology designed for a different purpose is adapted to local needs. Two-wheeled tractors designed for rice field ploughing in Japan became transportation device in Nepal's poor roads. In Rajasthan, Indian diesel pumps designed for groundwater irrigation is converted into a rural truck during non-irrigation season. Known locally as *jugads*, neither these vehicles nor most of their drivers have any registration or license, and their carbon footprint is significant.

Institutions cannot be grafted onto communities as "best practices" templates, but must evolve through social engagement; and for it to happen, the role of various social carriers become important. If greener technologies are to be promoted, who will be the social carriers, or from where will they come, that would champion their adoption? This calls for serious research initiatives to understand the existing mélange of old and new institutions within the desakota regions. It also calls for a review of the well-researched "community-based" resource management regimes for the desakota where in- and out-migration has resulted in a partial replacement of the "community" for self-seeking individualism that is not as amenable to the old ethical ideas of the "greater common good". This relates to the question of institutional "reach" and conflict resolution, that is, the ability of both community-based and formal governmental institutions to run water and other resource systems to mediate conflicting demands and pressures.

Potential points of entry include enabling frameworks for organizations to form by building on existing networked patterns of association in order to respond to environmental stewardship needs. Where shared activities are concerned, opportunities may exist in relation to other networks that create tangible, functional relationships between people. Specific opportunities could, for example, exist in association with financial and banking systems; energy (particularly electricity distribution) and similar networked physical systems such as those for irrigation and domestic water supply delivery, industry, farm and other sector-specific associations. Research on these topics could have very direct implications for the creation of institutions capable of maintaining ecosystems and ensuring sustainable access to services for the poor.

Specific areas where research could have a major impact on poverty alleviation include:

1. Conceptually driven empirical investigations of new institutional models beyond community or government-based water and resource management and conflict resolution in the desakota transition zones. The new institutional landscape in desakota regions calls for re-evaluation of many development orthodoxies including concepts of community and community participation; and
2. Empirically investigating the impact of institutional transitions underway in desakota areas, on the most vulnerable populations' access to resources and enjoyment of ecosystem services.

In addition to a broad array of development policy actors and practitioners, key sets of actors that would be particularly relevant to engage in research processes and target for dissemination on the above themes include those directly involved in legal and other institutions for conflict mediation and the design of institutions. Far too often the development of institutions and processes for environmental management and conflict mediation takes place with little involvement from key actors involved in formal legal systems. This can undermine the effectiveness of resulting arrangements. Because legal systems differ greatly, experiential and adaptive learning strategies tailored to the legal profession in different national contexts would be important for dissemination and capacity building. Such strategies should also engage with informal conflict mediation processes and institutions along with the actors active in such contexts.

6.2 Points of Entry for Change

How can research catalyze change in complex systems, such as those that characterize the desakota phenomenon? Knowledge is the essential foundation for informed action. It is critical pieces of new knowledge that can play a catalytic role enabling change processes. Conventional approaches to the identification of such "critical pieces of knowledge" follow the reductionist approach that underpins most modern science and the disciplinary silos associated with it. This approach is challenged in fundamental ways by the systemic nature of interactions in desakota contexts, where tipping point thresholds can be reached at the synergistic boundaries between natural and human systems. These systems are often addressed separately by the physical and social sciences, thus missing interactions that cross the interface. As a result, compartmentalized knowledge generated within disciplinary silos has limited utility for decision making, particularly at the local level where the impact of decisions is direct and tangible. Because such knowledge does not address the critical systemic interactions that span critical disciplinary boundaries, it cannot catalyze informed change processes.

The complexity of interactions between social and natural ecosystems in desakota environments, and their implications for ecosystem services and poverty alleviation requires a complex set of responses capable of crossing the conventional boundaries between disciplines. New ways of thinking are required to bridge the boundaries between local, national and global as well as between state, market and civic-movement based actors. As mentioned at the outset of this report, the research themes we have identified are intricately connected, and there is no analytical basis for making any one more of a priority than another. Entry points for research support cut across these themes, and relate to core concepts, data, research at different scales, and methods. Strategies that recognize and build off these core entry points will retain coherence and achieve impact despite the diversity and complexity of the phenomenon. These entry points are:

1. **Conceptual**: Unpacking and refining the conceptual frameworks in ways that more directly relate local perceptions of poverty to ecosystems services in desakota environments. In specific, refining the conceptual basis for understanding the relationships between ecosystems dynamics, risk, poverty, technology and institutions in rapidly evolving and highly interlinked cross-scale systems contexts is of vital importance to generating new insights on any of the specific research themes.

2. **Data Metrics**: The fundamental role of economic diversification and other processes driving the desakota phenomena have remained hidden because the criteria for data collection are shaped by static distinctions between "rural" and "urban" areas. Developing indices and other metrics for data collection that transcend these definitions and allow delineation and social or geographical "mapping" of desakota systems is of fundamental importance to addressing any of the research themes identified above. The potentially central role of desakota contexts, based as they are on increased mobility, energy consumption and lifestyle changes, as a major source of greenhouse gas emissions, for example, cannot be determined in the absence of such metrics. Data are the foundation for scientific dialogue and evidence based decision-making. Data also must not only be accessible to different users, including vulnerable groups and local decision-makers, but also socially acceptable to them if policy prescriptions made on the basis of such data dependent analysis are to see effective implementation. Overall, developing the basic indices and metrics needed to characterize desakota phenomena represent an essential first entry point on which virtually all subsequent research results ultimately depend.

3. **Interdisciplinary research at and across different scales**: Water as well as the desakota phenomenon are inherently interdisciplinary in that they are the focal points where several disciplines, both of soft and hard sciences, intersect. While multi-disciplinary studies allow experts to slice out that part of the problem amenable to the application of their disciplinary tools, they still require integrating into a package of action by some means. Interdisciplinary research, on the other hand, begins with experts of one discipline examining the problem from the perspectives of another discipline (e.g. an engineer trying to think through the economics of a water problem). While most policy environments are inherently interdisciplinary, much of academia is not, nor is such research academically rewarded. Interdisciplinary research that investigates these complex social-ecological interactions at local/micro, meso and regional levels, and across these different scales is required to craft effective and sustainable policy. Specific research questions are detailed in the above research themes. However, such research may be implemented in activities that include:
    a. Case studies of specific desakota contexts that document natural-social interactions and implications for ecosystem service and poverty interlinkages: Interdisciplinary research that investigates and documents drivers, impacts and both environmental management and livelihood strategies are required. It is in these concrete cases that the interactions can best be explored and understood. This includes 'basic' and applied science to understand these interactions. Preliminary cases were done as part of this study, but these were an extremely small sample, completed on relatively small scales, and one of the findings was the lack of existing or credible data. Substantial additional case material is required to generate new evidence, understanding, and potential interventions and strategies. These cases could be along transects such as in the case of the majority of ones for this report, or also explore more distant relationships between ecosystems and people who rely on their services. It is likely that any case studies would need to consider the implications of factors at large scales that may influence social-natural ecosystem interactions.
    b. Research at regional scales: This more macro scale of analysis may involve more basic and analytical research that may include, among others: 'tracking' of vulnerable desakota areas; transformative changes of watershed or catchment systems due to desakota development, including implications of climate-land cover-vegetation feedbacks and land use changes; and improved understanding of drivers.
    c. Action-oriented research initiatives: Interdisciplinary efforts to develop, test and evaluate technological, social and institutional innovations that may improve ecosystem management and poverty alleviation efforts. Select research initiatives should explore and learn from potential interventions that can lead to improved resource management and livelihoods. Such initiatives may include, for instance, trials of more resilient water infrastructure and management efforts that enhance provisioning and regulating services and alternative resource management institutions based on networks rather than geographic communities.

    Such research initiatives may include cross-regional comparisons or joint studies that may enable explorations of common research problems, as well as highlight regional or sub-regional specificities and unique responses required.

4. **Methodologies and tools**: The desakota context is characterized by unprecedented interlinkages between human and natural systems across all scales of interaction from the individual to the global and, as emphasized above, this necessitates interdisciplinary research across scales. At present, however, most research and research tools are locked within disciplinary silos and often are incapable of addressing multiple scales of analysis. Core methods for systems analysis in ecologically or culturally unique settings may, however, apply across many disciplines and scales that don't currently "talk" to each other. Exploration of common methods across the spectrum from case study techniques to network analysis and complex system modelling represents a key research entry point that will cut across virtually all of the thematic research issue areas and scales of analysis. Furthermore, the evolution of common methods, tools and techniques is a critical entry point for true collaboration across disciplines. Common methods are far more likely to erode disciplinary silos than any more topic based attempt to encourage multi-disciplinary collaboration.

Structuring a research program around the above points of entry, rather than primarily on the basis of individual themes that are impossible to prioritize across a global template, would represent a major advance toward spanning the divides between disciplines that limit the ability of research to generate knowledge that can be used as a basis for catalyzing change in dynamically complex contexts. Interdisciplinary research across different scales using, wherever possible, common concepts, common approaches to data management and common methods will we believe generate new insights of fundamental importance for addressing the interaction between ecosystem services and poverty in desakota contexts. In many cases, knowledge generated by research on individual themes would, of itself, be nothing new. Understanding the interactions between systems, between isolated pieces of information, between knowledge arenas and between the different voices engaged in shared learning can generate truly 'new' insights for addressing basic environmental and human poverty challenges.

6.3 Audiences and Communication Strategies

Research on the above topics will provide critical insights to key actors across a range of scales from government decision makers and officers in international organizations to community, business, academic and NGO leaders. In many ways these are not different from the audiences most research seeks to inform. What is critical given the complex dynamic of rapidly changing desakota systems is recognition that conventional research reports and dissemination strategies, while important, are likely to prove insufficient. Other forms of communication will be required in order to catalyze change among the diverse sets of private sector, community, NGO, and ill-defined government entities that shape behaviour in desakota regions. In many cases, the balance must shift from strategies that focus only on audiences consisting of governmental "decision makers" or fellow scientists toward less frequently addressed audiences in the private sector and in the "ethics communities" of social and environmental activists. The latter perform a very vital function as "social auditors" whose concerns, often regarding equity and justice, need to be addressed directly by the research community.

To be effective, any research on ecosystems services and poverty in desakota contexts must address and respond to critical questions regarding target audiences for research results. Unlike

research on "rural" or "urban" areas, conventional government institutions and the decision-makers associated with them often do not exist or have little ability to influence conditions on the ground. As a result, if they are to have an impact research actors will be forced to carefully, and possibly more broadly, select and engage with target audiences. In many cases the most effective audiences will be small: actor groups engaged in activities related to a specific research theme such as disaster risk reduction, transportation, disease or landuse management. As a result, rather than broadcasting research results through publications or media activities, in many cases the most effective strategies may involve narrowcasting to very small groups of stakeholders engaged in specific themes. Formal publications in academic journals or even the more widely circulated policy literature stand little chance of catalyzing real change at the grassroots level in dynamic desakota contexts. This said, it is important to recognize that conventional research dissemination techniques will remain essential in order to achieve certain types of impact. Formal academic publications are, essential in order to influence key global audiences such as the IPCC. They are also essential in order to justify change at a policy level within national governments or international organizations.

However, to achieve real change within desakota contexts, strategies that directly engage key actors in the research and interpretation of its results will be essential. Experiential learning strategies that directly expose key actors to issues inherent in managing the dynamics of change within desakota systems are, we believe, a central part of this. Adaptive learning process based approaches that emphasize iterative forms of interaction between researchers and decision makers as new knowledge is gained and refined can help build both engagement and the use of new knowledge as it emerges from the research. Processes are needed that rapidly cycle between the generation, dissemination, testing, application and re-evaluation of knowledge, in order to effectively inform policy and action to alleviate poverty and ecosystem services.

Conclusion

Processes of globalization and increasing mobility are creating unprecedented interlinkages in livelihood, economic, environmental, social and other systems across scales of interaction from the local to the global. The desakota lens highlights these linkages and their implications for livelihoods, poverty and ecosystem services in ways that are of fundamental importance for the development of practical strategies and policies. Where poor populations once depended on services from proximate ecosystems to meet basic fuel, fodder, water and other livelihood needs, now reliance is on distant ecosystems. Trade in grain and many other water intensive commodities represents a virtual flow of ecosystem services from producing regions to consumers. The ability to access such services depends on purchasing power, an outcome which is, in turn, intricately linked to livelihood diversification and intensification within mixed-economy desakota regions, coupled with trade, migration and other forms of mobility.

In addition to the creation of unprecedented interlinkages across scales, the mixture of "rural" agricultural and more "urban" service, manufacturing and other economic activities in the desakota context often intensifies pressures on local ecosystems and the services they provide. On one hand, environmental degradation associated with desakota dynamics often threatens both the provisioning and regulatory functions of ecosystems while, on the other the process of economic diversification changes both the dependency of livelihoods on ecosystem services and the incentives local communities have for environmental management. The net result is a highly dynamic environment in which the relationship between ecosystems services and poverty evolves rapidly both at local levels and across scales with un-researched tipping points between sustainable prosperity and irreversible collapse.

Such rapid change processes represent a fundamental challenge to conventional approaches to research and the incorporation of new knowledge in development strategies. Conventional approaches, while still necessary to generate new knowledge in many contexts, are incapable of responding sufficiently rapidly to maintain their relevance as change processes outpace the speed at which knowledge is generated and incorporated in policy and action. As a result, approaches to research that cycle rapidly between knowledge generation, experimentation, action, identification of new knowledge needs and back to research are essential.

Research also needs to be interactive across disciplines. The research themes identified in this report are not intended to be taken in a stand-alone manner but instead represent strands necessary for any integrated analysis of the desakota phenomenon and its implications for the relationship between poverty and ecosystem services across scales from the very local to global climate systems. Basic scientific research on ecosystems is essential to understand and identify effective points of intervention for the maintenance of key environmental services. At the same

time, such research must be far more effectively linked with other forms of research on social and economic systems if it is to translate into practical courses of action. Ultimately, policy must be informed by varied disciplinary concerns. It also must be based on processes that have heard from, and spoken to, not only government functionaries, but also voices from civic movements and business leaders across the scale from local to global. In doing so, networked approaches that incorporate many of the core research themes identified in this report are essential. Disconnected research on individual themes has, by itself, little chance of contributing to action on the ground or the formulation of effective policies whether at local, regional, national or global scales.

Cape Town Review

An ESPA review meet was held in Cape Town, South Africa, under the aegis of NERC/DfID/ESRC in Cape Town on 17-19 June 2008 that included representatives from their UK Project Management Group as well as Amazon-Andes, Sub-Saharan Africa, South Asia, China and the Desakota consortia. The meeting offered a valuable opportunity to reflect on the theoretical as well as practical implications of using desakota as a conceptual tool to unpack conventional approaches to development studies as well as various attempts at national planning that are too often locked within "rural development" or "urban planning" silos. It was also instructive to examine questions within environmental sciences raised by water management concerns refracted through the desakota lens.

In listening to the findings of the regional study consortia, glimpses could be discerned of the possibilities of desakota-type re-interpretation of their concerns. Indeed, it was the value of a different refractive take provided by the desakota approach on garden-variety environmental concerns, be they pollution or catastrophic transformation wrought by the stress of rapid change that was acknowledged to be of significant interest. In the case of coastal studies, where similar fuzziness of problem boundaries could be widely recognized, it was even suggested that there might be value to that particular assessment in adding a bit of desakota. Likewise, the Africa study had also taken a more "complex ecosystems approach" and found the desakota refractive lens valuable.

In summarizing, landscape ecosystem changes were recognized as the key finding with regards to the environmental sciences in the desakota. The points of specific interest acknowledged to be fundamental were the discontinuous or 'patchy' changes in land use over the landscape and the associated changes in ecosystem function (such as changes to the hydrological regime, with implications for water provision). Therefore, the 'patchy' landscape mosaic associated with the inherently unplanned, or even unguided, nature of desakota development, and impacts on ecosystems and the services they provide, were noted as key areas for future research.

In the social sciences, this seemingly anarchic institutional environment within the desakota was seen not only as an area for fruitful research, but was also realized with apprehension. A key point emphasized throughout this report is that, within the desakota, the rate of change in population demographics (whether increasing through high birth rates and in-migration or falling sharply in many rural areas due to out-migration) as well as changing consumption patterns are much faster than the institutional capacity to respond. This mismatch between the declining effectiveness of conventional rural or urban institutions and the institutional wherewithal to cope with the change has led to chronic environmental insults and injuries. This central theme led to the corollary that seeks new and more effective institutions for the desakota that can respond to the rapid changes

occurring therein before stress leads to a catastrophic tipping beyond the threshold. This theme resonated particularly well with the participants at the workshop.

The review meet also pointed out, along with the strengths, the weaknesses in the report. Some of the comments related to the difficulty of re-casting what has so far been observed in desakota terms. Indeed, in much of the environmental literature, specifically desakota assessments are hard to come by as they have not been done to any significant level as yet. Studies still are watershed based and the reviews of literature done for this assessment had to glean from this vast wealth of research writings those that howsoever fleetingly promised a "desakotish" look. Some of the comments asked of more rigour in hypothesis as well as more analytical work delineating "good" desakota from "bad". While the comments asking for more comprehensiveness in one or the other end of the rural-urban spectrum were fair, the short (seven months) time within which this research gap assessment was done means that these and many other questions raised by the desakota approach will have to be tackled by future ESPA research.

References

Aberra, E., and R. King (2005), Additional Knowledge of Livelihoods in the Kumasi Peri-Urban Interface (KPUI), Ashanti Region, Ghana, 65 pp, Development Planning Unit, University College London, London.

Adger, W. N., *et al*. (2002), Migration, Remittances, Livelihood Trajectories, and Social Resilience, *Ambio*, *31*(4), 358-366.

Agarwal, B. (2001) Participatory exclusions, community forestry, and gender: an analysis for South Asia and a conceptual framework. *World Development, 29*(10), 1623-1648.

Aggarwal, R. M. (2006), Globalization, Local Ecosystems, and the Rural Poor, *World Development*, *34*(8), 1405-1418.

Agrawal, A. (2001) Common property institutions and sustainable governance of resources. *World Developmen,t 29*(10), 1629-1672.

Allen, A., Davila, J.D., Hofmann, P. (2006) The peri-urban water poor: citizens or consumers? *Environment and Urbanization,* 18**,** 333-351.

Allen, A., *et al*. (2006), *Governance of Water and Sanitation Services for the Peri-urban Poor: A Framework for Understanding and Action in Metropolitan Regions*, 125 pp., Development Planning Unit, University College London, London.

Bangura, Y. (1997), Policy Dialogue and Gendered Development: Institutional and Ideological Constraints, UNRISD Discussion Paper 87.

Barnett, T.P., Adam, J.C. & Lettenmaier, D.P. (2005) Potential impacts of a warming climate on water availability in snow dominated regions. *Nature,* 438, 303-309.

Betts, R. A., Cox, P.M., Collins, M., Harris, P.P., Huntingford, C., Jones, C.D. (2004). "The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming." *Theoretical and Applied Climatology 78*, 157-175.

Borner, J., *et al*. (2007), Ecosystem services, agriculture, and rural poverty in the Eastern Brazilian Amazon: Interrelationships and policy prescriptions, *Special Section - Ecosystem Services and Agriculture - Ecosystem Services and Agriculture*, *64*(2), 356-373.

Bouma, M.J. (2003) Methodological problems and amendments to demonstrate effects of temperature on the epidemiology of malaria. A new perspective on the highland epidemics in Madagascar, 1972-1989. Transactions of the Royal Society of Tropical Medicine and Hygiene, 97, 133-139.

Bradford, A., *et al*. (2003), Wastewater irrigation in Hubli-Dharwad, India: implications for health and livelihoods, *Environment and Urbanization*, *15*(2), 157-170.

Bradsher, K. (2008), As Australia dries, a global shortage of rice: Drought contributes to shortage of food staple, International Herald Tribune, April 17, 2008

Brook, R. M., and J. D. Davila (Eds.) (2000), *The Peri-Urban Interface: a Tale of Two Cities*, 144 pp., School of Agricultural and Forest Sciences, University of Wales and Development Planning Unit, University College London, London.

Brown, C., and U. Lall (2006), Water and economic development: The role of variability and a framework for resilience, *Natural Resources Forum*, *30*, 306-317.

Bucini, G., Hanan, N.P. (2007) A continental-scale analysis of tree cover in African savannas. *Global Ecology and Biogeography,* 16, 593-605.

Bunn, S.E., Arthington, A.H. (2002) Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management,* 30, 492-507.

Chinoy, N.J., Barot, V.V., Michael, M., Barot, J.M., Purohit, R.M., Ghodasara, N.G., Parikh, D.J. (1994) Fluoride toxicity studies in Mehsana District, North-Gujarat. *Journal of Environmental Biology,* 15, 163-170.

Carvalho, G., *et al*. (2001), Sensitive development could protect Amazonia instead of destroying it, *Nature*, *409*, 131.

Caviglia-Harris, J. L. (2004), Household production and forest clearing: the role of farming in the development of the Amazon, *Environment and Development Economics*, *9*, 181-202.

Chen, M. A. (2007), Rethinking the Informal Economy: Linkages with the Formal Economy and the Formal Regulatory Environment, 14 pp, UN Department of Economic and Social Affairs.

Chinoy, N.J., Narayana, M.V., Sequeira, E., Joshi, S.M., Barot, J.M., Purohit, R.M., Parikh, D.J., Ghodasara, N.B. (1992) Studies on effects of fluoride in 36 villages of Mehsana District, North-Gujarat. *Fluoride, 25*, 101-110.

COMMAN (2004), Community Management of Groundwater Resources in Rural India, Commissioned Report, British Geological Survey, Wallingford.

Cooper, E., *et al*. (2005), World Resources 2005: The Wealth of the Poor—Managing Ecosystems to Fight Poverty, 266 pp, World Resources Institute in collaboration with United Nations Development Programme, United Nations Environment Programme, and World Bank, Washington DC.

Costa, M.H., Botta, A., Cardille, J.A. (2003) Effects of large-scale changes in land cover on the discharge of the Tocantins River, Southeastern Amazonia. *Journal of Hydrology, 283*, 206-217.

Cramer, W., Bondeau, A., Woodward, F.I., Prentice, I.C., Betts, R.A., Brovkin, V., Cox, P.M., Fisher, V., Foley, J.A., Friend, A.D., Kucharik, C., Lomas, M.R., Ramankutty, N., Sitch, S., Smith, B., White, A., Young-Molling, C. (2001) Global response of terrestrial ecosystem structure and function to CO2 and climate change: results from six dynamic global vegetation models. *Global Change Biology,* 7, 357-373.

Dale, V.H., Joyce, L.A., Mcnulty, S., Neilson, R.P., Ayres, M.P., Flannigan, M.D., Hanson, P.J., Irland, L.C., Lugo, A.E., Peterson, C.J., Simberloff, D., Swanson, F.J., Stocks, B.J., Wotton, B.M. (2001) Climate Change and Forest Disturbances. *BioScience, 51*, 723-734.

Dettinger, M.D., Diaz, H.F. (2000) Global Characteristics of Stream Flow Seasonality and Variability. *Journal of Hydrometeorology, 1*, 289-310

De Soto, H. (1989), The Other Path, Harper & Row, New York.

De Soto, H. (2000), *The Mystery of Capital- why capitalism triumphs in the West and fails everywhere else*, 276 pp., Basic Books, New York.

de Waal. A, and J. Tumushabe, (2003), *HIV/AIDS and Food Security in Africa,* DFID, London.

Dhiman, S.D., Keshari, A.K. (2006) Hydrogeochemical evaluation of high-fluoride groundwaters: a case study from Mehsana District, Gujarat, India. *Hydrological Sciences Journal-Journal Des Sciences Hydrologiques,* 51, 1149-1162.

Dixit A., Upadhya M., Tamrakar A. (2006), Pahadi Chetrama Pani Intejam (Water Management in the Moutain Regions), Nepal Water conservation Foundation, Kathmandu.

Dixit, A., *et al*. (2007), Flood Disaster Impacts and Responses in Nepal Tarai's Marginalised Basins, in *Working with the Winds of Change: Toward Strategies for Responding to the Risks Associated with Climate Change and other Hazards*, edited by Moench, M. and A. Dixit, pp. 119-157, ISET-International, ISET-Nepal and ProVention Consortium, Kathmandu.

Dongol, B.S., Merz, J., Schaffner, M., Nakarmi, G., Shah, P.B., Shrestha, S.K., Dangol, P.M. & Dhakal, M.P. (2005) Shallow groundwater in a middle mountain catchment of Nepal: quantity and quality issues. *Environmental Geology,* 49**,** 219-229.

Donner Jonathan (2007), The use of mobile phones by microentrepreneurs in Kigali, Rwanda: changes to business and social networks, *Information Technologies and International Development*, 3 (2), 3-19.

Douglas, I. (2004), Environmental Change in Peri-Urban Areas: Report and Recommendations, paper presented at Environmental Change in Peri-Urban Areas -A Scope Project-PUECH: Fifth regional meeting, Beirut, Lebanon.

Douglas, M. and and Ney, S (1998), Missing Persons: A Critique of the Social Sciences, University of California Press, Berkeley.

Doyle, M.W., Stanley, E.H., Strayer, D.L., Jacobson, R.B., Schmidt, J.C. (2005) Effective discharge analysis of ecological processes in streams. *Water Resources Research,* 41, W11411.

Drechsel, P. *et al*. (2007), Rural-Urban Food, Nutrient and Virtual Water Flows in Selected West African Cities, 39 pp, International Water Management Institute, Colombo.

Drimie, S. (2004), *The underlying causes of the food crisis in the Southern Africa region: Malawi, Mozambique, Zambia and Zimbabwe*, Oxfam GB Policy Research Paper, London, Oxfam GB.

Du, M.Y., Kawashima, S., Yonemura, S., Zhang, X.Z. & Chen, S.B. (2004) Mutual influence between human activities and climate change in the Tibetan Plateau during recent years. *Global and Planetary Change, 41*, 241-249.

Ebi, K. L., *et al*. (2007), Climate Change-related Health Impacts in the Hindu Kush-Himalayas, *EcoHealth*, *4*(264-270).

Ellis, F., Sumberg, J. (1998) Food production, urban areas and policy responses. *World Development,* 26, 213-225.

Faiola, A. (2008) The New Economics of Hunger. *The Washington Post*, April 27th, 2008. Retrieved from http://www.washingtonpost.com/wp-dyn/content/story/2008/04/26/ST2008042602333.html?hpid=topnews

Fan, C. C. (2001), Migration and labor-market returns in urban China: results from a recent survey in Guangzhou, *Environment and Planning A*, *33*, 479-508.

FAO (2008) Crop Prospects and Food Situation Report, #2, April 2008 accessed from ftp://ftp.fao.org/docrep/fao/010/ai465e/ai465e00.pdf

Farrington, J., *et al*. (2002), Sustainable Livelihoods Approaches in Urban Areas: General lessons, with illustrations from Indian cases, 60 pp, Overseas Development Institute, London.

Feddema, J. J., *et al*. (2005), The importance of land-cover change in simulating future climates, *Science*, *310*(5754), 1674-1678.

Foley, J.A., Levis, S., Costa, M.H., Cramer, W., Pollard, D. (2000) Incorporating dynamic vegetation cover within global climate models. *Ecological Applications, 10*, 1620–1632.

Foley, J.A., Costa, M.H., Delire, C., Ramankutty, N., Snyder, P. (2003) Green surprise? How terrestrial ecosystems could affect earth's climate. *Frontiers in Ecology and Environment, 1*, 38-44.

Foster, S., A. Lawrence, *et al*. (1998). Groundwater in Urban Development: Assessing Management Needs and Formulating Policy Strategies. Technical Paper. Washington, D.C., World Bank**:** 76.

Fuller, T. (2007a), In Laos, Chinese Motorcycles Change Lives, in *New York Times*, edited, p. 2, New York.

Fuller, T. (2007b). Chinese goods transform life in Southeast Asia International Herald Tribune**:** 2.

Global Nature Fund (2008), Laguna Fuquene, Colombia. Available from http://www.globalnature.org/docs/02_vorlage.asp?id=12716&domid=1011&sp=E&addlastid=&m1=110898&m2=110933&m3=111788&m4=12716, Accessed on 4 January 2008.

Godfrey, B. J., and J. O. Browder (1996), Disarticulated Urbanization in the Brazilian Amazon, *Geographical Review*, *86*(3), 441-445.

Gregory, P. (2005), A Synthesis of Peri-Urban Research of Kumasi, Hubli-Dharwad and Kolkata Peri-Urban Interfaces, 131 pp, Development Planning Unit, University College London, Tregaron.

Gupta, S.K., Deshpande, R.D. (1999) Water stress in Gujarat, India: Dimensions, development plans and peoples' movement for sustainable growth. *Water Resources Planning and Management*, 19-31.

Gurnell, A., Lee, M., Souch, C. (2007) Urban Rivers: Hydrology, Geomorphology, Ecology and Opportunities for Change. *Geography Compass, 1*, 1118-1137.

Gyawali, D., Schwank, O. *et al*. (1993), Rural-Urban Interlinkages: A Challenge for Swiss Development Cooperation, A Case Study Based on Nepalese-Swiss Development Experiences, INFRAS and IDA, Kathmandu.

Gyawali, D. (1996). *Economic Security in a Predominantly Informal World: South Asian Realities and Global Elation With Liberalization*; in Iftekharuzzaman (ed.) Regional Economic Trends and South Asian Security; published by the Regional Center for Strategic Studies, Colombo and Manohar Publishers and Distributors, New Delhi.

Gyawali, D (2003), Rivers, Technology and Society, Zed Books, London.

Gyawali, D., Allan, J.A. *et al*. (2006), EU-INCO water research from FP4 to FP6 (1994-2006) – a critical review. Luxemburg, Office for Official Publications of the European Communities, 86p.

Haack, B.N., Khatiwada, G. (2007) Rice and bricks: Environmental issues and mapping of the unusual crop rotation pattern in the Kathmandu Valley, Nepal. *Environmental Management, 39*, 774-782.

Haddad, L. and S. Gillespie (2001), *Effective food and nutrition policy responses to HIV/AIDS. What we know and what we need to know.* Food Consumption and Nutrition Division, Discussion Paper 112, International Food Policy and Research Institute, Washington, D.C.

Han, Z.S. (2003) Groundwater resources protection and aquifer recovery in China. *Environmental Geology, 44*, 106-111.

Hardoy, JE, Mitlin, D, Satterthwaite, D (2001) Environmental Problems in an Urbanizing World, Earthscan, London; McGranahan, G, Jacobi, P, Songsore, J, Surjadi, C and Kjellen, M (2001) The Citizens at Risk: from Urban Sanitation to Sustainable Cities, Earthscan, London.

Harris, N.M., Gurnell, A.M., Hannah, D.M., Petts, G.E. (2000) Classification of river regimes: a context for hydroecology. *Hydrological Processes, 14*, 2831-2848.

Hasan, A. (2002) Squatter settlements, housing and urban sustainability in Pakistan In R. Bradnock and G. Williams (eds.) South Asia in a Globalising World. Prentice Hall:

Hay, S.I., Cox, J., Rogers, D.J., Randolph, S.E., Stern, D.I., Shanks, G.D., Myers, M.F., Snow, R.W. (2002) Climate change and the resurgence of malaria in the East African highlands. *Nature, 415*, 905-909.

HLCLEP (2006), High Level Comission on Legal Empowerment of the Poor (HLCLEP): Overview Papert, 24 pp, High Level Comission on Legal Empowerment of the Poor (HLCLEP), New York.

Hoffman, W. (2006), Latin America's Logistics Lags; Latin America's lack of integrated transportation infrastructure impairs growth potential, firm says, in *Traffic World*, edited, p. 16.

Huntington, T.G. (2006) Evidence for intensification of the global water cycle: Review and synthesis. *Journal of Hydrology, 319*, 83-95.

IPCC (2007), *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability,* Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Summary for Policy Makers (April 6, 2007).

Janakarajan, S. (1994), Trading In Groundwater: A Source of Power and Accumulation, in *Selling Water: Conceptual and Policy Debates over Groundwater Markets in India*, edited by Moench, M., pp. 47-58, VIKSAT, Ahmedabad.

Janakarajan, S. (1999), Conflicts over the invisible resource in Tamil Nadu: Is there a way out, in *Rethinking the Mosaic: Investigations into Local Water Management*, edited by Marcus Moench, E.C., Ajaya Dixit, pp. 123-160, ISET and NWCF, Kathmandu.

Janakarajan, S., and M. Moench (2002), Wells and Illfare: Conditions and Characteristics of Groundwater Irrigation in Tamil Nadu, in *Understanding the Mosaic*, edited by Moench, M. and A. Dixit, Draft Manuscript, Delhi.

Jagannathan, N.V. (1987), Informal Markets in Developing Countries. Oxford University Press.

Johnson, K. (2000) *Television and Social Change in Rural India*. New Delhi, Sage

Junk, W.J., Bayley, P.B., Sparks, R.E. (1989) The flood-pulse concept in river-floodplain systems. *Dodge, D.P. (ed.). Canadian Special Publication in Fisheries and Aquatic Sciences,* 106.

Junk, W.J., Wantzen, K.M. (2004) The flood pulse concept: new aspects, approaches, and applications—an update. *Welcomme, R.L., Petr, T. (eds) Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries, 2*, 117–149.

Kang, S.Z., Su, X.L., Tong, L., Shi, P.Z., Yang, X.Y., Abe, Y.K., Du, T.S., Shen, Q.L., Zhang, J.H. (2004) The impacts of human activities on the water-land environment of the Shiyang River basin, an arid region in northwest China. *Hydrological Sciences Journal-Journal Des Sciences Hydrologiques, 49*, 413-427.

Kannel, P.R., Lee, S., Kanel, S.R., Khan, S.P., Lee, Y.S. (2007) Spatial-temporal variation and comparative assessment of water qualities of urban river system: A case study of the River Bagmati (Nepal). *Environmental Monitoring and Assessment, 129*, 433-459.

Lama, J.R., Seas, C.R., Leon-Barua, R., Gotuzzo, E., Sack, R.B. (2004) Environmental temperature, cholera, and acute diarrhoea in adults in Lima, Peru. *Journal of Health Population and Nutrition, 22*, 399-403.

Lambin, E.F., Geist, H.J., Lepers, E. (2003) Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources, 28*, 205-241.

Larsson, A. (2006), Empowerment of the poor in informal employment, 10 pp, Commission on Legal Empowerment of the Poor, New York.

Laurance, W.F. (2004) Forest-climate interactions in fragmented tropical landscapes. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences, 359*, 345-352.

Laurance, W.F., Williamson, G.B. (2001) Positive feedbacks among forest fragmentation, drought and climate change in the Amazon. *Conservation Biology, 15*, 1529-1535.

Lemke, P., Ren, J., Alley, R.B., Allison, I., Carrasco, J., Flato, G., Fujii, Y., Kaser, G., Mote, P., Thomas, R.H., Zhang, T. (2007) Observations: Changes in Snow, Ice and Frozen Ground. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (Eds S. Solomon & D. Qin & M. Manning & Z. Chen & M. Marquis & K.B. Averyt & M. Tignor & H.L. Miller), pp. 337-384. Cambridge University Press, Cambridge.

Lewis, J. A. (2007), The power of knowledge: information transfer and acai intensification in the peri-urban interface of Belem, Brazil, *Agroforestry Systems*, *DOI 10.1007/s10457-007-9096-x*.

Li, K.Y., Coe, M.T., Ramankutty, N., De Jong, R. (2007) Modeling the hydrological impact of land-use change in West Africa. *Journal of Hydrology,* 337, 258-268.

Ma, J.Z., Wang, X.S., Edmunds, W.M. (2005) The characteristics of ground-water resources and their changes under the impacts of human activity in the arid Northwest China - a case study of the Shiyang River Basin. *Journal of Arid Environments, 61*, 277-295.

Lukes, S. (2005), *Power- A Radical View*, 200pp., Palgrave Macmillion, London.

Magadza, C.H.D. (2000) Climate Change Impacts and Human Settlements in Africa: Prospects for Adaptation. *Environmental Monitoring and Assessment,* 61, 193-205.

Majeed, A. (2004) *Balochistan – Water Sector Issues and Options*. World Water Day 2004 - Water and Disasters, 6 pp. IUCNP.

Martens, P., Kovats, R.S., Nijhof, S., De Vries, P., Livermore, M.T.J., Bradley, D.J., Cox, J., McMichael, A.J. (1999) Climate change and future populations at risk of malaria. *Global Environmental Change, 9*, S89-S107.

McGee, T.G. (1991), Emergence of Desakota Regions in Asia: Expanding a Hypothesis, in Ginsburg, N., Koppel, B. and McGee, T.G. (eds) *The Extended Metropolis: Settlement Transitions in Asia*, University of Hawaii Press, Honolulu.

McGranahan, G., *et al*. (2004), Rural-urban change, boundary problems and environmental burdens, 27 pp, International Insitute for Environment and Development, London.

McGregor, D., *et al*. (Eds.) (2006), *The Peri-Urban Interface: Approaches to Sustainable Natural and Human Resource Use*, 336 pp., Earthscan, London.

MEA (2005) Ecosystems and Human Well-Being: Health Synthesis. In: *Ecosystem Services and Human Wellbeing.* (Core Writing Team: Corvalan, Hales, S., McMichael, A.) World Resources Institute, Washington, DC, 63 pp.

Meier, M.F., Dyurgerov, M.B., McCabe, G.J. (2003) The health of glaciers: Recent changes in glacier regime. *Climatic Change,* 59, 123-135.

Mendoza, E. (2006), Eugenio Mendoza, MBIA managing director & head of new business development in Latin America and Canada, discusses the company's funding program for insured infrastructure projects in Mexico., in *Latin Finance*, edited.

Merz, J., Nakarmi, G., Shrestha, S., Dahal, B.M., Dongol, B.S., Schaffner, M., Shakya, S., Sharma, S., Weingartner, R. (2004) Public water sources in rural watersheds of Nepal's Middle Mountains: Issues and constraints. *Environmental Management, 34*, 26-37.

Moench, M., *et al*. (Eds.) (2002), *The Fluid Mosaic: Water Governance in the Context of Variability, Uncertainty and Change*, 66 pp., ISET and NWCF, Kathmandu.

Moench, M., and A. Dixit (Eds.) (2004), *Adaptive Capacity and Livelihood Resilience*, 214 pp., Institute for Social and Environmental Transition-Boulder and Kathmandu, Kathmandu.

Moench, M. and A. Dixit, Eds. (2007). *Working with the Winds of Change: Toward Strategies for Responding to the Risks Associated with Climate Change and other Hazards*. Kathmandu, ISET and ISET-Nepal.

Moench, M., and S. Stapleton (2007), Water, Climate Risk and Adaptation, 80 pp, ISET-International, Working Paper 2007-01, Co-operative Programme on Water and Climate and Newater, Delft, Nederlands.

Mohieldeen, Y. (1999), Responses to Water Scarcity: Social Adaptive Capacity and the Role of Environmental Information. A Case Study from Taiz, Yemen, 75 pp, Water Issues Study Group, School of Oriental and African Studies, University of London, London.

Mustafa, D. and Qazi, U. (2007) Transition from Karez to Tubewell Irrigation: Development, Modernization and Social Capital in Balochistan, Pakistan. *World Development*, *35*(10), 1796-1813.

Narain, U., *et al*. (2005), Poverty and the Environment: Exploring the Relationship between Household Incomes, Private Assets, and Natural Assets. Discussion Paper 05-18, Resources for the Future, Washington DC.

Narayan, D., *et al*. (2000), *Voices of the Poor: Can Anyone Hear Us?* , Published for the World Bank, Oxford University Press., New York, N.Y.

Nilsson, C., Svedmark, M. (2002) Basic principles and ecological consequences of changing water regimes: Riparian plant communities. *Environmental Management, 30*, 468-480.

Ngwenya, B.N. & Kgathi, D.J. (2006), HIV/AIDS and access to water: a case study of home-based care in Ngamiland, Botswana. *Physics and Chemistry of the Earth*, 31, pp 669-680.

OECD (2007), *Web Atlas of Regional Integration in West Africa,* OECD, Paris.

Olago, D., Marshall, M., Wandiga, S.O. (2007) Climatic, socio-economic, and health factors affecting human vulnerability to cholera in the Lake Victoria basin, East Africa. *Ambio, 36*, 350-358.

Olden, J.D., Poff, N.L. (2003) Redundancy and the choice of hydrologic indices for characterizing streamflow regimes. *River Research and Applications, 19*, 101-121.

Olson, D.M., Dinerstein, E., Wikramanaya, E.D., Burgess, N.D., Powell, G.V.N., Underwood, E.C., D'amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P., Kassem, K.R. (2001), Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience,* 51**,** 933-938 and information from related website http://www.nationalgeographic.com/wildworld/terrestrial.html

Pandey, J.S., Devotta, S. (2006) Assessment of environmental water demands (EWD) of forests for two distinct Indian ecosystems. *Environmental Management, 37*, 141-152.

Pascual, M., Ahumada, J.A., Chaves, L.F., Rodo, X., Bouma, M. (2006) Malaria resurgence in the East African highlands: Temperature trends revisited. *Proceedings of the National Academy of Sciences of the United States of America, 103*, 5829-5834.

Patz, J.A. (2001) Public health risk assessment linked to climatic and ecological change. *Human and Ecological Risk Assessment,* 7, 1317-1327.

Patz, J.A., Campbell-Lendrum, D., Holloway, T., Foley, J.A. (2005) Impact of regional climate change on human health. *Nature, 438*, 310-317.

Patz, J.A., Hulme, M., Rosenzweig, C., Mitchell, T.D., Goldberg, R.A., Githeko, A.K., Lele, S., Mcmichael, A.J., Le Sueur, D. (2002) Climate change - Regional warming and malaria resurgence. *Nature, 420*, 627-628.

Pelling, M. (1998) Participation, social capital and vulnerability to urban flooding in Guyana, *Journal of International Development*, 10, 203-226.

Pelling, M (2003a) The Vulnerability of Cities: Natural Disaster and Social Resilience, London: Earthscan.

Pelling, M (2003b) Toward a political ecology of urban environmental risk: the case of Guyana. In Zimmerer, K S and Basset T J (Eds.) *Political Ecology: An Integrative Approach to Geography and Environment-Development Studies*, New York: Guilford Publications, 73-93.

Petts, G.E. (1996) Water allocation to protect river ecosystems. *Regulated Rivers: Research and Management, 12*, 353-365.

Piao, S.L., Friedlingstein, P., Ciais, P., De Noblet-Ducoudre, N., Labat, D., Zaehle, S. (2007) Changes in climate and land use have a larger direct impact than rising CO2 on global river runoff trends. *Proceedings of the National Academy of Sciences of the United States of America, 104*, 15242-15247.

Pielke, R. S., *et al*. (2007), An overview of regional land-use and land-cover impacts on rainfall, *Tellus*, *59B*, 587-602.

Pinay, G., Clement, J.C., Naiman, R.J. (2002) Basic Principles and Ecological Consequences of Changing Water Regimes on Nitrogen Cycling in Fluvial Systems. *Environmental Management, 30*, 481-491.

Poff, N.L., Allan, J.D., Palmer, M.A., Hart, D.D., Richter, B.D., Arthington, A.H., Rogers, K.H., Meyer, J.L., Stanford, J.A. (2003) River Flows and Water Wars: Emerging Science for Environmental Decision Making. *Frontiers in Ecology and the Environment,* 1, 298-306.

Polanyi, K. (1944, 1957), *The Great Transformation: the political and economic origins of our time*, Beacon Press, Boston.

Ramankutty, N., Foley, J.A., Norman, J., Mcsweeney, K. (2002) The global distribution of cultivable lands: current patterns and sensitivity to possible climate change. *Global Ecology and Biogeography, 11*, 377-392.

Rees, H.G., Collins, D.N. (2006) Regional differences in response of flow in glacier-fed Himalayan rivers to climatic warming. *Hydrological Processes, 20*, 2157-2169.

Rietkerk, M., Dekker, S.C., De Ruiter, P.C., Van De Koppel, J. (2004) Self-Organized Patchiness and Catastrophic Shifts in Ecosystems. *Science, 30*5, 1926-1929.

Rodrigues, C. U. (2007), From family solidarity to social classes: Urban stratification in Angola (Luanda and Ondjiva), *Journal of Southern African Studies*, *33*(2), 235-250.

Rubiano, J., M. Quintero, R. Estrada and A. Moreno (2007), Multiscale análisis for promoting integrated watershed Management, Unpublished manuscript.

Rudel, T., Coomes, O., Moran, E., Achard, F., Angelsen, A., Xu, J., Lambin, E. (2005), Forest transitions: towards a global understanding of land use change, *Global Environmental Change,* 15, pp 23-31.

Rutkowski, T., Raschid-Sally, L., Buechler, S. (2007) Wastewater irrigation in the developing world - Two case studies from the Kathmandu Valley in Nepal. *Agricultural Water Management, 88*, 83-91.

Sajor, E. E., and R. Ongaskul (2007), Mixed Land Use and Equity in Water Governance in Peri-Urban Bangkok, *International Journal of Urban and Regional Research*, *31*(4), 782-801.

Sarewitz, D. (1996). Frontiers of Illusion: Science, Technology, and the Politics of Progress, Temple University Press, Philadelphia.

Sargana, M.A. (2006) What Made Telecom A Success Story — Lessons Learnt Be Replicated In Other Sectors Of The Economy. Retrieved from http://www.pta.gov.pk/index.php?option=com_content&task=view&id=800&catid=95&Itemid=229 on April 28th, 2008

Scheffer, M., Holmgren, M., Brovkin, V., Claussen, M. (2005) Synergy between small- and large-scale feedbacks of vegetation on the water cycle. *Global Change Biology, 11*, 1003-1012.

Schweers,W., Lu Bu, Chen Yinjun, Xiao Bilin, and Chen Youjian (2008), Aspects of groundwater use and salinity in the North China Plain. 2nd International Salinity forum: Salinity, Water and Society – Global Issues, Local action, March 31-April 3, 2008, Adelaide.

Sharma, R. H., and N. M. Shakya (2006), Hydrological changes and its impact of water resources of Bagmati watershed, Nepal, *Journal of Hydrology*, *327*, 315-322.

Sharma, S., Bajracharya, R.M., Sitaula, B.K. & Merz, J. (2005), Water quality in the Central Himalaya. *Current Science,* 89**,** 774-786.

Shukla, P. R., *et al*. (2003), Development and Climate: An Assessment for India, 154 pp, Indian Institute of Management, Ahmedabad.

Simon, David (1996) Transport and Development in the Third World, Routledge, London.

Smith, M.E. (1989), The Informal Economy, in Plattner, S. (ed) *Economic Anthropology*, Stanford University Press.

Sternberg, L.D.S.L. (2001) Savanna-forest hysteresis in the tropics. *Global Ecology and Biogeography, 10*, 369-378.

Stoian, D. (2005), Making the Best of Two Worlds: Rural and Peri-Urban Livelihood Options Sustained by Nontimber Forest Products from the Bolivian Amazon, *World Development*, *33*(9), 1473-1490.

Sultana, P., Thompson, P.M. (1997) Effects of flood control and drainage on fisheries in Bangladesh and the design of mitigating measures. *Regulated Rivers: Research & Management, 13*, 43-55.

Tacoli, C. (1999), Understanding the Opportunities and Constraints for Low-Income Groups in the Peri-Urban Interface: The Contribution of Livelihood Frameworks, 11 pp, Development Planning Unit, University College London, London.

Tacoli, C. (2002), Changing rural-urban interactions in sub-Saharan Africa and their impact on livelihoods: a summary, 47 pp, International Institute for Environment and Development, London.

Tacoli, C. (2007), Migration and adaptation to climate change, 2 pp, International Institute for Environment and Development, London.

Takken, W., Vilarinhos, P.D.T.R., Schneider, P., Dos Santos, F. (2005) Effects of environmental change on malaria in the Amazon region of Brazil. In: *Environmental Change and Malaria Risk: Global and Local Implications.*. Wageningen Ur Frontis Series 9.

Taylor, J. E. (2001), Migration: New Dimensions and Characteristics, Causes, Consequences and Implications for Rural Poverty, in *Food, Agriculture and Rural Development: Current and Emerging Issues for Economic Analysis and Policy Research*, edited by Stamoulis, K.G., Food and Agriculture Organization of the United Nations, Rome.

Thanh, H. X., *et al*. (2005), Livelihood diversification and rural-urban linkages in Vietnam's Red River Delta, 29 pp, International Institute for Environment and Development.

Turner, M. D. (1999), Conflict, Environmental Change, and Social Institutions in Dryland Africa: Limitations of the Community Resource Management Approach, *Society and Natural Resources*, *12*, 643-657.

Twyman, C., and R. Slater (2005), Hidden livelihoods? Natural resource-dependent livelihoods and urban development policy, *Progress in Development Studies*, *5*(1), 1-15.

Thomas, J.J. (1992), Informal Economic Activity, *London School of Economics handbook in economics*, Harvester Wheasheaf, UK.

Ubels, J., and A. Wevers (1996), Assistance to Capacity Building for Integrated Water Management: a comparison of Netherlands support to water sectors in six countries, Organisation for Economic Co-operation and Development Development Assistance Committee.

UNECP Collaborating Centre on Energy and Environment, Ahmedabad, India.

Start, D., and C. Johnson (2004), Livelihood Options? The Political Economy of Access, Opportunity and Diversification, 56 pp, Overseas Development Institute, London.

UNEP (2006) Environmental Considerations of Human Displacement in Liberia, UNEP, accessed from http://postconflict.unep.ch/liberia/displacement/ 28 April 2008.

UNEP (2007) Global Outlook for Snow & Ice. p. 235 pp.

UNFCC (2007), Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries, 68 pp, United Nations Framework Convention on Climate Change, New York.

UN HABITAT (2007) Global Report on Human Settlements 2007: Enhancing Urban safety and Security, Earthscan, London

Urban Harvest (2007), Agricultural Urbana y Periurbana en Lima Metropolitana: una estrategia de lucha contra la pobreza y la inseguridad alimentaria, 39 pp, Centro Internacional de la Papa, Urban Harvest, Lima.

van Steenbergen, F. (1997) Understanding the sociology of spate irrigation: cases from Balochistan. *Journal of Arid Environments*, *35*, 349-365.

Van Vuuren, D.P., Sala, O. E., Pereira, H. M. (2006) The future of vascular plant diversity under four global scenarios. *Ecology and Society,* 11, 25 [online] URL: http://www.ecologyandsociety.org/vol11/iss22/art25/.

Vedeld, P., *et al*. (2004), Counting on the Environment Forest Incomes and the Rural Poor, 114 pp, Environmental Economic Series (informal) of the World Bank, Washington D.C.

Vittor, A.Y., Gilman, R.H., Tielsch, J., Glass, G., Shields, T., Lozano, W.S., Pinedo-Cancino, V., Patz, J.A. (2006) The effect of deforestation on the human-biting rate of Anopheles darlingi, the primary vector of falciparum malaria in the Peruvian Amazon. *American Journal of Tropical Medicine and Hygiene, 74*, 3-11.

Vörösmarty, C.J., Sahagian, D. (2000) Anthropogenic Disturbance of the Terrestrial Water Cycle. *BioScience,* 50, 753-765.

Vorosmarty, C. J., *et al*. (2000), Global Water Resources: Vulnerability from Climate Change and Population Growth, *Science*, *289*, 284-288.

Wagner, D., *et al*. (2005), Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries, 144 pp, The International Bank for Reconstruction and Development, The World Bank, Washington D.C.

WHO (2003), Climate change and human health: risks and responses. Summary, World Health Organisation, World Meteorological Organisation and UNEP.

World Bank (2005) Pakistan. Country Water Resources Assistance Strategy. Water Economy: Running Dry. World Bank: Agriculture and Rural Development Sector, South Asia Region.

Xenopoulos, M.A., Lodge, D.M., Alcamo, J., Marker, M., Schulze, K., Van Vuuren, D.P. (2005) Scenarios of freshwater fish extinctions from climate change and water withdrawal. *Global Change Biology, 11*, 1557-1564.

Xu, J.X. (2001) High-frequency zone of river desiccation disasters in China and influencing factors. *Environmental Management, 28*, 101-113.

Yu, L., Cao, M., Li, K. (2006) Climate-induced changes in the vegetation pattern of China in the 21st century. *Ecological Research, 21*, 912–919.

Zhou, G., Minakawa, N., Githeko, A.K. & Yan, G.Y. (2004) Association between climate variability and malaria epidemics in the East African highlands. *Proceedings of the National Academy of Sciences of the United States of America,* 101, 2375-2380.

Zoomer, A. (2006), Pro-Indigenous Reforms in Bolivia: Is there an Andean Way to Escape Poverty?, *Development and Change*, *37*(5), 1023-1046.

Desakota Study Team and their Institutions

Institute for Social and Environmental Transition - Nepal (ISET-Nepal)
Kathmandu, Nepal
- Dipak Gyawali, Team Leader (Research Director)
- Ajaya Dixit (Executive Director)
- Madhukar Upadhya (Program Director)
- Binod Sharma (Consultant)
- Ashok Dhakal (Associate)
- Deeb Raj Rai (Associate)

Institute for Social and Environmental Transition – International (ISET-International)
Boulder, Colorado. USA
- Marcus Moench (Director)
- Elizabeth Fajber (ISET Associate)
- Sarah Opitz-Stapleton (Research Associate)
- Kenneth MacClune (Research Associate)
- Anuradha Kamath (Consultant)
- Sonam Bennett-Vasseux (Program Officer & Research Associate)
- Elisabeth Caspari (Assistant Director)

King's College London
Department of Geography, London, United Kingdom
- Angela Gurnell (Director, Centre for Environmental Assessment, Management and Policy, Professor of Physical Geography)
- Daanish Mustafa (Lecturer in Geography)
- Helen Moggridge (Lecturer in Geography)
- Glenn McGregor (formerly Director, Centre for Environmental Assessment, Management and Policy, Professor of Physical Geography)
- Mark Pelling (Reader in Human Geography)
- Simon Gosling (Ph.D Candidate)
- Alice Jones (Research Assistant)

Centre for Global Change (CGC)
Dhaka, Bangladesh
- Ahsan Uddin Ahmed (Executive Director)

Chinese Academy of Agricultural Sciences (CAAS)
Institute of Agricultural Economics and Development, Beijing, China
- Dr. Liu Jing (Senior Economist)
- Dr. Liang Shumin (Economist)
- Prof. Zhu Lizhi (Senior Economist, Director)

Institute of Agricultural Resources and Regional Planning
Beijing, China
Dr. Wilko Schweers (Integrated CIM Expert, Groundwater Utilization)
Prof. Cai Dianxiong (Soil Physicist, Director Department of Land and Water Management)

Institute for Social and Environmental Transition (ISET-Pakistan)
Fawad Khan (Director)
Niemat (Research Assistant)

International Centre for Tropical Agriculture (CIAT)
Cali, Colombia
Glenn Hyman (Senior Scientist)
Sam Fujisaka (Consultant)
Mariano Mejia (Information and Documentation Specialist)

Rhodes University
Consortia for Ecosystem Services and Poverty Alleviation in Sub-Saharan Africa
Grahamstown, South Africa
Julia Cloete (Researcher)

University of Cape Town
Department of Historical Studies
Cape Town, South Africa
Natascha Visser (Research Assistant)

Winrock International India
Delhi, India
Shashikant Chopde (Coordinator, Adaptation Group and Senior Programme Officer-Natural Resource Management)

Acknowledgements

The Desakota Study Team would like to acknowledge the valuable suggestions and critical comments provided by different reviewers as well as those who participated in various meetings of the study team. It must, however, be stated that the views expressed herein represent those of the study team members alone.

Peer reviewers
Professor Terry McGee
Professor Geoffrey Petts

Inputs were also received from:

For the Sub-Saharan Literature Review: Shenoa Shackleton, Associate Professor at Rhodes University and Mike Mortimore, Professor at Drylands Research, Crewkerne, United Kingdom

For contributions to the Miyun case study: Zheng Haixia from the College of Management, Beijing Union University.

Desakota Study Team would also like to acknowledge the valuable comments received from NERC/ESRC/DfID, specifically Caroline Culshaw, Anna Balance and Pamela Kempton, during the various scoping and inception meetings.

Re-imagining the Rural-Urban Continuum