WP/PUS/04/2016

Working paper series

Periurban Water Security

February 2016

Water (in-)security, conflict and cooperation in relation to climate change in peri-urban south Asia: Integrated report of scoping studies in Bangladesh, India and Nepal

Periurban water security

Conflict and cooperation over natural resources in developing countries (CoCooN)

Conflict and cooperation in the management of climate change (CCMCC)

2014 – 2018

Funded by:

NWO

Netherlands Organisation for Scientific Research

Acknowledgement: We would like to express our gratitude to NWO: Netherlands Organisation for Scientific Research for funding the project titled "Climate Policy, Conflicts and Cooperation in Peri-Urban South Asia: Towards Resilient and Water Secure Communities". We are also grateful to the peri-urban community in Hyderabad, Gurgaon, Kulna and Kathmandu for their time and cooperation during our field research.

Citation: Roth, Dik *et al.*, 2016. 'Water (in-)security, conflict and cooperation in relation to climate change in peri-urban south Asia: Integrated report of scoping studies in Bangladesh, India and Nepal', WP/PUS/04/2016, Peri-urban water security working paper series, South Asia consortium for interdisciplinary water resources studies (SaciWATERs), Sainikpuri, Secunderabad, Telangana.

First published in February, 2016

For further information please contact:

SaciWATERs
H.No. B-87, 3rd Avenue,
Sainikpuri, Secunderabad - 500 094, Telangana, India.
Telefax : +91- 40 - 27116721, 27117728
Website: www.saciwaters.org/cocoon

Scientific coordination and research teams:

Scientific coordination:

Dik Roth (Wageningen University)

Poulomi Banerjee (SaciWATERs)

Additional writing, compilation and editing of the integrated report:

Dik Roth is Assistant Professor at Wageningen University, The Netherlands

Research team Bangladesh:

M. Shah Alam Khan is Professor at IWFM, BUET, Dhaka, Bangladesh

Rezaur Rahman is Professor at IWFM, BUET, Dhaka, Bangladesh

Rashed Jalal is Research Associate at IWFM, BUET, Dhaka, Bangladesh

Jannatul Naima Moon is Research Associate at IWFM, BUET, Dhaka, Bangladesh

A.T.M. Zakir Hussain is Executive Director at Jagrata Juba Shangha (JJS), Khulna, Bangladesh

Sheikh Nazmul Huda is Manager at Jagrata Juba Shangha (JJS), Khulna, Bangladesh

Research team India:

Gurgaon:

Vishal Narain is Associate Professor at MDI, Gurgaon, India

Hyderabad:

Poulomi Banerjee is Senior fellow at SaciWATERs, Hyderabad, India

Monica Priya is Research Associate at SaciWATERs, Hyderabad, India

Anamika Barua is Executive Director at SaciWATERs, Hyderabad, India

Manoj Jatav is Research fellow at SaciWATERs, Hyderabad, India

Manish Maskara is Research Associate at SaciWATERs, Hyderabad, India

With support and assistance from Sumit Vij and Pratik Mishra

Research team Nepal:

Jasmina Van Driel

Otto Hoffmann is Thematic Manager at MetaMeta

Saroj Yakami is Researcher at MetaMeta

Cecilia Borgia (MetaMeta)

Anushiya Shrestha is PhD student at Wageningen University, The Netherlands

Philippus Wester is Chief Scientist at ICIMOD

Contents

Water (in-)security, conflict and cooperation in relation to climate change in peri-urban south Asia: Integrated report of scoping studies in Bangladesh, India and Nepal

Abstract

This report integrates the main findings of three scoping studies executed in the framework of the project 'Climate policy, Conflicts and Cooperation in Peri-Urban South Asia: Towards Resilient and Water Secure Communities', funded by NWO/DFID. The report consists of four chapters. Chapter 1 provides general background information ae well as objectives, points of departure and limitations of the research. Chapter 2 describes the four peri-urban research areas in tree countries that are part of this project: Khulna in Bangladesh, Gurgaon and Hyderabad in India, and Kathmandu in Nepal. Chapter 3 looks into the knowledge gaps about the transformation processes related to water, urbanization and climate change, and presents the final selection of sites in each of the peri-urban areas for research, development and capacity-building in the framework of this project. Chapter 4 gives an overview of the main findings from the scoping studies in each of the research sites.

1. Introduction: objectives, approaches, and methods

1.1. Why this scoping study: background and objectives

The project 'Climate Policy, Conflicts and Cooperation in Peri-Urban South Asia: Towards Resilient and Water Secure Communities', funded in the framework of the research programme *Conflict and Cooperation in the Management of Climate Change* (CCMCC)[1], deals with water (in-)security, conflict and cooperation in relation to urbanization and climate change in the context of peri-urban areas. The general objective of the CCMCC program is 'to strengthen the evidence on the impact of climate change and climate change policies on conflict or cooperation in developing countries and in particular to strengthen the evidence on the impact of policies and financing mechanisms to address the problem of climate change on cooperation and conflict' (NWO/DFID 2012). Its three guiding questions are:

- What are the dynamics of cooperation and / or conflict?
- What can we effectively do to build the resilience of poor communities?
- What does this mean for policies and programs?

Specific objectives of the program are, first, the production of robust evidence on the dynamics of cooperation and conflict over natural resources in relation to climate change and climate change policies (the *knowledge, research and innovation perspective*); second, the development of tools and perspectives for conflict-sensitive climate change policy development and financing mechanisms that effectively contribute to the resilience of poor communities in developing countries (the *development perspective*); third, the development of capacities of institutions, groups and individuals, to investigate, provide advice on and implement tools for conflict-sensitive climate change policy development and financing mechanisms (the *capacity development perspective*) (NWO/DFID 2012).

Problematic access to water, water insecurity and water-related conflicts are increasingly influencing the daily lives, livelihoods and futures of many millions of people in developing countries. Nowadays there is a growing attention to issues of water security in so-called 'peri-urban areas'. Produced by urbanization

[1] jointly funded by NWO and the UK Department for International Development (DFID).

processes and connecting 'the urban' and 'the rural' in complex ways, peri-urban areas are highly dynamic environments characterized by, among others, intensified migration and settlement, increased resource exploitation by a variety of 'traditional' and newly emerging social actors building up a variety of new stakes and interests in peri-urban resources, changing economic activities and livelihoods, and ambiguities in the administrative, legal-institutional and policy spheres (see e.g. Allen 2003; Narain and Nischal 2007).

Together with urbanization, climate change is increasingly recognized as an important driver of changes in peri-urban areas that may deeply influence current and future water (in-)security of inhabitants of these dynamic zones. These processes, moreover, may do so in ways that form a benefit and opportunity for some, while creating, reproducing or sharpening existing forms of social differentiation and inequality for others. However, these dimensions, as well as issues of conflict and cooperation around water security in peri-urban areas in a context of urbanization and climate change, are relatively under-researched scientifically. In addition, the combined impacts of (peri-) urbanization and climate change on water security are only very gradually being recognized as deserving attention in the policy world.

This project, then, fills an important gap, not only in the knowledge, research and innovation perspective, but also in terms of its potential contributions to development policies and practices, and to processes of capacity development. The project investigates the general questions and relationships that form the core of the CCMCC program through an in-depth assessment and comparison of conflict and cooperation related to water (in)security in four highly dynamic peri-urban areas in three countries of South Asia: Khulna in Bangladesh, Hyderabad and Gurgaon in India, and Kathmandu in Nepal. Located in different agro-ecological, geological and climatic zones, the peri-urban areas of these four rapidly growing cities represent a wide diversity of issues related to urbanization, climate change, water (in-)security, and cooperation and conflict. These South Asian cities have been preselected for several reasons: first, in their diversity, all four cases are very clear illustrations of the various important transformations in water security in relation to urbanization, climate change and issues of conflict and cooperation. Second, important insights and lessons can be derived from the study of these processes in different contexts of urbanization, water resources availability and use, agro-climatic conditions and climate variability and change. Third, the current project consortium can build on a considerable knowledge base as well as scientific and organizational-institutional networks built in previous research projects (e.g. Narain *et al.* 2013).

However, within the scope of these pre-selected cases of peri-urban areas, further choices need to be made for the implementation of project activities in the *knowledge, research and innovation*, *development*, and *capacity building* dimensions of the CCMCC program. In order to be able to optimally integrate these elements it was decided to start with a preliminary research trajectory that yields basic data and insights on the role of conflict and cooperation around peri-urban water in a context of urbanization and climate change, as well as the options and potential sites for further in-depth research, interventions, and capacity-building activities. In this report the results of this research are presented. The report integrates and summarizes the main findings of three country-level scoping studies (for scoping studies, see e.g. Levac *et al.* 2010) conducted in Bangladesh, India, and Nepal respectively. Research for the scoping studies was conducted between April and December 2014 in Bangladesh; from October to December 2014 and from April to September 2015 in India; and from June to August 2015 in Nepal[2].

[2] Research in Nepal started relatively late because of a crucial change in the Nepalese consortium partners shortly after the start of the project. Once a new start had been made, the April / May 2015 earthquakes led to further delays in the Nepali part of the project. Since September the fuel crisis is causing new problems with transport to the field.

General aims of the scoping study reported on here were:

(1) A short review of the scientific state-of-the-art knowledge on peri-urban water issues in South Asia (focusing on the three selected countries, four cases);

(2) Exploratory research on peri-urban water issues issues in three countries (Bangladesh, India, and Nepal) to gain a better understanding of the socio-political, institutional and other dynamics of peri-urban water security, urbanization and climate change in relation to conflict and cooperation;

(3) Inventory of the knowledge gaps and research, development and capacity building opportunities and needs emerging from this preliminary research;

(4) Identification of potential foci, sites and / or cases to be selected for further in-depth scientific research in relation to (pilot) developmental interventions and capacity-building activities.

1.2. Conceptual-theoretical points of departure and approaches

In the Theory of Change that was part of the proposal for this project, processes of urbanization and climate change are identified as major forces shaping peri-urban water (in-)security (see annex: figure 1). In this model water (in-)security is approached as the outcome of the interplays between resource endowments, technologies and institutions with processes of urbanization and climate change in a wider setting of skewed and inequitable access to water (due to differing abilities of people to mobilize crucial mediating technologies and institutions). In terms of governance, the absence of integrative frameworks for rural and urban water resources management planning and unclear property rights in water were identified, as well as a lack of cognizance in the academic and policy worlds of the combined effects of urbanization and climate change on peri-urban water security, and of the possible implications of climate change policies on the vulnerabilities and water insecurities of peri-urban populations. These are assumed to create potential for conflict and to weaken community resilience. Through its knowledge-innovation, development and capacity-building perspectives, however, this project should contribute to the strengthening of community resilience and the devising of pathways to equitable and sustainable institutional transformations to increase water security, and to turn potential for conflict into opportunities for cooperation.

Research challenges

The conceptual-theoretical challenges of the type of research needed for this project are many. First, a program like CCMCC, with its combination of scientific (research, knowledge, innovation), developmental, and capacity-building dimensions, requires navigating the boundaries between critical scientific analysis of complex processes of socio-environmental transformation on one hand, and the need for research to provide clear and unambiguous input for policy makers and other 'deliverables' on the other. The issues dealt with in this program, however, can be approached scientifically through various conceptual-theoretical lenses based in and on quite different ontologies (basic conceptions of the nature of reality) and epistemologies (ways of knowing that reality) of nature, water, climate, society and the relationships between them. Conceptual-theoretic choices based on these, in turn, are related to various methodological options for studying the processes and relationships involved.

Various conceptual-theoretical lenses may be mutually compatible, but they may also be quite different and even contradictory in various of their key dimensions, including the scientific language used. They are always based on specific ways of framing certain issues as societal problems (e.g. in how to theorize the relationships between 'nature' and 'society', between 'the social' and 'the environmental'), the scientific questions that should be asked to make sense of them and, related to that, the degree of their manageability and the formulation of possible solutions in dealing with them. Choice of specific conceptual and theoretical approaches and lenses through which problems are framed in certain ways (and not in others) has consequences in terms of the scope for recognizing specific solutions as relevant or irrelevant, feasible or impossible, central or marginal. It makes a difference, for instance, whether we assume the complexly related problems of water, climate and society to be unambiguously knowable in terms of clear cause-effect relations and manageable in uncontested, controlled ways with (almost) predictable results or outcomes, or as complex, contingent or 'wicked' problems characterized by basic uncertainties, contestations and contrasting framings of problems and solutions.

The scientific framing of problems of climate change in terms of vulnerability and adaptation, for instance, which is basic to the CCMCC program, is without doubt an important one, but not necessarily neutral and uncontested; nor is the framing of policy solutions in terms of capacity-building and community resilience. While some see these as the one and only relevant scientific and policy language to make sense of the processes at stake and to make them manageable to open up pathways for interventions towards adaptational improvements, others would see them as specific, 'post-political', ways of framing that themselves require critical scientific inquiry and questioning (e.g. Swyngedouw 2010; Taylor 2015). So rather than entailing relatively simple and self-evident choices, the conceptual-theoretical grounding of a project like this is nothing less than an ongoing struggle.

A second challenge, related to the above-mentioned point, concerns the widely differing experiences in the various country-level project teams with specific research approaches, methods and their conceptual-theoretical grounding. This requires a gradual working towards a shared basis for further in-depth research towards a shared understanding of peri-urban water security in relation to ongoing developmental and capacity-building activities. In the scoping study, each of the teams, taking the Theory of Change as starting point, experimented with various research approaches to peri-urban water security, conflict and cooperation – pragmatically combining locally established and available expertise with new approaches where relevant and possible. We regard this gradual building up and expanding of research capabilities as a major aim of this project, which is also part of its internal capacity-building ambitions in the course of project implementation.

Theoretical points of departure

The teams involved in the scoping studies worked with various combinations of conceptualizations and theorizations of the issues researched in this project.. Main theoretical sources of inspiration were:

- Vulnerability, adaptation, and resilience theories;
- Political ecology and political economy;
- Interdisciplinary socio-technical approaches to water control;
- Theories of (land and) water rights, water (in-)security, and access;
- Theorizations of conflict, cooperation and collective action;
- Theories on policy processes and knowledge – policy interfaces;
- Framing theory.

1.3. Research questions and methods

Research questions

The following general research questions guided the scoping studies:

(1) What knowledge from earlier research on peri-urban processes around water security, climate change (policies) and conflict / cooperation is available?

(2) What are the insights from available knowledge and preliminary research on the socio-political, institutional and other dynamics of peri-urban water security, urbanization and climate change in relation to conflict and cooperation?

(3) What knowledge gaps and *research*, *development* and *capacity-building* needs are emerging from this preliminary research, with special reference to the key domain of the CCMCC program?

(4) Which potential foci, sites and / or cases can be selected for further in-depth scientific *research* in relation to *development* and *capacity-building* activities?

Within the framework of these general research questions, the research teams in the three countries each had their own context-dependent focus in terms of questioning and analysing specific dimensions of the relationships between water security, urbanization, climate change and conflict / cooperation. Contextualizing the more generic questions and issues for each of the specific research locations is a crucial precondition for better scientific understanding and hence, more grounded forms of developmental intervention and capacity-building. Below an overview is given of some of the specific research focuses of the three country teams:

Bangladesh

- With climate change more prominently on the policy agenda in this country, there was specific attention to the ways in which climate change (policies) and interventions impact on social relations (changing access and control of resources; climate-related migration) and the extent to which altered social relations affect policy choices;

India (Hyderabad / Gurgaon)

- Research on the traditional linkages between community and water, and the impact of climatic variability and urbanization on these;
- The emergence of new patterns of relationships among actors in terms of access and use of water, and the role of conflict and cooperation in them;
- Exploration of water use practices along the canals that link the rural and (peri-)urban, with a focus on interface situations among water users: conflicts and cooperation; emerging insecurities and vulnerabilities; farmers' cropping and irrigation choices;
- An analysis of narratives around water conflict and to see if and how they relate to climate change and urbanisation.

Nepal

- Exploration of the implications of recent administrative changes – mainly the transformation of VDCs into wards under a number of municipalies – for water security, institutions, as well as conflict and cooperation;
- The role of traditional water systems (e.g. surface irrigation systems; water spouts) and the changes in this under the influence of wider socio-environmental changes;
- (unexpected:) The impact of the 2015 earthquakes.

Research methods

An important objective of the scoping study is the selection of sites for further research, developmental activities and capacity-building, and an exploration of the options and possibilities for such further research and related activities. All teams made use of most of the following 'mixed' (quantitative / qualitative) research tools and methods:

- Literature review and review of other secondary sources on the relevant issues;
- Review of policies and policy documents, especially in the domains of urbanization, water resources and climate change;
- Review of literature on relevant concepts, theories and methods;
- Inventory of available knowledge and professional experience from earlier studies and project involvements;
- Methods for determining peri-urbanity (cluster analysis; principal component analysis);
- Actor / institutional mapping; stakeholder analysis (knowledge, perception, information, interests, positions, alliances and importance related to a particular issue);
- Qualitative research among and with stakeholders in the potential sites; focus group discussions, group consultations; key informant interviews; expert and practitioner interviews; community meetings; meetings with policy makers and authorities etc.;
- Semi-structured interviews with a variety of respondents in various actor groups, based on, among others, theoretical sampling and snowball sampling;
- Regular meetings and joint site visits (between researchers and stakeholders);
- Specifically organized workshops for stakeholder consultation; direct stakeholder engagement in research;
- Hydrological analysis and the use of other quantitative material / studies where relevant (e.g. water availability / water requirements; water transfers / transports; quantities of water used for specific purposes etc.);
- Use of case studies (e.g. the study of conflict / cooperation cases);
- Ethnographic field research methods, including field observations and participatory observation.
- Visual tools: Photo Voice.

There were also differences and specific research / selection foci depending on the specific research contexts in the three countries or on specific choices for approaching relevant issues:

Site selection methods

Within the general objectives and research questions for the scoping study, site selection criteria were developed on the basis of specific characteristics of the areas concerned. An account of the site selection methods used in each of the four cases in three countries is given below.

Bangladesh

In the Bangladesh scoping study research on the peri-urban regions of Khulna (see annex: map 1) a distinction was made between conflict classes and mechanisms. While 'class' includes the nature of conflicts (e.g. social, economic, etc.), 'mechanism' suggests a plausible explanation of conflict emergence and evolution (declined productivity, grievance, climate-induced migration, urbanization, etc.). Such an approach to conflict was assumed to help better understand both the conflicts as well as the probable spaces for creating or promoting cooperation. On the basis of this, applied to case studies, a 'life cycle' of different conflicts and potential areas of cooperation can be constructed and a better understanding of the causes of conflicts can be reached.

During the study, focus group discussions, interviews and direct observations were conducted to select the primary study sites. Secondary information on the area was also considered in this process. Site selection criteria included heterogeneity in land use, mixed institutional arrangements, diversity in livelihood options including dependence on urban resources, urban-peri-urban hydrological linkages and water use nexus, and vulnerability to water stress. The 'water linkages' between the urban and peri-urban areas taken into consideration included both physical (e.g. canal, river) and 'virtual' linkages (e.g. groundwater transfers). At the same time, severity and importance of site-specific physical and socio-economic issues related to water conflict, such as industrial water extraction, water logging, water/resource exploitation and climate migration, were also considered. The site characteristics and site-specific 'conflict issues' were considered for selecting the preliminary sites. Table 1 gives the names and major issues in the 16 sites selected at this stage (see annex: table 1).

Selection of the preliminary study sites was finalized in a stakeholder meeting where the site characteristics and issues were elaborately discussed, while giving priority to sites that most clearly relate to climate change and urbanization processes. At this stage, based on these discussions and suggestions by stakeholders, ten study sites were finally selected, *Alutala* followed by *Harintana* being the most relevant sites (see annex: table 2). Currently research and capacity-building activities are being conducted in four communities of *Alutala*. More detailed research and capacity-building activities will be conducted with the communities at this site to understand the conflict dynamics, and to promote cooperation.

India

The Indian team used a different site or case selection methodology for Hyderabad and Gurgaon respectively, in view of the fact that the unit of analysis is different for both (see annex: map 2). For Gurgaon the unit of analysis is the canal, while for Hyderabad it is the village. Thus in Gurgaon the scoping study research focused on three canals that represent the flows of water from rural to urban areas, and vice versa. These canals are (1) the Gurgaon Water Supply Channel; (2) the National Capital Region (NCR) Channel; (3) the Gurgaon Jhajjar Wastewater Canal (see below; selected sites; see annex: map 3). The research site selection objective for Gurgaon was, first, to ascertain whether these canals will be relevant sites for research, development and capacity-building activities and, second, which sites and issues would qualify for specific project attention.

For Hyderabad (Hyderabad Metropolitan Area; HMA; see annex: map 4), several methodological and analytical steps were taken for definitive site selection. First, a combination of K-Mean cluster analysis and principal component analysis was used to determine the extent of peri-urbanity of a number of potential research sites (blocks). These 40 blocks (excepting) the urban core, were categorised under three major headings: (1) peri-urban to urban (11 blocks); (2) peri-urban to peri-urban (13 blocks); and (3) rural to peri-urban (16 blocks). Next, peri-urban villages were identified in the blocks for shortlisting of study villages (through key person Interviews, consultations, combined with visual observations). A list of 17 indicators based on the literature was used here, leading to identification of a cluster of villages. Finally, a combined approach of key persons' consultations at various levels, literature review and review of earlier research findings from SaciWATERs work was used to identify the presence of forms of conflict and cooperation over water in the peri-urban villages, related to issues of urbanization and climate change.

Nepal

In Nepal also a stepwise selection procedure was followed for selection sites in peri-urban Kathmandu (see annex: map 6). The primary study area selected for Kathmandu Valley is the Hanumante River basin (annex: map 7), which encompasses parts of Bhaktapur and Lalitpur Districts. First, a literature review was undertaken on secondary sources and earlier studies on sites in peri-urban Kathmandu, showing different dimensions of water security due to urbanization and climate change. Second, a round of meetings and discussions with resource persons from the Nepal Engineering College was held. This institute has been involved in water research in Kathmandu Valley for the past 10 years. Major point stressed during these meetings was the fact that it would be beneficial to take a wider area such as a river (sub-) basin or watershed as unit of investigation in order to really analyse the different flows of water resources from the peri-urban fringes to the urban centres and the dynamics around these flows, at various levels. Third, in March 2015 a consultative meeting with resource persons in the field of water management in Kathmandu Valley was held to obtain input into the final selection of study areas for in-depth research. The major outcome of the meeting was an overview of potential thematic and geographic research areas based on participants' experience, knowledge and discussions.

After these steps field studies were executed. Between June and August 2015 reconnaissance visits were undertaken to potential in-depth study areas (wards): Jhaukhel, Dadhikot, Sudal, Siddhipur, Lubhu, Godavari and Bhaktapur municipality (all part of the Hanumante river basin). During the field study work, checklists prepared in advance were used as a guidance tool for interaction with various stakeholders[3]. Finally, a preliminary review was undertaken to obtain a deeper insight into the policy frameworks for water resources management, climate change and urban planning. A primary aim is to gain a first understanding of the various ways in which these shape the dynamics around water security, conflict and cooperation in the management of peri-urban water resources.

The smaller study areas within the Hanumante basin were selected on the basis of the criteria presented below. In the selection process a distinction was made between *geographic* case studies (situations quite specific to (an) area(s) within the Hanumante Basin) and *thematic* case studies (situations with regard to water (in)security, as they occur throughout the Kathmandu Valley). The selection process consisted of two rounds:

(1) Short-listed sites round 1: short-listed study areas and thematic cases based on exploratory meetings with experts and the outcomes of the consultative meeting:

A. *Geographic areas:* area between Gokarna and Sundarijal; Sundarijal (headwaters of the Bagmati river); Kodku, Godavari; Lele, Lalitpur; Jhaukel VDC as part of the Hanumante basin; Taudaha, Kathmandu; Matatirtha VDC;

B. *Thematic cases:* peri-urban agriculture; real estate development; water distribution systems in the Kathmandu Valley; stone spouts – traditional water management systems in the valley; rainwater harvesting; dynamics of water extraction, water transfer and environmental impact; water rights, policies and institutions.

(2) Short-listed sites round 2: outcomes of field visits, literature review and expert consultations:

A. *Geographic areas:* Jhaukhel; Dadhikot; Godavari; Lubhu; Sudal; Siddhipur;

B. *Thematic cases:* forces that affect the peri-urban fringes: peri-urban agriculture and real estate development; traditional water systems – irrigation canals and stone spouts; peri-urban to urban water transfer: private tankers; municipal water supply (the Kathmandu Valley Drinking Water Company); inter-basin water transfer (the Melamchi project).

Based on the inputs from the steps described above, the following selection criteria were formulated in order to select case studies for in-depth research (see annex: table 3):

(1) Peri-urban in nature: urbanization; increasing pressure on water resources, including pressures and scarcities due to water transfers to urban areas; or areas that, due to their location, have to deal with direct consequences of urbanisation such as wastewater flows from households or industry to peri-urban

[3] In a later stage of in-depth research, informal meetings and visual tools like Photo Voice will also be increasingly used to capture the views, perceptions and ideas of representatives from various stakeholder groups. This enables people to capture challenges of water security from their personal perspective, providing room for different viewpoints.

agriculture;

(2) Sites where significant dynamics in natural resource use (for instance: multiple claimants of water resources), livelihoods, and population growth can be observed;

(3) Existence or potential for latent tensions and conflicts about (or related to) water use, access and rights, and/or existence of cooperation mechanisms and institutional transformations related to peri-urban processes and characteristics;

(4) Climate variability and climate change;

(5) Sites with a hydrological (either directly or indirectly) linkage to the urban area;

(6) Accessibility of the location for research and other project-related activities.

1.4. Limitations of the scoping study

The first important limitation of the study is the fact that the research teams in the three countries, consisting of consortium staff and researchers of IWFM / BUET and JJS in Bangladesh, SaciWATERs and MDI in India, and ICIMOD, MetaMeta and WUR in Nepal, have widely differing experiences with, capacities for and focuses on specific research approaches, methods and their conceptual-theoretical grounding. Second, changes in the composition of the consortium in 2014 (replacing NEC with MetaMeta in Nepal), as well as internal staff changes in the Bangladesh, Indian, and Nepalese teams, have complicated and delayed the research process and related activities. Third, the severe earthquakes in Nepal (April-May 2015) have had serious consequences for research activities in the months immediately after this disaster. Conditions for research only returned to normal by July 2015, to become again influenced by the fuel crisis from September 2015 onwards.

2. Exploring four peri-urban research areas

This chapter introduces the four preselected cases of cities (Khulna in Bangladesh; Gurgaon and Hyderabad in India; Kathmandu in Nepal) and their peri-urban areas (see annex: maps 1-5). It concisely discusses issues of water (in-)security, urbanization and climate change, as well as aspects of conflict and cooperation around water resources that are known and have been observed in earlier and ongoing research.

2.1. Khulna (Bangladesh)

Khulna (officially: Khulna City Corporation; KCC; see annex: map 1) in southwestern Bangladesh lies on the Late Holocene-Recent alluvium of the Ganges deltaic plain in the north and Ganges estuarine plain in the south (Adhikari *et al.* 2006). It is the third largest (46 sq. km.) metropolitan city of Bangladesh. Geographically, Khulna City is located on a natural levee of the Rupsha and Bhairab rivers, and characterized by the Ganges tidal floodplains with low relief, criss-crossed by rivers and water channels and surrounded by tidal marshes and swamps. Historically Khulna was a market town and seat of administration. During the early days, tobacco and sugarcane were traded here and it had a trade link with Calcutta. Khulna became a municipality in 1884, and linked with railway in 1985. Industrialization started in the 1960s (Murtaza 2001). Demographic characteristics show that population growth in Khulna is rapid (3.8 percent), especially due to rural-urban migration. The gross population density is very high, about 18,000 per km square. Many people are engaged in informal sector activities (Murtaza 2001).

The average height of Khulna is about 3.32 metres above sea level. The area comprises of mostly flat land with two natural ground slopes in different directions: one from northwest to southwest, parallel to the general low direction of the Bhairab River (upper reach) and Rupsha River (middle to lower reach); another from northeast to southwest, which may facilitate sea water intrusion to the aquifer system of the Khulna. Thus, both the urban and peri-urban areas in Khulna are relatively flat, on average only 2.5 metres above sea level. This makes them vulnerable to cyclonic storm surges and poor storm water drainage, especially under conditions of climate change. Increasing temperature and humidity create an increasingly favourable condition for the formation of cyclones in the Bay of Bengal. Increase in the frequency of severe cyclones is suggested by the occurrence of two recent devastating cyclones – Sidr in May 2007 and Aila in November 2009. These cyclones, accompanied by high storm surges, caused widespread damage to properties and the loss of human and animal lives. Increase in soil salinity, due to long-standing saline water on farmlands from storm surge inundation, has deeply affected crop cultivation.

Due to its deltaic location, climate change effects are increasingly felt in the following three major ways, especially by poor and vulnerable sections of the Khulna population: (1) sudden onset events, e.g. floods and cyclones; (2) slow onset processes, e.g. coastal erosion and salinity intrusion; (3) cascade effects, e.g. aggravation of existing problems by straining overstretched public services (Roy *et al.* 2013). Huq *et al.* (1994) examined the effects of a one-metre sea rise scenario and identify Khulna District as one of the three most vulnerable districts in Bangladesh, with about 80 percent of the area prone to inundation, affecting 3 million people. Aggravated flooding, salinity intrusion and storm surges are identified as other consequences of the sea level rise. Hanson *et al.* (2011) rank Khulna 13th among the 20 most vulnerable port cities worldwide on the basis of a combined consideration of climatic and socio-economic changes. This ranking also projects the risk of population exposed to coastal flooding due to sea level rise and storm surge in 2070, and finds Khulna at the 6th place, seeing a more than 700 percent increase in exposure. In terms of damage as a percentage of overall gross domestic products (GDP), Hallegatte *et al.* (2013) rank Khulna 8th among the 10 most vulnerable coastal cities. Such climatic hazards are aggravating the existing urbanization impacts, while environmental and other forms of migration are shaping and re-shaping the peri-urban characteristics and dynamics in Khulna. As many migrants settle in the peri-urban areas, competing claims and contestations around the limited resource base and livelihood opportunities create conflicts over control of resources.

Water insecurity in peri-urban communities is aggravating due to exposure to climate change and urbanization, and the lack of capacity to mitigate their impacts. Urbanization in Khulna is sustained mainly by the acquisition and conversion of agricultural land and water bodies in the peri-urban areas. The present urbanization and growth trends of Khulna indicate that the area covered by water bodies, low lands and fallow lands is decreasing, whereas the built-up areas are expanding (Ahmed 2011). The resulting altered land entitlements and water access and rights are leading to stresses on the lives and livelihoods of peri-urban communities. Current climatic trends and variability are perceived to have multi-dimensional effects on water security in the peri-urban areas. A significant portion of the peri-urban population depends on crop farming, daily labour, private service and small business. These people are relatively poorer, have smaller asset bases, attained lower education level and have less access to political or social leadership. They are likely to be more vulnerable to climate-induced hazards and disasters. Increasing heat stress during the pre-monsoon summer season is likely to bring discomfort to the lives of these people, particularly to the elderly and physical labourers.

Domestic water demand for drinking, bathing, washing and cleaning is likely to increase due to the rising temperature and humidity, particularly during the pre-monsoon season. The increased demand may add to the stresses for women, who usually take the burden of household water collection. Increasing water levels, accompanied by higher rainfall, may exacerbate the flooding problem in Chhoto Boyra and the water-logging problem in Labonchara. A growing area of agricultural land in Alutala may come under tidal influence, impacting on soil salinity and cropping patterns; part of the land may be converted to shrimp aquaculture (ghers). Sharecroppers, small farmers and agricultural labourers may be adversely affected by such change in land use.

The anticipated changes in future climate are also likely to have an impact on human health. There is already a prevalence of water-borne diseases, such as diarrhoea, cholera, typhoid, dysentery and jaundice, and skin and eye infections among the peri-urban communities. The summer season is the peak time of occurrences of such diseases. Incidences of such diseases may increase in future due to an increase in flooding and water-logging from increased rainfall and river water levels.

In peri-urban Khulna water conflicts among different users are very complex. The nature and dynamics of these complexities depend on several bio-physical, social, economic and political factors. Water insecurity-induced conflicts in the Khulna area are largely constituted by a number of stressors related to urbanization, climate change, and regional and upstream interventions in the hydrological systems. Some stressors, such as wastewater pollution and solid waste disposal, originate locally due to urbanization, while others such as salinity intrusion and reduced upstream freshwater flow are the results of climate change and/or interventions in the flow regime. Contestations around ever more intensively used peri-urban resources is creating conflicts and undermining community resilience. This is evident, for example, from the consequences of urban land development projects on peri-urban land in Chhoto Boyra, or from urban elites taking control over peri-urban water resources in Alutala. Peri-urban biophysical systems and processes are also being altered by urbanisation. Urban wastewater and solid wastes have degraded water bodies such as the Mayur River.

2.2. Gurgaon (India)

Gurgaon is a city located in the North-West Indian state of Haryana (see annex: map 3), which has traditionally been India's food basket. It is located at 200 metres above sea level in a semi-arid subtropical agro-climatic zone. Starting from the 1980s, it has witnessed rapid growth and land use change, transforming what was once a sleepy village into a modern city. Currently it has a population of 1.8 million and a population growth of 7-8 percent. Land has been acquired by the state and by private real estate developers to build high-rise residential buildings, shopping malls and recreation centres, as well as to provide infrastructure to support urban growth. Several multinationals and corporate giants have their offices and headquarters located in the city. This process of land acquisition has been mainly from the neighbouring villages and rural areas.

Often closely related to land conversion and appropriation, and concomitant changes in land use, water resources and the ways in which they are used and controlled have also undergone radical changes. Generally the peri-urban areas of Gurgaon are characterized by a growing demand for water and pressure on available water resources, both surface and groundwater. With the conversion of land, common grazing land and water bodies are disappearing as well. As a result of the growing dependence on groundwater resources, the groundwater table is declining. Other widely experienced problems are flooding and damage to agriculture by excess water in low-lying areas, water pollution, and a growing reliance on wastewater for irrigation (see Narain 2009; 2010; 2014; Narain and Nishal 2007).

Like Hyderabad (see below), Gurgaon is experiencing climate variability in the form of temperature, rainfall, and soil moisture changes. These changes are having a direct bearing on peri-urban water resources and become manifest in falling groundwater tables and the drying up of surface water bodies. This interconnection between climate variability and water is more precariously felt in the transitional spaces or peripheries of these cities.

Understanding conflicts around peri-urban water resources requires an understanding of changing land and water uses, the changing field of claimants and bases of claims, access and control of these resources, and the contestations related to these changes. Water transfer canals are representative of these contestations and conflicts. Therefore research on water conflicts and cooperation in peri-urban Gurgaon is located along a number of canals that represent the flows of water from rural to urban areas, and vice versa. These are:

1) Gurgaon Water Supply Channel, the source of water to the city of Gurgaon; it cuts through several peri-urban villages and carries water to the water treatment plant at Basai that supplies water to Gurgaon;

2) The NCR (National Capital Region) channel, built parallel to it more recently to augment the supply of water;

3) The Gurgaon Jhajjar wastewater canal that carries the urban wastes of the city; wastewater is used widely as a source of irrigation in the peri--urban villages.

2.3. Hyderabad (India)

The city of Hyderabad (see annex: map 4) is located on the Deccan plateau at an average of 542 metres above sea level. It has a tropical climate with pronounced wet / dry seasons, with rainfall largely concentrated in the wet season. The city covers an area of 7,228 km^2 and currently has a population of around 8 million. With a growth rate of 4-5 percent, it is one of the fastest growing cities in India, and hence undergoing rapid demographic, social, economic, environmental and other changes, especially since the 1990s. The Hyderabad Metropolitan Area (HMA), that falls under the jurisdiction of the Hyderabad Metropolitan Development Authority (HMDA), has been selected as a study area for this project. HMDA is vested with the responsibility of planning, co-ordinating, supervising, promoting and securing the development of HMA. Geographically, this area is largely located in the river basins of the rivers Krishna and Godavari, and a number of smaller sub-basins such as the Musi and Manjeera rivers. It has become the centre of economic activities like IT development, the services sector, and pharmaceutical industry, while investing in the development of gated residential complexes, ultra-modern shopping malls and multiplexes. City cleaning programmes, road construction, and market-based reforms should make Hyderabad a 'smart city'.

However, this development strategy has its social and environmental trade-offs, which are increasingly visible in the peri-urban areas where populations, livelihoods, and land use are changing, while water insecurity is growing (Census of India 2011). While coverage by the Hyderabad Metropolitan Water Supply and Sewerage Board is limited, traditional water harvesting structures and water bodies have disappeared or are heavily degraded. A study by SaciWATERs in collaboration with the Department of Science and Technology (2012) reported that, between 2004 and 2012, 13 lakes disappeared in the Mir Alam Basin located in the metropolitan area of the city. A growing number of people rely almost completely on groundwater for their drinking and domestic needs. Poorer groups rely exclusively on municipal sources of groundwater provided through bore wells and mini water tanks, and wealthier groups rely on private tankers or personal bore wells. Water tankers are crucial in transporting raw water from agricultural wells in peri-urban villages into the city for commercial enterprises, construction sites and city residents (Janakarajan *et al.* 2007; Prakash 2014).

These trends are especially increasing water insecurity among marginalised social groups in peri-urban areas. Privileged classes, who can pay for water, put pressure on governments to ensure regular supply and promote the water tanker economy (Prakash 2014). Since groundwater is practically free and unregulated, those with land and the proper documents can indiscriminately sink borewells, obtain electricity connections and pump water either for their own consumption or for sale. A trend of shorter rainy seasons and decrease of rainfall since the 1980s contributes to the problems by further increasing reliance on groundwater in peri-urban Hyderabad (Ramachandraiah *et al.* 2008). Where the prospects for peri-urban agriculture are diminishing, farmers increasingly sell water to tanker companies, thus contributing to the depletion of groundwater resources (See Prakash *et al.* 2015; Joy *et al.* 2014). Wastewater irrigation is on the increase, based on flows from industries and the city (IWMI 2003; Prakash 2014). Evidence of the occurrence of conflicts related to these developments is growing.

2.4. Kathmandu (Nepal)

Kathmandu, the capital of Nepal, is situated in Kathmandu Valley at an average altitude of 1,350 metres above sea level. The valley is a relatively circular intermontane basin with a diameter of approximately 25 km surrounded by hills on all sides with an average altitude of 2,800 metres above sea level (Pradhananga *et al.* 2012). Covering around 665 km^2, it is home to 5 municipal towns, including Kathmandu. The water in the valley is supplied mainly by the Bagmati River and its various tributaries. The Bagmati basin has a total catchment area of approximately 3,750 km^2 and originates in the Shivapuri hills, just north-east of Kathmandu. The settlement history of Kathmandu Valley goes back thousands of years. Historically it has always been an important cultural and trade hub between India and Tibet. The core of Kathmandu

Valley is formed by three historic cities – Kathmandu, Lalitpur and Bhaktapur (see annex: map 6). With an average growth rate of 4.75 pecent per year Kathmandu is currently one of the fastest growing metropolitan cities in South Asia (Pant 2012).

Urbanization in Kathmandu Valley is characterized by urban sprawl expanding towards formerly predominantly rural areas (Thapa and Murayama 2009). Population growth in the valley started in the 1960s and accelerated from the 1970s. The construction of the ring road in the mid-1970s created a strong incentive for rapid urban growth beyond the traditional city cores, extending to the rural areas in the periphery. The process of urbanization and the subsequent expansion of built-up area to the peripheral rural landscape has resulted in the emergence of rural-urban intermediary areas, differentiated by the kind of mixed rural-urban economy and livelihoods that is characteristic of peri-urban areas (Allen 2003; Brook *et al.* 2003; Narain and Nischal 2007).The valley is now among the fastest-growing urban agglomerations in South Asia (Muzzini and Aparicio 2013; ICIMOD 2007). The population of Kathmandu Valley increased from 1.6 million in 2001 to over 2.5 million in 2011, a decadal increase of over 56 percent (CBS 2001; 2012); it is projected to reach 5 million by 2025.

Traditionally, the valley was home to an intricate water supply system that dates back as far as 500 AD. Water from the surrounding hills of the valley was transported through open canals, irrigating the agricultural fields and recharging ponds at the edges of the cities. These recharging ponds in turn ensured water could be supplied to various parts of the cities by an intricate underground canal system that would simultaneously filter the water. People within the cities could access this clean water through so-called hitis, traditional water taps and spouts. However with increasing urbanization this system has largely disappeared; many of the hitis have either dried up or become literally buried under the pillars of 'modern' development.

Kathmandu Valley is nowadays faced with increasingly severe water security challenges regarding both quantity and quality of water. The main sources of water are currently the Bagmati River and its tributaries, as well as groundwater. It is estimated that the Kathmandu Valley Water Supply Company can at present only meet 23 percent of the total water demand during the dry season and about 38% during the monsoon season. The current water demand in the valley is 360 million litres per day (MLD), while piped water supply is 123 MLD in the wet season and 76 MLD in the dry season (KUKL 2014; see Shrestha, A. 2012). This has forced people throughout urban areas to seek out alternative water sources. Many of these sources are located in peri-urban areas. Thus, water is increasingly diverted from rural and peri-urban agricultural and domestic uses to meet urban residential, industrial and recreational needs (Sada and Shrestha 2013; Narain *et al.* 2013).

This rapid urban expansion (JICA 2012; Thapa and Murayama 2009) and increasing water stress have increased such peri-urban to urban water transfers by both state and private actors, to fill the water demand gap (Shrestha, A. *et al.* 2013; 2014). One example are the operations of water tankers: over 90 per cent of private water tanker supplies in Kathmandu Valley is extracted from peri-urban groundwater resources (Shrestha 2011). Studies have shown the drying of stone spouts and drawdown of the water table as a result of this (Shrestha et al. 2013). These processes are likely to be exacerbated by extensive sand mining and a variety of other water-intensive economic activities in peri-urban areas (Sada and Shrestha 2014). Other consequences of urbanization and growing water demand are the deterioration of surface and groundwater (Chapagain and Kazama 2012; Shrestha 2007), unprecedented pressure on and depletion of groundwater (Sada *et al.* 2013; Shrestha 2007; S.D. Shrestha 2012; Yoden 2012; Pradhananga 2012), and the growing importance and increasing use of wastewater in peri-urban agriculture (International Water Management Institute 2006; Narain *et al.* 2013).

In this context of increasing pressures on, and changing uses, rights and control of peri-urban water resources, both conflicts and new institutions, forms of organization and cooperation are emerging. These developments have impelled, for instance, the emergence of groundwater markets, especially during the dry season when the municipal (KUKL) water supply becomes almost negligible. These water markets manifest themselves at different levels: individual (profit-based), community (service-based) and commercial (profit-based) (Dongol *et al.* 2012). The latter concerns the largest volume of water transfer and is mostly operated by water tankers (see above). Water extraction by water tankers has already been prohibited in certain parts of the valley due to opposition from peri-urban communities (Dongol *et al.* 2012). As current groundwater extraction rates exceed recharge by a factor 6, groundwater levels are declining by an average of 2.5 meters per year (Pant 2012). Moreover, peri-urban groundwater irrigation is increasing, due to declining traditional surface water irritation systems and competition over surface water.

Climate change and variability will probably add to these trends. Although little research has been done on climatic trends in Kathmandu valley, studies have projected that the pressures from increasing water demand on Kathmandu are exacerbated by climate change and variability. For Nepal as a whole, Global Climate Models (GCMs) predict a rise in temperature between 0.5 and 2.0 ^{0}C (NCVST 2009, in Bartlett *et al.* 2010) over the next 15 years, and an even larger increase over the next 45 to 75 years. This would increase the evapotranspiration rate and could thus change the water balance in certain parts of the valley. The projections for mean annual precipitation are less conclusive (Bartlett *et al.* 2010). However, various recent models and studies, primarily the Intergovernmental Panel on Climate Change (IPCC), predict that the summer monsoon will become more intense and more variable, with more frequent extreme precipitation events (IPCC 2007, in Bartlett *et al.* 2010).

3. Knowledge gaps and final site selection

3.1. Knowledge gaps in peri-urban studies

An important objective of this scoping study was the identification of research / knowledge gaps and the exploration of options for further research, development and capacity-building dimensions of this CCMCC project. There is a huge knowledge gap in understanding both (peri-)urbanisation and climate-induced water (in)security, as well as the interactions between them, in the developing world. There is a growing scientific interest in the water literature and the peri-urban literature in water-related conflicts and forms of cooperation, negotiations of actor interests, access, rights and entitlements, and institutional processes. However, there still is a lack of understanding of the scalar dynamics of processes of urbanization and climate change in relation to water (in-)security, conflict and cooperation. It is important to assess how different actors are variously positioned in these processes, how they experience and perceive them, and how power dynamics, knowledge, politics, and relative exposure to climatic vulnerabilities and urbanization shape conflicts and cooperation with regard to water resources.

There also exists a knowledge gap in understanding the direct and indirect impacts of urbanisation and climate change on the lives of the poor and vulnerable whose capacity to adapt to such changes are low, and the extent to which approaches of building resilience by enhancing their capacity to adapt to changes by empowering them through various awareness-generating activities are feasible. These aspects are crucial in a peri-urban context. Peri-urban areas are subject to institutional neglect by the state, and policies have either proven to be inadequate to deal with an increasing and competing demand for water or incurred trade-offs, leading to conflicts and contests. The existing institutional structures and arrangements are not able to cope with the rapid changes, due to overlapping roles and responsibilities or lack of institutional capacity. There is, moreover, a serious lack of understanding of, and sensitivity to, peri-urban water insecurity and climate issues in relation to conflict and cooperation among officials and policy makers. An important contribution of this project, linking knowledge, development and capacity-building dimensions, can be to support necessary institutional changes by activities that generate awareness among policy makers and make them more sensitive to these processes and issues, so that an effective management strategy can be developed.

In line with the general aims of questions dealt with in the CCMCC program, the following knowledge / research gaps and knowledge needs were identified:

1. Understanding of how urbanization and climate change interact in inducing water insecurity in peri-urban settings, creating potential for conflict and / or cooperation;

2. How current water, climate change and other relevant policies influence peri-urban areas and to what extent they (might) create potential for water-related cooperation / conflict;

3. In what ways and to what extent these social-environmental transformations around water, land and other resources in peri-urban areas produce, reproduce or bring about changes in conditions of poverty, inequality, social differentiation, resilience and vulnerability.

4. The options that can be identified on the basis of this analysis for conflict solution and stimulation of cooperation in ways that strengthen the position of the most vulnerable and marginalized groups that are affected by water insecurities.

In the following section more detailed information is given on the final selection of sites for further research, focused not only on closing the knowledge gaps concerning peri-urban water security in relation to urbanization and climate change, conflict and cooperation, but also on linking new understandings and insights to an agenda for development and capacity-building in the selected areas.

3.2. Final selection of sites for research, development and capacity-building

Bangladesh

The predominant characteristics of the peri-urban areas of Khulna are heterogeneity in land use, mixed institutional arrangements, diversity in livelihood options including dependence on urban resources, urban–peri-urban hydrological and water use linkages, and vulnerability to water stress. These characteristics and the site-specific 'conflict issues' were considered for selecting the preliminary sites. Both physical and socio-economic characteristics like industrial use, water logging, resource use, presence of urban pockets, and climate migration were considered as selection criteria. Site selection criteria also included 'water linkages' (e.g. canal, river; groundwater transfer) between the urban and peri-urban areas. In the final selection of research locations and cases, priority was given to those that most clearly relate to climate change processes for which there is evidence in the area concerned. The final selection also involved discussion with stakeholders in a sharing meeting. Based on those discussions and suggestions from the stakeholders the list of sites was narrowed down to 10 (see annex: tables 1 and 2).

The following case studies are planned to be conducted to analyse the conflict and cooperation dynamics in relation to peri-urban water security, climate change and urbanization. Several cross-cutting issues will also be considered in the studies. The cases were selected during the scoping study based on a combination of literature review and feedback from the field.

Exploring the hydro-social system: urban and peri-urban conflicts, and impacts of urbanization and salinity intrusion

The Rupsha-Bhairab and the Mayur rivers are hydraulically linked through an intricate network of canals and water bodies in and around Khulna city. Both rivers play important roles in trade, commerce, industries, livelihoods and ecosystem sustenance in the urban and peri-urban areas. The Mayur river is shared by urban and peri-urban residents for various uses. Although it provides important ecosystem services and functions to the urban and peri-urban residents of Khulna, it has been facing severe threats due to unplanned and unregulated urbanization. Future projections indicate that it will probably be further affected by salinity intrusion and sea-level rise due to climate change. These compounding effects of climate change and urbanization will reduce water availability in the river and aggravate the water insecurity in the area.

Urbanization impacts and groundwater transfer (from Fultala)

The growing land development business in Khulna is responsible for filling up of the open water-bodies in the peri-urban areas. Competition among different user groups in urban and peri-urban areas for the scarce water resources increases with domestic and industrial water demands, and reduces the surface and groundwater resources. This competition is creating complex water use conflicts among the urban and peri-urban residents. The nature and dynamics of these conflicts are governed by various social, economic and political factors, and are visible in three major ways, to be further researched. First, urban wastewater flow limits freshwater availability in both urban and peri-urban areas, and creates conflicts between urban and peri-urban residents as well as among urban residents themselves. Second, urban water supply is planned to be augmented by transferring groundwater from peri-urban areas. This water transfer plan, presently postponed, was protested against by the peri-urban residents because it would severely deplete their local groundwater. Third, culture fisheries, practiced in the peri-urban stretches of the Mayur River and adjoining areas, require saline water whereas agriculture requires freshwater. Urban elites, who own most of the peri-urban fish farms, influence the control of saline water flow through the downstream regulator at Alutala, limiting freshwater availability for peri-urban agriculture.

Drinking water scarcity (with special attention to gender aspects)

Previous studies and preliminary assessment of potential sites reveal that peri-urban communities in Khulna are primarily vulnerable to the unavailability of freshwater for drinking and domestic uses. Since most of the surface water and ground water sources are polluted or saline, inhabitants have to look for distant sources to collect water. The weight of this burden of water collection varies across economic classes and among men, women and children. Urban drinking water supply is almost entirely based on groundwater. The public provider Khulna Water Supply and Sewerage Authority (KWASA) serves only 30% of the urban population through a piped distribution system; the rest of the population depends on personal or community-based hand tube wells (HTWs). The situation is particularly bad during the dry season, when the water in the Mayur and nearby *khals* becomes extremely polluted. People with no other choices have to use this water for washing and bathing. In some areas, women and children have to walk long distances to collect drinking water. Sometimes people are forced to drink tubewell water contaminated with arsenic and iron in the absence of a (nearby) alternative safe source of water.

Water pollution

Surface water pollution is another cause of water insecurity in the Khulna area. Peri-urban communities, particularly those dependent on the Mayur river and other polluted water sources, are extremely vulnerable to degrading water quality. Wastewater generated in the city is discharged into the Mayur river through 22 open drains. The pollution of the river's water limits the livelihood opportunities based on agriculture and aquaculture that previously existed in the peri-urban areas. The aquatic environment is severely degraded in Gollamari, where a major outfall discharges urban waste-water into the Mayur river. Water logging, a major problem in Harintana, Labonchara, Rayer Mahal and Sachibunia in the event of heavy and continuous rainfalls, also causes pollution of local surface water bodies. Other major sources of water pollution include industrial wastes and bathing of cattle. Salinity intrusion and arsenic contamination in groundwater are also reducing water access and security.

Institutional arrangements (the Alutala sluice gate)

In peri-urban areas the situation with regard to water management institutions tends to be unclear and full of gaps. According to local people, neither the Khulna City Corporation (KCC) nor the local government authority take the responsibility for fulfilling basic community needs. Inhabitants of South Labonchara, situated at the city corporation boundary, stated that they pay all taxes as per KCC rules and regulations, but receive no KCC facilities (electricity, water supply, school, health facilities) as these are not in place. KCC and KWASA have been trying to augment water supply to meet the increasing urban demand. A plan to import groundwater from a peri-urban area through a pipeline was severely resisted by local activists and civil society. It was eventually postponed by a court decision in a case filed by the Bangladesh Environmental Lawyers Association (BELA), although at that time 40 percent of the project funds had already been invested. A plan of KWASA to import river water from a location some 40 kilometres away from the city is facing uncertainty since the salinity level at the source has already exceeded the projected level. They have also planned to construct a surface water treatment plant and an impounding reservoir to augment water supply in the city. However, these plans and strategies are solely aimed at addressing urban water supply and vulnerabilities.

Peri-urban agriculture (changing livelihoods)

Agriculture in peri-urban Khulna is almost entirely dependent on surface water and rainwater. Surface water bodies have been diminishing because of the spread of urban built-up areas, encroachment by urban users, and urban waste-water pollution, resulting in changes in cropping practices of the farmers. They rarely cultivate *boro* rice and are switching from rice to vegetables, which can be irrigated with less water or with wastewater. Salinity-tolerant crop varieties are also being introduced as the soil and water salinity are increasing. Some farmers are converting their agricultural lands to practice fish farming. In extreme situations, farmers sell off their agricultural lands to developers and move to non-agriculture based livelihoods.

India

In India, the selection of sites for further research took pace in both Gurgaon and Hyderabad (see above). The following sites have been selected:

Gurgaon

As discussed above, the proposed research on water conflicts and cooperation is located along canals that represent the flows of water from rural to urban areas, and vice versa. The canals selected for this are:

(1) The Gurgaon Water Supply (GWS) channel: the source of water to the city of Gurgaon; it cuts through several peri-urban villages and carries water to the water treatment plant at Basai that supplies water to the city of Gurgaon;

(2) The National Capital Region (NCR) channel that was built parallel to it more recently to augment the supply of water;

(3) The Gurgaon-Jhajjar wastewater canal that carries the urban wastes of the city; the wastewater is used widely as a source of irrigation in the peri-urban villages (see map 3).

Though the study was situated in four peri-urban villages in Gurgaon district (Chandu, Budhera, Kaliawas and Iqbalpur), the primary unit of analysis was not these four villages but the three canals that pass through them (the GWS, NCR and the Gurgaon-Jhajjar wastewater canal). The GWS and the NCR originate from the same source (River Yamuna) in Sonepat District. The study area also comprises the Chandu-Budhera Water Treatment Plant located within Budhera village, which treats the water from the NCR canal. The entire research area is about a five-kilometre stretch of these canals. However, with great agro-ecological and topographical diversity it makes for an excellent site for studying social relations around water. The villages as secondary fields of study are important locations in understanding other dynamics of peri-urbanity and land acquisition.

Hyderabad

Using the mixed quantitative and qualitative tools described above, the following study sites (see annex: map 5) have been identified for further research (and development / capacity-building):

(1) Peddapur village in Sadasivpet Mandal;
(2) Edthanur in Sangareddy Mandal;
(3) Chitkul in Patancheru Mandal;

(4) Anajpur village in Hayatnagar Mandal;
(5) Bowrampet in Qutbullapur Mandal.

Peddapur is a village with a mainly backward-caste population, the majority of whom work as agricultural labourers. Until the 1990s irrigated agriculture was primarily dependent on surface sources. Canals and other sources (tanks, lakes, ponds) provided sufficient water for agricultural and other economic uses, while wells were used for domestic uses. However, under the influence of climate variability and growing competition for water, this pattern has changed, water use increasingly depending on groundwater, mainly from bore-wells. Few households have piped connections for domestic uses; the majority depends on community taps. Surface sources are increasingly drying up, while groundwater use exceeds recharge. One of the causes of increasingly intensive groundwater use is the shift towards commercial, more water-intensive crops. Livestock has decreased because of water shortage. Important trends are marginalization of small farmers, increase of tenancy, and growing dependence on industrial labour. Growing water scarcity and increasing urban demands has led to conflicts with the Hyderabad Metropolitan Water Supply and Sanitation Board (HMWSSB). Thus it illustrates conflicts about water between peri-urban and urban institutions.

Edthanur and *Chitkul*, both under the jurisdiction of Hyderabad Metropolitan Development Authority (HMDA), have undergone rapid changes since the 1970s. The population largely consists of lower-caste people, many of whom are migrants. Formerly agrarian societies in the semi-arid zone, both villages were dependent on surface water sources (tanks, lakes, ponds) for agricultural and domestic water uses. However, the changes of the last decades, both climate variability, population increase and industrialization, have caused a decrease in cultivated area. The last decades have especially seen an increasing industrial pollution with chemical and toxic waste, as a consequence of which many people have shifted to the use of groundwater (which is also of low quality). Land is increasingly left fallow or sold away and a decrease in livestock can also be seen. Several decades of anti-pollution protests and activism have not been able to effectively empower the villagers and protect their interests. Thus, the case illustrates issues of negotiation, contestation and conflict between villages and industries about water pollution, with important consequences for village life and livelihoods, public health, and access to water.

Anajpur used to be a very fertile cereal-producing area. However, it has undergone radical changes from the 1980s under the influence of urbanization, a process that brought film, textile and dyeing industries to the area. Under the jurisdiction of HMDA, the village has an, in majority, lower-caste population with a substantial percentage of migrants. Many inhabitants have moved from traditional occupations and farming to industrial labour in recent decades, thus radically changing villagers' livelihoods. Main sources of water that used to be important for agriculture - mainly surface sources like tanks, lakes and ponds - have now dried up due to changes in rainfall patterns (including also unseasonal rainfall that damages standing crops). Low rainfall has also led to a fall in the groundwater table, in turn causing the drying up of formerly fertile land. The operations of industries, in the meantime, have led to a deterioration of groundwater, making surface and well water unsuited for either agricultural or domestic use, causing dropping farm yields, and leading to radical changes in livelihoods. Conflicts emerged, among others, about the construction of a check dam that threatens water security of the inhabitants.

Bowrampet, facing acute water shortages in the past few years, has a mixed population including many migrants. Until the 1980s this was a predominantly agrarian society dependent on surface water from lakes and ponds and rain water for irrigation, and dug wells for other purposes. After that, groundwater bore wells became an increasingly important source of water for agricultural and other uses. Domestic supply is increasing provided through RO (reverse osmosis) plants in combination with other sources of supply. Peri-urban land use changes caused by urbanization and growing water scarcity are deeply influencing peri-urban livelihoods. These processes of change cannot be clearly attributed to either climate change or urbanization as separate factors, they act in combination. The changes described above are leading to both conflicts about water between various actors, as well as new forms of cooperation such as forms of water sharing and joint organization of access to water.

Nepal

Geographic study areas

The preliminary insights from the various reconnaissance visits are outlined below, according to the various selection criteria given below. On the basis of these a selection of cases was made for further research.

A. Degree of heterogeneity in land use and land cover:

- Jhaukhel: sand mining, many brick kilns, factories (tobacco, dye), commercial agriculture, water bottling plants, land plotting, rapidly growing residential areas, road access;
- Dadhikot: few brick kilns, rapidly growing residential areas, land plotting, commercial agriculture, road access;
- Sudal: many brick kilns, slowly growing residential areas, road access;
- Siddhipur: rapidly growing residential areas, commercial agriculture, road access;
- Godavari: Rapidly growing residential areas, land plotting, commercial agriculture, road access.

B. Elements present for conflict and/or cooperation:

- Jhaukhel:
  - Brick kiln-owned boring is used for irrigation for timely rice transplantation, while the groundwater table is depleting and becoming inaccessible to the poor;
  - Policy priority is given to drinking water, affecting the irrigation sector and causing increasing conflicts over limited water resource for irrigation.

- Dadhikot:
  - Moving from community water supply systems to private water supply for more equitable sharing of water (private taps at homestead), adding both inter- and intra-sectoral conflicts and cooperation for water security;
  - Rapid urbanization and growing demand for water, resulting in expansion of the coverage area of systems and a search for new water sources.
  - Collapse of irrigation canal network in increasingly residential areas (i.e. reduced command area for irrigation).

- Sudal:
  - No distinct conflicts on water uses by different stakes are observed;
  - Farmers are getting timely water for irrigation;
  - Drinking water is not a big threat yet, slow urbanization;
  - Irrigation water: in the areas with brick kilns, farmers get free water for irrigation provided by the operator; cooperation that also increases the dependency of farmers on them (and future conflict potential, e.g. about rights and access to water).

- Siddhipur:
  - 24 hours of continuous supply of drinking water; overflow from the system goes to irrigation system.
  - Problems with metering system (dysfunctioning; cheating).

  Godavari:

- Good source of water;
- Other adjoining VDCs depend on Godavari for irrigation and drinking water.

C. Degree of multiple (competing) claims:

- Jhaukhel:
  - Water transfer from Jhaukhel to Bhaktapur Municipality (for domestic purpose), either via tankers or jars/bottles;
  - Domestic and productive use of water in Jhaukhel: brick kilns, sand mining, irrigation, drinking water, dye factories, commercial farming, poultry, tobacco.

- Dadhikot:
  - Water from the stream from Dadhikot does not transfer/go to urban area; water from adjoining VDC for drinking purposes;
  - Irrigation: water diverted from Mahadev Khola (also Charkhandi khola irrigation systems), while spring sources ultimate draining into the rivers are tapped for drinking water supply;
  - Water uses in drinking water, commercial agriculture, irrigation, brick kiln etc.

- Sudal:
  - The drained water from Sudal passes to urban areas i.e. hydrological movement of water from peri-urban to urban area;
  - Groundwater extraction and stream water used for brick kiln, irrigation;
  - Spring source used for drinking water.

- Siddhipur:
  - Drainage water moves along peri-urban areas (no surface water transfer from peri-urban to urban area hydrologically);
  - Drinking water is transferred from another VDC via a pipe network (overflow water is sent to irrigation system during night time).

- Godavari:
  - Community drinking water users committee operating the drinking water system;
  - Distilleries, illegal tankers operation not allowed nowadays by the users' committee.

D. Degree of urban - peri-urban hydrological linkages:

- Only for Sudal, the stream enters the urban areas;
- In other cases either it flows in peri-urban areas or in the border area between urban and peri-urban areas.

E. Degree of (perceived) vulnerability to water stress:

- Jhaukhel:
  - Groundwater stress is high;
  - Each year, the groundwater table is decreasing.

- Dadhikot:
  - The source in VDC is insufficient to fulfil community demand (from Mahadev Khola);
  - Newly developed drinking water supply with source in adjoining VDC.

- Sudal:
  - Presently drinking water is not a problem;
  - Plan to take water from adjoining VDC where dam construction is ongoing for both irrigation and drinking water.

- Siddhipur:

- In the past groundwater used for domestic and productive uses;
- Last 8-9 years: domestic water from a pipe network (source lies in adjoining VDC, from Godavari stream);
- Groundwater used in case of turbid water from the pipe supply system;

- Godavari: hardly any water stress is perceived in Godavari.

F. Climate change vulnerability ranking:
- Bhaktapur was ranked as highly vulnerable in the climate change variability mapping exercise undertaken in 2010 by the Government of Nepal as part of the National Adaptation Plan of Action;
- Most of the Hanumante Basin falls within the Bhaktapur District.

Thematic case studies

The following three thematic case studies were selected after consultations and field work:

Forces affecting the peri-urban fringes: agriculture and real estate development:

Peri-urban areas are experiencing dramatic changes due to urban sprawl, declining farm size and increasing population density (Veenhuizen and Danso 2007). Market driven changes can be seen in farming methods, such as a shift from staple and resilient crops toward more perishable vegetable and commercial crops, and increasingly market-oriented intensive production based on agrochemicals and mono-cropping. However, after many years of using agrochemicals in peri-urban farming, declining yields and increasing vulnerability to pests have become manifest due to declining soil fertility (Bhatta *et al.*, 2011). In reaction NGOs, cooperatives and private initiatives started promoting organic-based agriculture. Later, government authorities also started supporting the concept, and started initiatives to promote organic farming in peri-urban areas. Both demand and supply of the products of organic agriculture are growing.

Another important force is the use of wastewater for irrigation. Untreated domestic sewage is used by plugging sewers to divert sewer water, by direct pumping, or diversion of water from polluted rivers. The water is mainly used for rice transplantation and vegetable farming. Health hazards experienced by communities include skin problems like itching and blisters on hands, feet, and lower legs, and intestinal parasites (Rutkowski *et al.* 2007).

Traditional water systems – irrigation canals and stone spouts (or hitis):

With urbanization pressure, the agricultural land around the *hitis* (in most of the cases) gets occupied with housing. Where *hitis* are a major source of drinking water, the users are rapidly increasing. Examples in, among others, Patan show that these systems often are the main domestic water source for poor families and poor renters (UN-HABITAT 2008). In 1985, the then Nepal Water Supply and Sewerage Committee proposed to install a water collection system in Alkwo Hiti to feed the municipal pipes. Locals could not agree as they were afraid that this intervention of the government agency would make them loose the water right of the *hiti*. Later on, the municipality supported the system with two PVC water tanks for a community-based water management system from Alkwo hiti. Initially the system, which has its own rules and regulations, served 150 households, which was extended to 180 later. Each household gets 250-300 litres of water delivered every day. This shows how *hiti* systems are hybridized to meet the changing lifestyle of urban water users. Dug wells provide similar examples: water is pumped from a well and conveyed to the surrounding houses through flexible pipes, or stored on overhead tanks to be distributed later.

Although more studies have been done on changes and degradation of traditional water systems in urban areas, little has been documented about the issue and their implications in peri-urban areas. Nonetheless these problems are growing with increasing urban expansion into these areas. Shrestha *et al.* (2014) discuss the degradation of traditional water infrastructures in Lubhu. Dovan River Rajkulo (a state-sponsored irrigation system) in Lubhu has degenerated since it was damaged by a flood in 1996. Furthermore, local residents have been illegally draining their household sewage into the underground canal. The lack of maintenance of the irrigation systems in Lubhu can be attributed to the vastly increased building activity in the area. Similarly, the nine ponds in Lubhu (that were used as alternative sources of domestic water and irrigation, and also contributed to groundwater recharge) either decreased in size, been filled for the construction of public infrastructure, or privately encroached upon. Likewise, although no record was found of traditional stone spouts in the VDC, the five remaining stone spouts (Sankhadevi Dhara, Amrit Dhara, Bhagbati Lachi Dhara, Gaphal Dhara and Jharu Dhara) are either completely dry or only partially in use, making Lubhu entirely dependent on external water sources.

Peri-urban to urban water transfers:

Three tiers of water transfer have been observed. The first one is at the local level, i.e. from peri urban areas to urban areas nearby. The second one consists of transfers of water within Kathmandu Valley over longer distances from peri-urban to urban areas, for example via private tankers. The third one is the inter-basin transfer of water. For the planned research it is important to zoom in on how these various forms (tiers) across scales interact and mutually influence each other. This will entail studying the interactions between various users and claimants ('stakeholders') in dealing with the water-related changes, and especially the role of institutional change, cooperation and conflict. The challenge will be not so much to analyse the various uses separately (e.g. the tanker operators, the irrigators), but to design case studies for in-depth research that make it possible to get to understand more of their interactions in terms of access, rights, uses, institutions, etc.

Emergence of a private water market (tanker operation) is due to the gap left by the combined services of traditional sources and piped water supply (Moench and Janakarajan (2006). Tanker operator supply mainly groundwater from dug wells and borings, and in some cases surface water from stream and springs. Important locations from where the tankers extract groundwater are Jhaukhel VDC, Manamaiju VDC, Jorpati VDC, Gothatar VDC, and Matatirtha VDC. Different sizes of tanks are available for water transfers from these location, varying from small tanker trucks (5-7 thousand litres) to large tanker trucks (12 thousand litres). According to earlier studies in 2009, 9 percent of the total demand in Kathmandu Valley is fulfilled by private tanker operators, at a total water demand in the valley of 280 MLD (KUKL, 2009). According to Moench (2001) and Moench and Janakaranjan (2006), private tanker operators distribute an average of 6 MLD (19 percent of the total supply by the Nepal Water Supply Corporation). Recent studies shows that this has increased to 25.5 MLD which accounts for 39 percent of the total supply.

4. Major findings from the scoping studies

4.1. Major findings from Khulna, Bangladesh

The scoping study identified the major issues and challenges in the primarily-selected sites. Other findings are categorized under the cross-cutting themes of case studies mentioned earlier. The study indicates that freshwater is scarce in the area, due to high levels of salinity in the groundwater and surface water, and pollution of the Mayur river, an important freshwater body that needs to be saved to serve both the urban and peri-urban areas. The existing water insecurity would further aggravate with the continuing trends in urbanization and climate change. The more specific findings are summarized below:

Water security, urbanization and climate change

- The prevailing water insecurity of the peri-urban communities in Khulna is aggravating due to their exposure to different stressors of climate change and urbanization, and the lack in their capacity to mitigate the impacts.
- Urbanization in Khulna is sustained mainly by the acquisition and conversion of agricultural land and water bodies in the peri-urban areas. The present urbanization and growth trends of Khulna indicate that the areas covered by water bodies, lowlands and fallow lands are decreasing, whereas the built-up areas are increasing. The resulting altered land entitlements, water access and rights are leading to stresses on the lives and livelihoods of peri-urban communities.
- The peri-urban biophysical systems and processes are being altered by urbanization. Urban wastewater and solid wastes have degraded the common water bodies such as the Mayur river and the local environment.
- Current climatic trends and variability are perceived to have multi-dimensional effects on water security in the peri-urban areas. A significant portion of the peri-urban population depends on crop farming, daily labour, private service and small business. These people are relatively poorer, have smaller assets bases, attained lower education level and have less access to political or social leadership. They are likely to be more vulnerable to climate change induced hazards and disasters.
- Domestic water demand for drinking, bathing and washing-cleaning is likely to increase due to the rising temperature and humidity, particularly during the pre-monsoon season. The increased demand may add to the stresses for the women, who usually take the burden of household water collection.
- Increasing temperature and humidit creates a more favourable condition for the formation of cyclones in the Bay of Bengal. These cyclones, accompanied by high storm surges, are likely to cause more frequent damage to properties and the loss of human and animal lives. Increase in soil salinity, due to long-standing saline water on farmlands from storm surge inundation, will limit crop cultivation and reduce productivity.
- Increasing river water levels, accompanied by more intense rainfall events, may exacerbate the drainage and flooding problems. Also, more agricultural lands may come under tidal influence, resulting in an increase in soil salinity, changes in the cropping pattern, and conversion to shrimp aquaculture.
- The anticipated changes in future climate are likely to have an impact on human health. The summer season is the peak time of occurrences of such diseases. Incidences of such diseases may increase in future due to an increase in flooding and water-logging from increased rainfall and river water levels.

Policy, programs and practices

- The Master Plan for the city projects that the metropolitan area will be more than doubled in its areal extent in future. However, there is no clear indication on how Khulna Water Supply and Sewerage Authority (KWASA) will meet the future water demands in the urban and peri-urban areas.
- Although adaptation measures are being planned through the construction of climate-resilient urban

infrastructure and augmentation of freshwater supplies for the city, none of these measures addresses the water insecurity in the peri-urban areas.
- Peri-urban communities are adapting to their water insecurity through collective action, water conservation practices, and changes in livelihoods and agricultural practices.

Stressors, Water Conflict and Contestation

- The nature and dynamics of water conflict in peri-urban Khulna depend on several bio-physical, social, economic and political factors. Water insecurity-induced conflicts are closely linked with urbanization, climate change, and regional and upstream interventions in the hydrological systems.
- Stressors such as wastewater pollution and solid waste disposal originate locally due to urbanization, while others such as salinity intrusion and reduced upstream freshwater flow are the results of climate change and/or interventions in the flow regime.
- Contestation for peri-urban resources is creating conflicts and undermining community resilience. This is evident from the consequences of urban land development activities, or urban elites taking control over peri-urban water resources.

4.2 Major findings from Gurgaon and Hyderabad, India

Gurgaon

Cooperation and 'forced cooperation' in the use of wastewater

Wastewater is an important aspect of rural-urban water flows. There is evidence of both cooperation, 'forced cooperation' and conflicts in its use, under multiple legal-institutional repertoires; both statutory and non-statutory forms of water allocation and distribution can be found (legal pluralism). Farmers access wastewater through pipe outlets, sanctioned by the state Irrigation Department. A wastewater 'right' is thus created with legitimacy in the state. However, once wastewater is used, it is distributed among irrigators based on bhaibandi (brotherhood; mutual cooperation). Members of a bhaibandi network cooperate in maintenance of the watercourses, on the basis of physical proximity to the fields.

- There is also 'forced cooperation' in the use of wastewater. On account of its high organic content, farmers prefer to use it for 2-3 years, after which they anticipate that the productivity of the land declines. Its use is associated with notions of impurity. Most farmers felt forced to use wastewater because of the loss of tube wells. Among the four villages where the scoping study was carried out, only one had widespread use of wastewater, mainly for topographical reasons (low elevation of fields).
- Wastewater is used mainly for the cultivation of paddy and wheat. The wastewater irrigated produce finds its way into the wholesale market. However, farmers who cultivate mainly for self-consumption tend to avoid using wastewater. There are also cases where farmers would ordinarily not use wastewater but are forced to do so; for instance, if their neighbours irrigate using wastewater, the wastewater may seep into their fields as well.

Conflicts around the use of wastewater

- Conflicts around wastewater tend to develop in a broader overall context of cooperation, such as when irrigating farmers forget to seal the outlet after irrigating their land with wastewater, causing the wastewater to spill over in other farmers' fields. These are usually not very violent or protracted conflicts, that can be solved relatively easily.
- Many farmers feel cheated by state policy regarding wastewater supply. They had expected to receive sewage water from Gurgaon. However, soon this was mixed with industrial waste from Manesar (though officers of the Irrigation Department deny this). Farmers whose fields are damaged by seepage

from the NCR channel regularly seek compensation from state authorities, a subject of some tension.

The impact of climate change

- Perceived changes in climatic patterns and climate variability add to a sense of water insecurity, as they may create uncertainty about the crop watering days. With the changes in climatic patterns experienced and interpreted as such by farmers, it is difficult to decide on the watering days. Sudden rises in temperature may induce farmers to immediately irrigate, while a reversal to cold temperatures in combination with water in the fields may severely damage crop and soil.
- State policies for crop failure or damage caused by changes in climatic factors actually deepen inequity and increase the vulnerability of tenants who lease or sharecrop land in particular. In a peri-urban context, tenancy arrangements are quite common, especially with the peri-urban elite, who often migrate to the city but maintain a hold on their land through tenancy arrangements. Sudden rainfall in February / March ('freak rainfall', often associated with climate change) damages the winter crops. The impacts are borne disproportionately by tenants. Landowners actually gain doubly: from the tenants who have already paid them, and from compensation for crop failure by the state. Thus, such policies exacerbate inequity between land-owners and sharecroppers.

New transactions along canals: conflict and cooperation

- The NCR and GWS channels have been built to carry water to treatment plants to meet the needs of the city; residents of the villages through which these canals pass are not allowed to use this water. However, peri-urban communities have devised their own ways to benefit from the water. Though, in principle, farmers are not allowed to use this water for irrigation, tubewells have been installed near the canals in order to benefit from the rise in the local water table. Water is then transported through underground pipes to far-off fields. Though farmers, in principle, allow these pipes to pass beneath their fields (bhaichaara), often there are conflicts around this, based on animosity.
- An important new practice is renting out these tubewells by other farmers, against payment for the diesel cost plus around Rs. 80 per hour of pumping. A common practice is also to buy a small plot of land adjacent to the canals that allows access to the sweet water. Based on bhaibandi or social relations, farmers may also install tubewells on the fields of their friends or relatives without having to buy those lands, when these fields are located over 'good quality water' or next to canals. This represents another form of cooperation around groundwater in peri-urban contexts. Increasingly, however, landowners along the NCR channel and the wastewater canal are reluctant to sell plots of land. These forms of cooperation, therefore, are in a state of flux and are weakening.

Hyderabad

Water-related contestation, conflict and cooperation

- Differential use, access and sharing of surface and groundwater water resources have resulted into contestations, potential conflicts and cooperation in peri-urban Hyderabad. Contested water use across different caste, class and occupational groups are more latent in nature in the case of irrigation. Such conflicts seldom take an aggressive turn, particularly if it is between upstream and downstream users of a check dam or between commercial and traditional farming groups. Many conflicts get resolved temporarily with the intervention of village doras (landlords), or forcefully suppressed by more powerful parties through compensation and informal agreement.
- Violent agitation and protest movements can be seen with potable and non-potable water use between peri-urban and urban areas, particularly across farmers, industries and local governments. Resolution of such disputes often involves statutory laws, punishments, and compensation by court. Cooperation, on the other hand, ranges from informal groupings of particular communities or households to secure their water needs, to more 'informed cooperation' in the form of formal petition,

consultation, dialogue and negotiation undertaken by NGOs and civil activist groups. However whether conflicts will remain as petty fights across different contending uses or will be transformed into 'informed cooperation' depends on power politics, caste and leadership.

Climate, urbanization and changing livelihoods

- The late onset of the monsoon and successive droughts for the last 20 years coupled up with rapid urbanization and industrialization from the 1990s has resulted in acute water scarcity for livelihood-related activities like agriculture, livestock, aquaculture, pottery, etc. Severe droughts have accelerated a job shift of the irrigation functionaries of dalit origin and other backward communities, following the rapid development of non-agricultural sectors. Two kinds of conflicts can be seen with regard to irrigation water use: first, between traditional paddy cultivators of tank irrigation system and borewells irrigators practicing water intensive commercial agriculture like floriculture and vegetable gardening; second, between farmers (Reddy and Velama community) essentially selling groundwater from their private borewell and farmers who does not have the access to groundwater as they do not have borewells.
- Traditional tank irrigation system started collapsing where in three to five out of every ten years tanks fail (with no water at all) and in two years tanks under-perform (with insufficient water for irrigating all the command area). Farmers in Anajpur village reported that Indirammasar cherevu, the most important source of water for the village reached its full tank level only in 2013, after nine years. Withering of such valuable surface water bodies has a direct bearing on the wet paddy irrigation system undertaken in the tank command area. Lack of water in the tank has resulted in reduction in the cropping season from three to one each year.

Water transfers, water quality and water allocation conflicts

- The expansion of water tanker markets is one of the critical means of rural-urban water transfer. Extensive mining of groundwater by big landowners in villages like Bowrampet has an adverse effect on the groundwater aquifer, affecting the life and livelihood of the majority of the villagers. Disputes and agitation often lead to contestations and conflicts between farmers selling water, who are often very few, and the rest of the villagers. Some households cope with the situation by depending on private water suppliers such as tankers. Those who are unable to cope with shortage dispute with the panchayat.
- Conflicts revolving around water quality are particularly observed in Chitkul and Edthnoor village, where industrialization from the 1980s has resulted in heavy pollution of both surface water and subsurface aquifers. Water quality conflicts are more complex, as several stakeholders like the community, industries and local government are involved in the process, and compensation is never enough to cover the loss of life and property. Two decades of consistent protest by the villagers have resulted in securing water for Chitkul amd Ethanoor. However, compensation paid to 14 villages affected by heavy industrial pollution of the Nakkabagu river didn't even cover seed costs for the farmers.
- Conflicts around drinking water scarcity in peri-urban areas are more prominent between communities and the local government, and reflect absence of clear-cut norms of equitable water allocation and distribution in these transitional areas. Allocation norms have evolved according to local situations, size and nature of projects and historical socio-political relations. Such dynamic and transitory areas that lack government recognition and effective institutional arrangements, particularly with regard to water supply, fall prey to misallocation. Peddapur provides a classic example of conflicts related to equity, access and allocations by the Water Board of Hyderabad (HMWSSB). The struggle has been going for ten years. With the present TRS government there is hope among the villagers that their long-standing contestations will turn into an agreement with the municipal

government.

- Cooperation at the micro level is seen in the form of collective sharing of tanker water by group of households in Bowrampet and building a checkdam at Chinnavagu rivulet in Anajpur. More formal cooperation in the form of petition, revolt and movement can be seen with the demand for Manjira water supply by the villagers of Peddapur and compensation for pollution of Nakkabagu river by Chitkul and Edthnoor.

4.3 Major findings from Kathmandu, Nepal

Wastewater use

- Wastewater irrigation, using either sewerage systems water or other heavily polluted sources (rivers; streams) has emerged and expanded in various areas. In Dadhikot, for instance, wastewater is used for the cultivation of paddy and commercial vegetable farming. Untreated waste and sewerage from dye and garment industries are spilling directly into the river, water from which is used for irrigation. Farmers from Dadhikot use wastewater / polluted sources because other surface water options for irrigation are lacking and roundwater from dug wells is not sufficient.
- There is a lack of water flow in the existing canal systems. Hence farmers see wastewater as an additional source, compared to farmers in the middle sections of the canal system. This access may be quite crucial as farmers have to irrigate during transplanting time, when the monsoon is delayed and alternatives are not available.

Unregulated extraction of sand and groundwater (in Jhaukhel): sand mining has detrimental effects on groundwater recharge and the groundwater level. It deteriorates the recharge zone (as sand acts as a sponge). However, both government bodies and operators ignore voices from the community who try to stop these practices, as sand mining also has benefits for those who leased out their land to sand miners or have related interests. Changing land characteristics from sloping to flat terrain adds value to the land; in some cases farmers could shift from maize to rice farming. People complain about the lack of monitoring of these practices by the responsible government authorities. In addition to this, excessive extraction of groundwater for commercial water vending (e.g. tanker operators and bottling companies) and brick kilns, causing rapid decline of the groundwater level, contributes to the drying-up of traditional water sources like kuwa and dug wells, often used by poor and marginal groups.

In Jhaukel mutually beneficial forms of cooperation have emerged between brick kiln operators and farmers: kiln operators provide free water (extracted groundwater) to farmers who lease out their land to kilns, ensuring timely transplanting of the paddy. Farmers can timely plant paddy and harvest, which also guarantees timely operation of the brick kiln. Kilns pay much money to landowners who lease their land. The majority of farmers produce rice and wheat in the area. They lease out their land during the dry season, when most of the farmer grows wheat. The amount that brick kiln operators pay to farmers is approximately 3-4 folds of what they earn from wheat farming, attracting farmers to lease out their land easily. Another practice here concerns cooperation between neighbours for groundwater extraction through renting out / charging pump operation for irrigation. The pump owner charges around NRP 250-300 per hour, for pumping, maintenance and fuel costs. Other forms of irrigation-based cooperation are found between head-enders and tail-enders, for instance in Mahadevkhola Raj Kulo (Dadhikot): during the irrigation period, farmers in Dadhikot acquire water from morning (5 am) until the evening (7 pm); afterwards the tail-enders receive water.

Syangtang and Uttisghari Drinking Water Supply Systems (DWSS) are examples of both forms of cooperation and competition. There is cooperation between the drinking water system operator and people in the source area (Syangtang DWSS). As part of the cooperation, Syangtang DWSS has given a job to a person from the water source area. Additionally, it provides the materials needed to repair the taps and its fittings required for the people in the source area. People in the water source area agreed with use of the water source in their area by the system. Growing competition, on the other hand, is occurring between Syangtang and another household-based water supply system: Uttisghari DWSS. The two systems exist in the same Village Development Committee (VDC) and currently want to expand their coverage within the VDC, thus becoming competitors.

Tank operators are major users of groundwater, using both shallow and deep tube-wells. They play a vital role in supplying the drinking water demand of Kathmandu valley. Such a water market has emerged due to the fact that Kathmandu Upatyaka Khanepani Limited (KUKL) is unable to meet the demand. It could only supply 25 percent of drinking water during the dry, and 41% during the rainy season (KUKL, 2012). According to a study by KUKL (2009), tankers supply 9% of the total demand of Kathmandu valley, which accounts for 39 percent of the supply by KUKL. This has also contributed to the boom of water tanker entrepreneurs in Kathmandu valley (i.e. from 42 in 2007 to 116 numbers in 2009). Sometimes this causes problems of water quality and related health problems (e.g. E Coli).

The inter-basin Melamchi water transfer project for drinking water is considered the most viable long-term alternative in order to ease the chronic water shortage situation in Kathmandu valley. It has been designed to divert 510 MLD of water in three phases (170 MLD in each phase), from three rivers in Sindhupalchowk District: Melamchi, Yangri and Larke. However, due to political instability, conflicts, contractors' performance, and corruption the project could not meet several deadlines. As of August 2015, more than 50 percent of the tunnel work still needs to be done.

References

Ahmed, B. 2011. 'Modelling spatio-temporal urban land cover growth dynamics using remote sensing and GIS techniques: A case study of Khulna City', Journal of Bangladesh Institute of Planners 4: 16-33.

Bartlett R. et al. 2010. Climate Change Impacts and Adaptation in Nepal. International Water Management Institute IWMI Working Paper 139, 35p. Colombo Sri Lanka. Available at: http://indiaenvironmentportal.org.in/files/Climate%20Change%20Impacts.pdf (Accessed: 17th November 2014).

Allen, A. 2003. 'Environmental planning and management of the peri-urban interface: Perspectives on an emerging Field. Environment & Urbanization 15 (1): 135–147.

Bhatta, G. D. and Doppler, W. 2011. 'Smallholder peri-urban organic farming in Nepal: A comparative analysis of farming systems.' Journal of Agriculture, Food Systems, and Community Development 1(3): 163–180.

Brook, R. ; Purushothoman, S. and Hunshal, C. (eds). 2003. Changing frontiers: The peri-urban Interface Hubli–Dharwad. India. Bangalore: Books for Change.

CBS. 2001. Statistical year book of Nepal. Central Bureau of Statistics, HMG, Nepal

CBS. 2012. National population and housing census 2011 (National Report) Government of Nepal, National Planning Commission Secretariat Central Bureau of Statistics Kathmandu, Nepal.

Chapagain, S.K. and Kazama, F. 2012. 'Overview of chemical quality of groundwater in the Kathmandu Valley.' In: S. Shrestha, D. Pradhananga and V.P. Pandey (eds) Kathmandu Valley Groundwater Outlook. Asian Institute of Technology (AIT), The Small Earth Nepal (SEN), Center of Research for Environment Energy and Water (CREEW), International Research Center for River Basin Environment—University of Yamanashi (ICRE-UY), Kathmandu, Nepal. pp. 49-55.

Dongol, R.; Kansakar, L.; K., Bajimaya, S.; Maharjan, S. and Shrestha, D. 2012. 'Overview of water markets in the Kathmandu valley.' In: Shrestha, S., Pradhananga, D., Pandey, V.P. (eds) Kathmandu Valley Groundwater Outlook. Asian Institute of Technology (AIT), The Small Earth Nepal (SEN), Center of Research for Environment Energy and Water (CREEW), International Research Center for River Basin Environment – University of Yamanashi (ICRE-UY), pp 100-111.

Hallegatte, S.; Green, C.; Nicholls, R. J. and Corfee-Morlot, J. 2013. 'Future flood losses in major coastal cities', Nature Climate Change 3: 802-806.

Hanson, S.; Nicholls, R.; Ranger, N.; Hallegatte, S.; Corfee-Morlot, J.; Herweijer, C. and Chateau, J. 2011. 'A global ranking of port cities with high exposure to climate extremes,' Climatic Change 104: 89-111.

Huq, S., Ali, S. I. and Rahman, A.A. 1994. 'Sea-level rise and Bangladesh: A preliminary analysis,' Journal of Coastal Research 14: 44-53.

ICIMOD. 2007. 'Kathmandu Valley Environment Outlook.' International Center for Integrated Mountain Development (ICIMOD), Kathmandu Nepal. ISBN: 978 92 9115 019 9.

Janakrajan, S.; Butterworth, J.; Moriarty, P. and Batcheloret, C. 2007. 'Strengthened city, marginalized periurban villages: Stakeholder dialogues for inclusive urbanization in Chennai, India', (available at http://www.bvsde.paho.org/bvsacd/cd67/Peri-urban/cap3.pdf).

JICA. 2012. 'Data collection survey on traffic improvement in Kathmandu valley; final report.' Japan International Cooperation Agency Nippon KOEI CO., LTD. Eight-Japan Engineering Consultants.

Joy, K.J.; Paranjape, S. and Bhagat, S. 2014. 'Conflicts around domestic water and sanitation in India: Cases, issues and prospects.' Forum for Policy Dialogue on Water Conflicts in India (SOPPECOM). Pune: SOPPECOM.

KUKL. 2014. 'Sixth anniversary report.' Kathmandu Upatyaka Khanepani Limited, Kathmandu, Nepal.

Levac, Danielle, Heather Colquhoun, and Kelly K. O'Brien. 2010. 'Scoping studies: advancing the methodology.' Implementation Science 5 (69): 1-9.

Moench, Y. 2001. 'Water dynamics in a three part system: investigation of municipal private and traditional public water supply systems in Kathmandu, Nepal.' Institute of Social and Environment Transition and Nepal Water Conservation Foundation.

Moench, M. and Janakarajan, S. 2006. Water markets, commodity chains and the value of water. Water Nepal, Nepal Water Conservation foundation, Kathmandu, Vol.12, No. 1, pp.81-114.

Murtaza, G. 2001. 'Environmental problems in Khulna City, Bangladesh: A spatio-household level study.' GBER 1 (2): 32-37.

Muzzini, E. and Aparicio, G. 2013. Urban growth and spatial transition in Nepal: An initial assessment. Washington, D.C.: The World Bank.

Narain, V. 2009. 'Growing city, shrinking hinterland: Land acquisition, transition and conflict in peri-urban Gurgaon, India,' Environment and Urbanization 21 (2): 501–512.

Narain, V. 2010. 'Peri-urban water security in a context of urbanization and climate change: A review of concepts and relationships.' Peri-Urban Water Security Discussion Paper Series, No. 1. Hyderabad: SaciWATERs.

Narain V. 2014. 'Whose land? Whose water? Water rights, equity and justice in a peri-urban context,' Local Environment 19 (9): 974–989,

Narain, V. and Nischal, S. 2007. 'The peri-urban Interface in Shahpur Khurd and Karnera, India.' Environment and Urbanization 19 (1), pp. 261-273.

Narain, V.; Shah Alam Khan, M.; Sada, R.; Singh, S. and Prakash, A. 2013. 'Urbanization, peri-urban water (in)security and human well-being: a perspective from four South Asian cities.' Water International 38 (7): 930-940.

NWO / DFID. 2012. Call for proposals. CoCooN – Conflict and Cooperation over Natural Resources in Developing Countries. 2012 2nd round – Call for full proposals. CCMCC - Conflict and Cooperation in the Management of Climate Change. The Hague: Netherlands Organisation for Scientific Research (NWO-WOTRO) / Department for International Development (DFID).

Pant, B. 2012. 'Issues of urban governance in Nepal: with special reference to Kathmandu metropolitan city.' Unpublished paper.

Pradhanang, S.M.; Shrestha, S.D. and Steenhuis, T.S. 2012. 'Comprehensive review of groundwater research in the Kathmandu valley, Nepal.' In: S. Shrestha, D. Pradhanang and V.P. Pandey (eds) Kathmandu Valley Groundwater Outlook. Asian Institute of Technology (AIT), The Small Earth Nepal (SEN), Center of Research for Environment Energy and Water (CREEW), International

Research Center for River Basin Environment—University of Yamanashi (ICRE-UY), Kathmandu, Nepal. pp.6-18.

Prakash, A. 2014. 'The peri-urban water security problem: A case study of Hyderabad in Southern India', Water Policy 16: 454–469.

Prakash, A.; Singh, S. and Brouwer, L. 2015. 'Water transfer from peri-urban to urban areas: Conflict over Water for Hyderabad City in South India. Environment and Urbanization ASIA 6 (1): 41-58.

Ramachandraiah, C.; Westen, A.C.M. and Prasad, S. (eds.). 2008. High-tech urban spaces: Asian and European perspectives. New Delhi: Manohar.

Roy, M.; Hulme, D. and Jahan, F. 2013. 'Contrasting adaptation responses by squatters and low-income tenants in Khulna, Bangladesh', Environment and Urbanization 25 (1): 157-176.

Rutkowski, T.; Raschid-Sally, L. and Buechler, S. 2007. 'Wastewater irrigation in the developing world – Two case studies from the Kathmandu Valley in Nepal.' Agricultural Water Management 88 (1): 83-91.

Sada, R. and Shrestha, A. 2013. 'Report on state of sand mining in peri-urban Kathmandu: Case of Jhaukhel VDC.' SaciWATERs.

Sada, R.; Shukla, A. and Shrestha, A. 2012. 'Adapting to peri-urban water Insecurity Induced by Urbanization and Climate Change, Kathmandu, Nepal', Peri Urban Water Security Discussion Paper Series, Paper No. 6, SaciWATERs.

Sada, R.; Shrestha, A.; Shukla, A. and Melsen, L. 2014. 'People's experience and facts of changing climate: impacts and responses.' International Journal of Climate Change Strategies and Management 6(1): 47-62.

Shrestha, A. 2012. http://periurbansouthasia.blogspot.com/2012/07/newspaper-article-published-in-national.html (accessed 30 July 2015).

Shrestha, A.; Karki, K.; Shukla, A. and Sada, R. 2013. 'Groundwater extraction: Implications on local water security of peri-urban Kathmandu, Nepal.' Peri Urban Water Security Discussion Paper Series,No7, SaciWATERs. http://saciwaters.org/periurban/discussion-paper-7.pdf

Shrestha, A.; Sada, R. and Melsen, L. 2014. 'Adapting to peri-urban water insecuity induced by urbanization and climate change.' Hydro Nepal: Journal of Water, Energy and Environment 14.

Shrestha, R.R. 2007. 'Eco home for sustainable water management. A case study in Kathmandu, Nepal.' Kathmandu: UNDP.

Shrestha, S.D. 2012. 'Geology and hydrogeology of groundwater aquifers in the Kathmandu Valley.' In: Shrestha S., Pradhananga D., Pandey V.P. (eds) Kathmandu Valley Groundwater Outlook. Asian Instiitute of Technology (AIT), The Small Earth Nepal (SEN), Center of Research for Environment Energy and Water (CREEW), International Research Center for River Basin Environment – University of Yamanashi (ICRE-UY), pp. 21-30.

Swyngedouw, E. 2010. 'Apocalypse forever?: Post-political populism and the spectre of climate change.' Theory, Culture & Society March/May 2010 27: 213-232,

Taylor, M. 2015. The political ecology of climate change adaptation. Livelihoods, agrarian change and the conflicts of development. London: Routledge – Earthscan.

Thapa R. B. and Murayama Y. 2009. Examining spatiotemporal urbanization patterns in Kathmandu Valley, Nepal: Remote sensing and spatial metrics approaches. Remote Sensing 1(3), 534-556.

UN-HABITAT. 2008. 'Water movements in Patan with reference to traditional stone spouts.' UN-HABITAT Water for Asian Cities Programme Nepal, Kathmandu. Pp 29-37

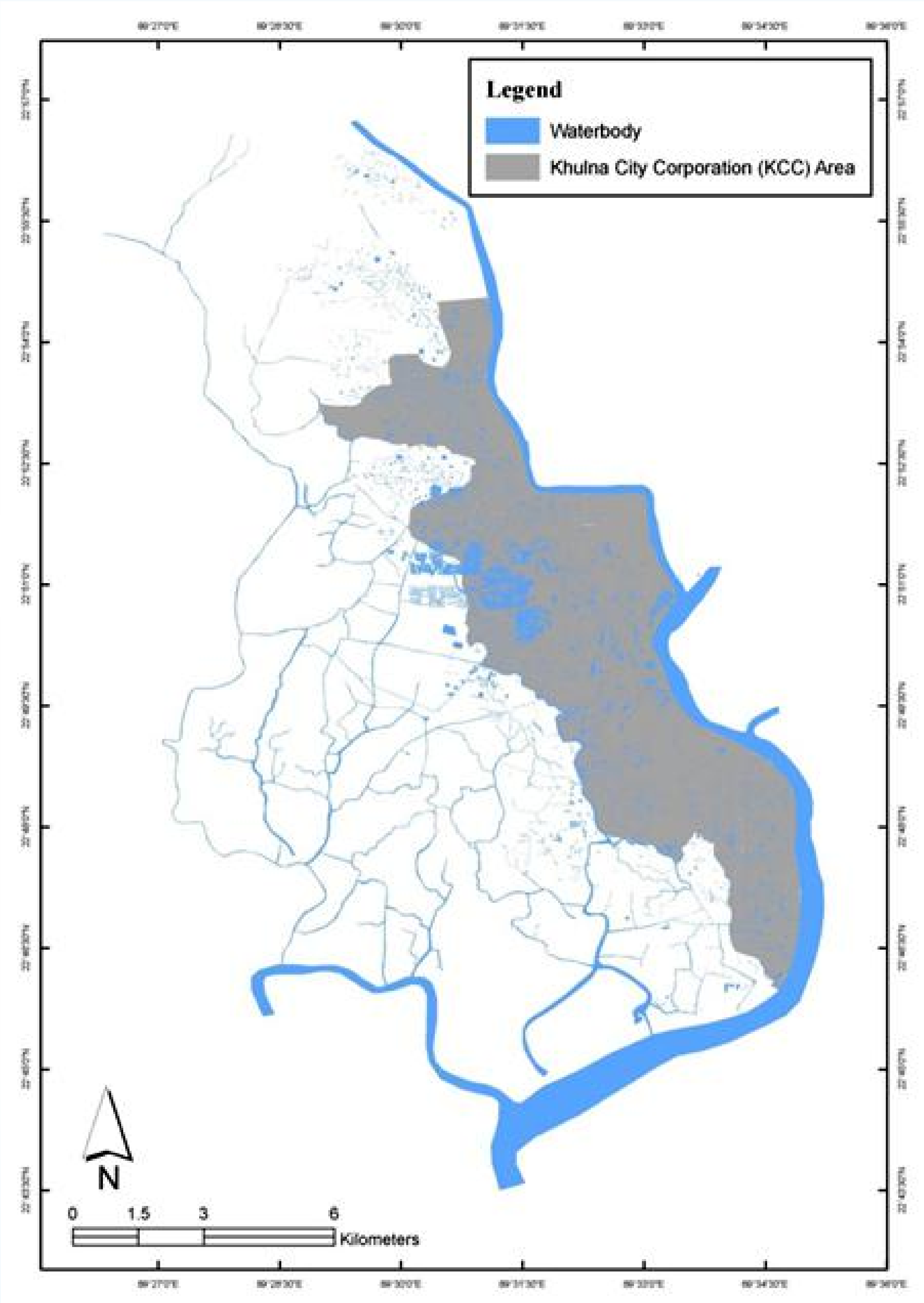
Veenhuizen, R. van and Danso, G. 2007. 'Profitability and sustainability of urban and peri-urban agriculture.' FAO Agricultural Management, Marketing and Finance Occasional Paper No 19. Rome: FAO.

Yoden, K. 2012. Analysis of domestic water use in the Kathmandu Valley. In: Shrestha, S.; Pradhananga, D. and Pandey, V.P. (eds) Kathmandu Valley Groundwater Outlook. Asian Instiitute of Technology (AIT), The Small Earth Nepal (SEN), Center of Research for Environment Energy and Water (CREEW), International Research Center for River Basin Environment – University of Yamanashi (ICRE-UY), pp. 77-89.

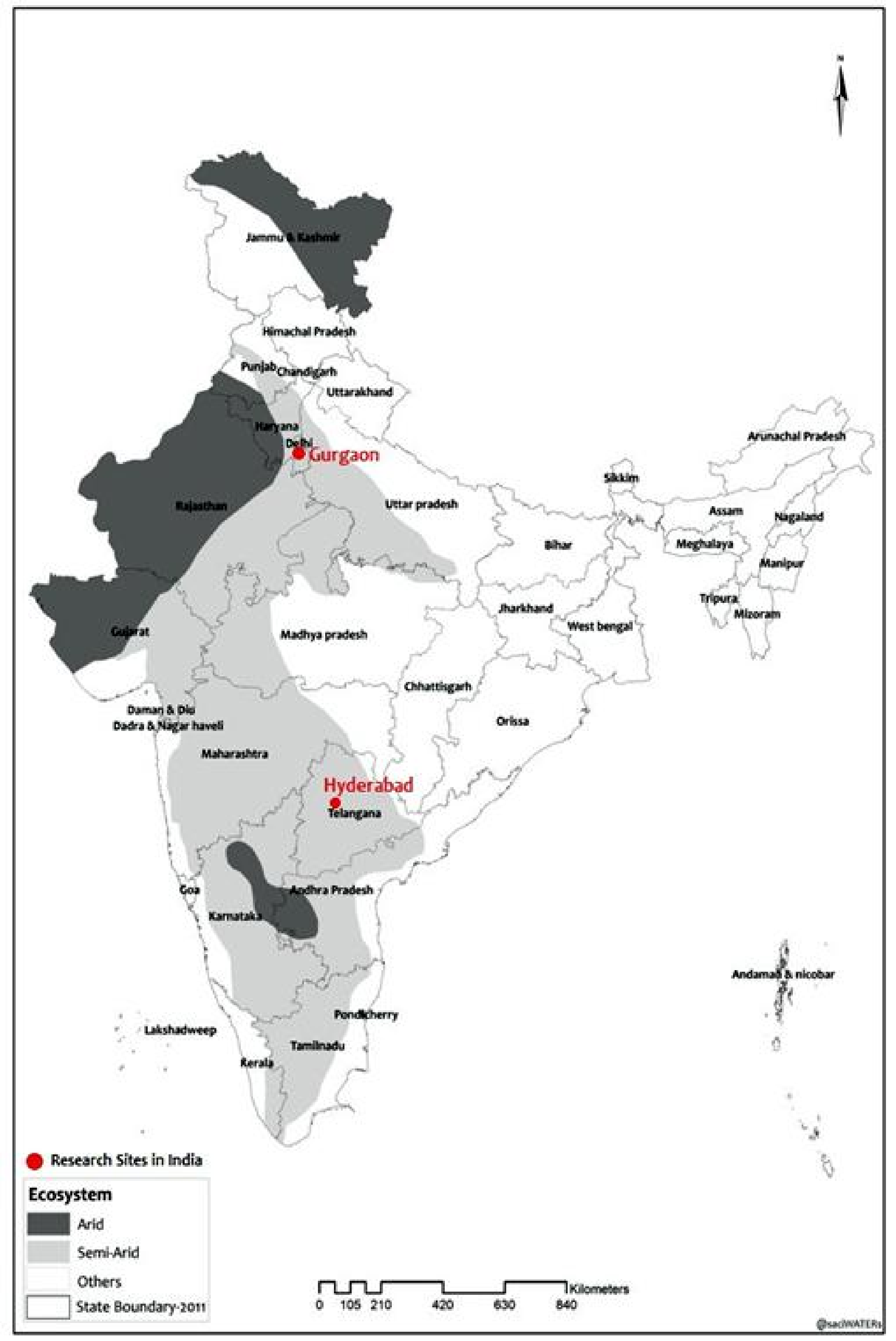
Annex: maps, tables and figures

Maps

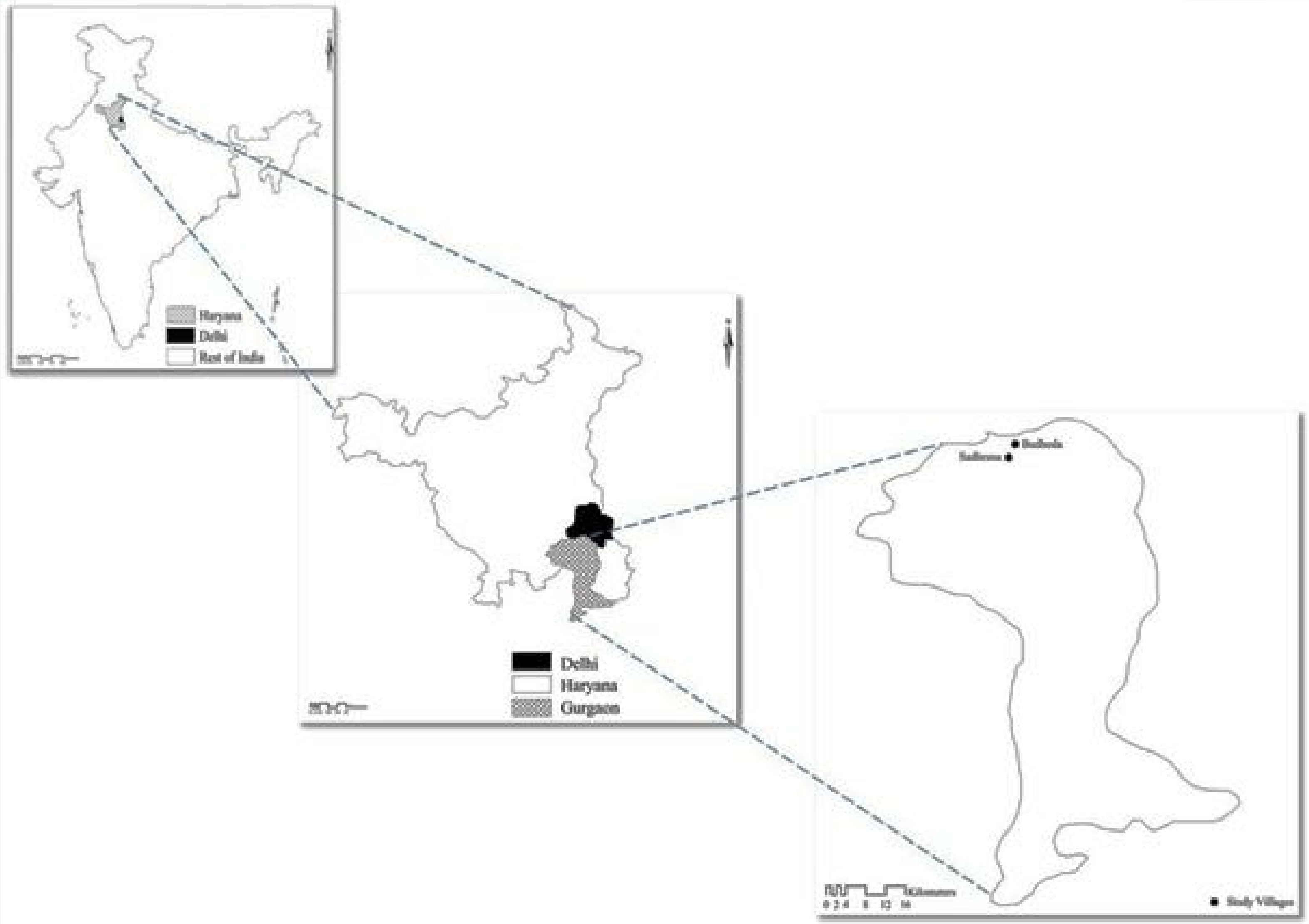
Map 1: Khulna and its peri-urban areas (Bangladesh)



Map 2: Location of the peri-urban sites in India

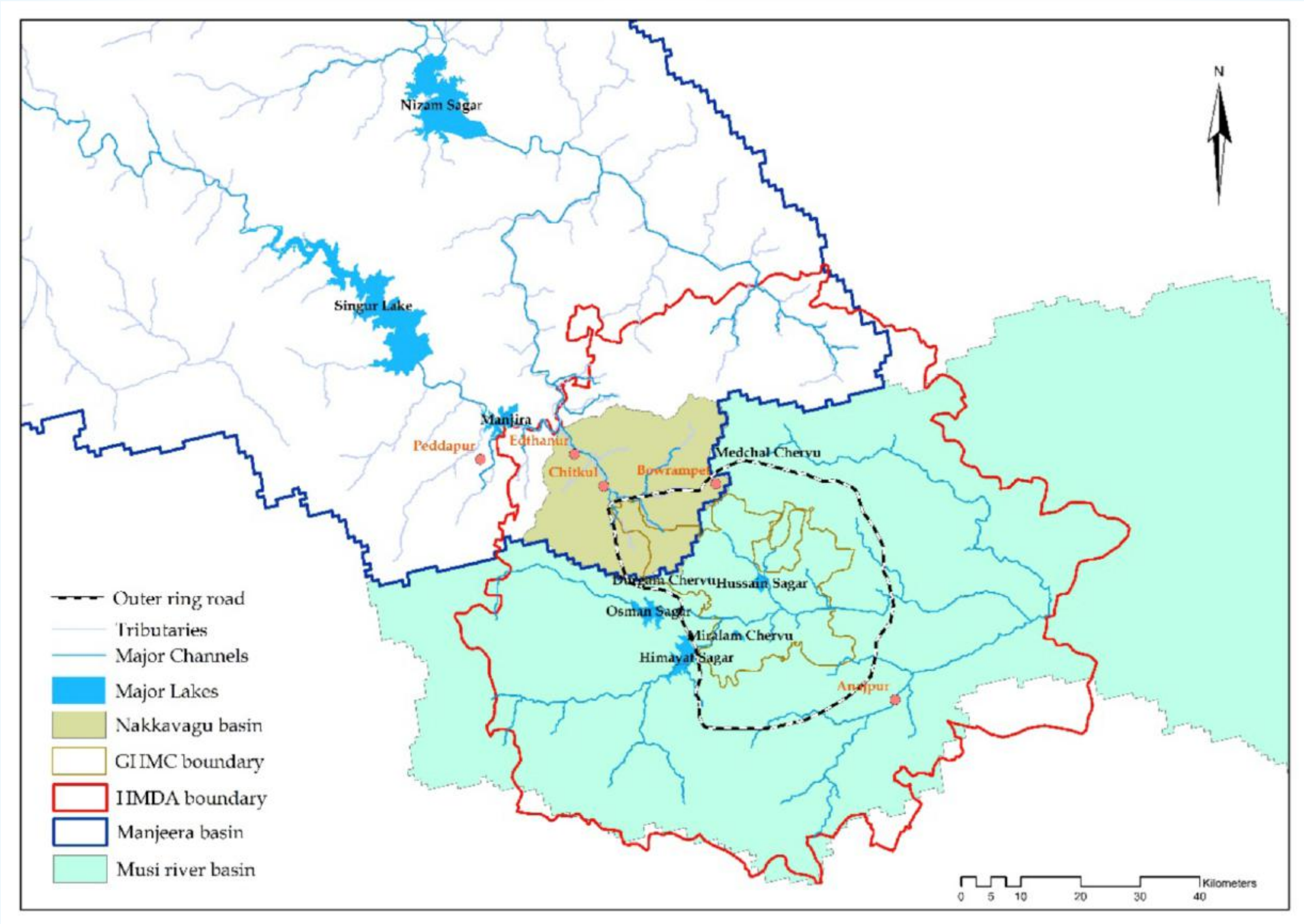


Map 3: Gurgaon and its peri-urban areas (India)

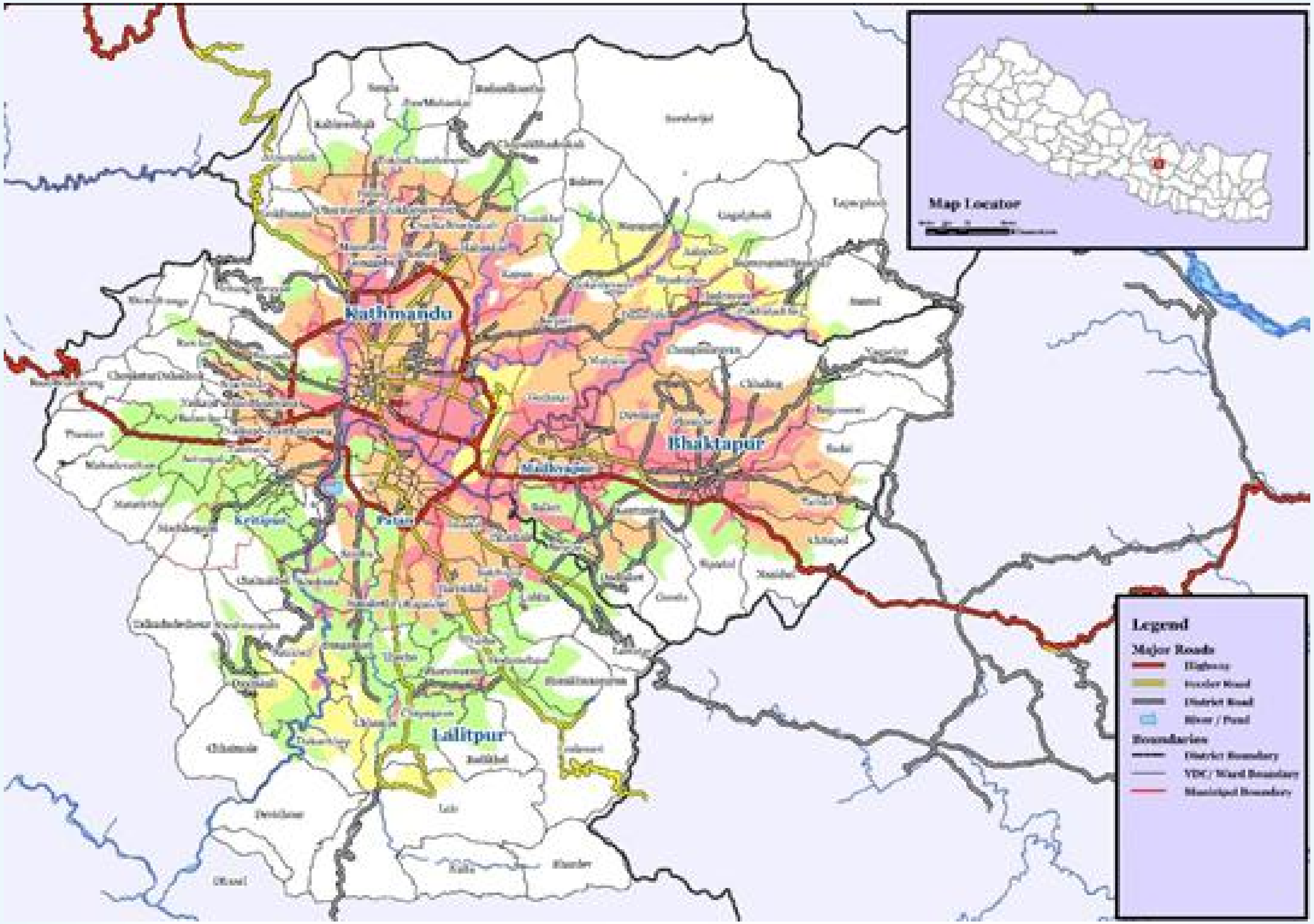


Map 4: Hyderabad and its peri-urban areas (India)

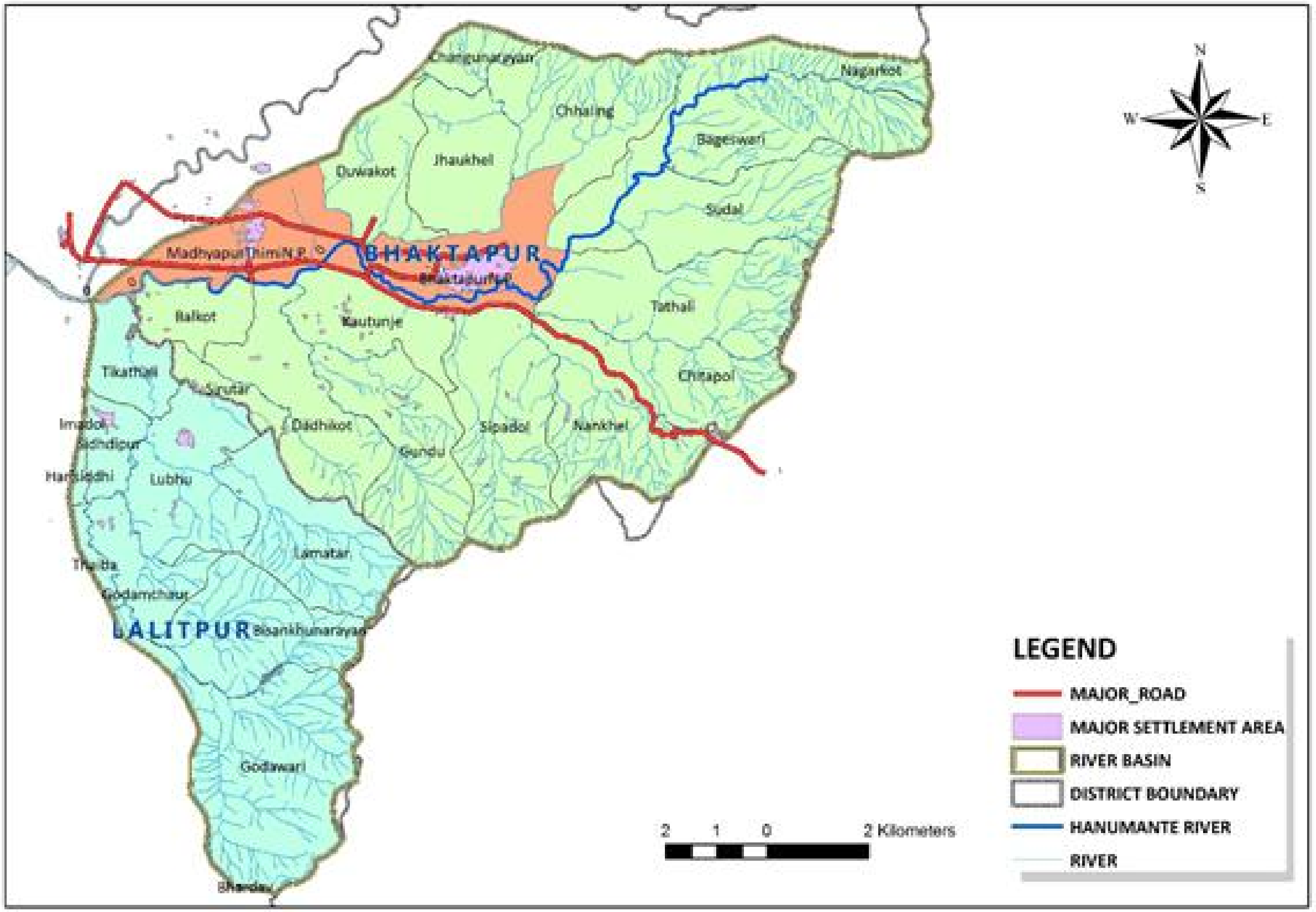
Map 5: Location of case study villages Hyderabad



Map 6: Kathmandu and its peri-urban areas (Nepal)



Map 7: Hanumante river basin



Tables

Table 1: Preliminary selection of study sites in Bangladesh

Site		Major Issues	
1	Alutala	-	Waste dumping, Fishermen-Farmer conflicts
2	Putimari	-	Waste dumping, Fishermen-Farmer conflicts
3	Tetultala	-	Farmer-Fisherman conflicts
4	Shantinagar	-	Women's burden for collecting water
5	Harintana	-	Scarcity of water for agriculture
6	Chanmari	-	Water logging
7	South Labonchara	-	Salinity in tube-well water
8	Sacibunia	-	Poor water related services by authorities
9	Greenland Abashon Area	-	Water related cooperation
10	Bastuhara Slum	-	Water scarcity
11	Khalishpur Railway Slum	-	Water scarcity
12	Natunbazar Slum	-	Water scarcity
13	Bagmara Khalpar Area	-	Water logging in rainy season
14	Rayermahal	-	Sluice gate operation
15	Rupsha	-	Water vendor/Water business
16	Mashiali	-	Pipe irrigation system

Table 3: Selection criteria for geographic study sites, Nepal

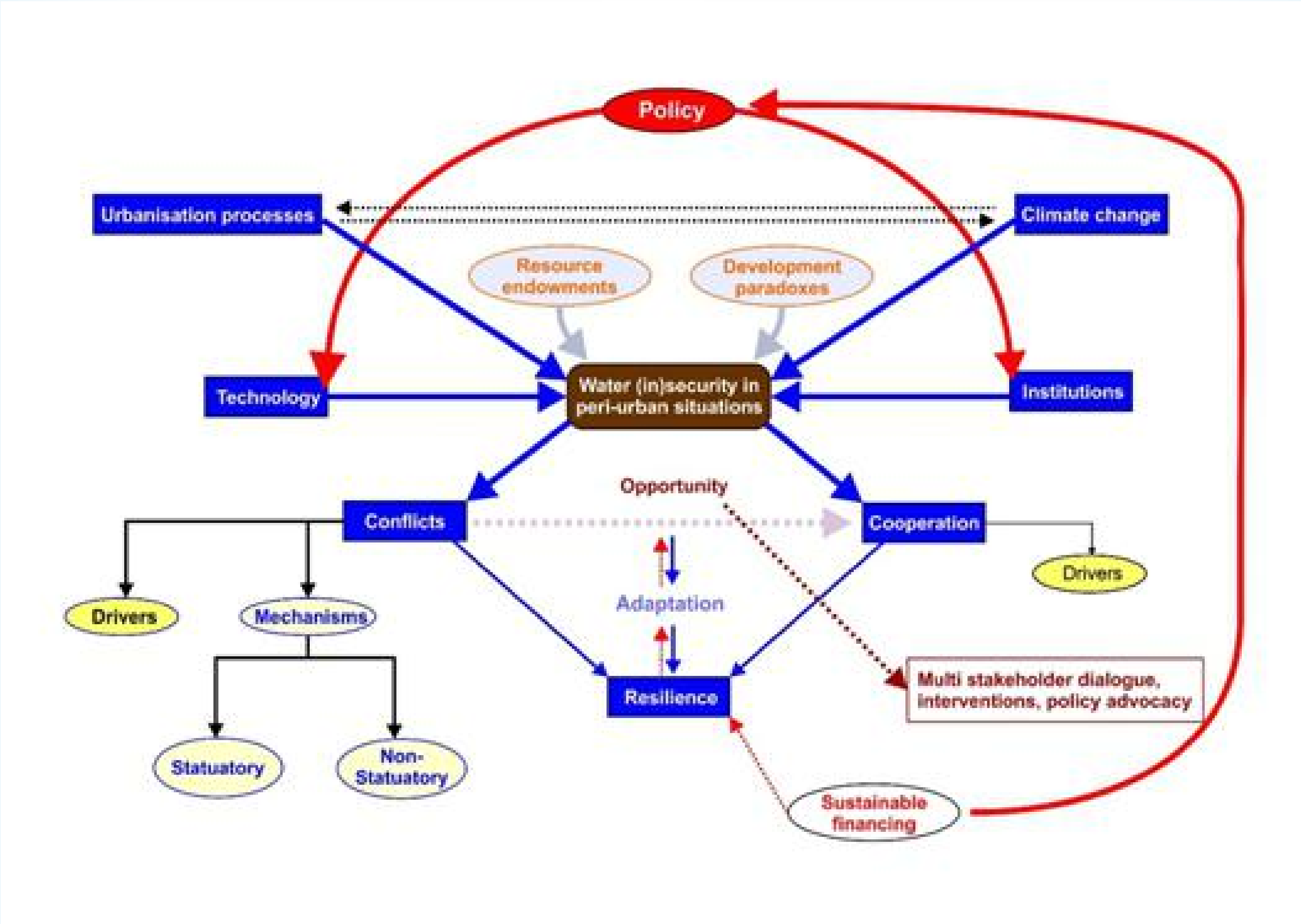
Criteria -> Area	Degree of heterogeneity in land use/land cover	Elements present for conflict/ cooperation	Degree of multiple (competing) claims	Degree of urban-peri-urban hydrological linkages	Degree of vulnerability to water stress (or perceived)	Climate change vulnerability ranking
Jaukhel	Very High (5)	High (4)	Very High (5)	Very High (5)	Very High (5)	Medium (3)
Dadhikot	High (4)	Medium (3)	Medium (3)	Low (2)	High (4)	Medium (3)
Sudal	Medium (3)*	Low (2)	Low (2)	Very Low (1)	High (4)	Low (2)
Siddhipur	Medium (3)	Low (2)	Low (2)	Very Low (1)	Low (2)	Low (2)
Godavari	Medium (3)	Low (2)	High (4)	Medium (3)	Low (2)	Low (2)

*Though in parts of the year agriculture products are cultivated, most of the land is covered by brick kilns

Table 2: Sites selected by stakeholders in Bangladesh

Site		Issues
1	Alutala	- Administrative conflicts (sluice gate operation) - Fishermen-farmer water distribution conflicts - Upstream-downstream conflicts - New migrated urban area - Land graber-fisherman conflicts - Sweet water-saline water conflict - Community participation is present
2	Harintana	- Fishermen-farmer water distribution conflicts - Upstream-downstream conflicts - Water logging due to unplanned settlements. - Scarcity of irrigation water and low agricultural production - Decrease of cultivable land due to rapid urbanization - Lowering of water table - Decrease in soil nutrient
3	Labonchara	- Water logging - Drinking water scarcity - Water pollution - Salinity in surface and ground water - KWASA is constructing a reservoir is south Labonchara
4	Bastuhara Slum	- Drinking water problem - Wastewater problems
5	Khalishpur Railway Slum	- Water scarcity - Over-extraction of ground water by water vendor and industries - Lowering of water table in dry season
6	Gollamari	- Drainage Outlet of KCC - Solid waste dumping from slaughter house - Dumping of clinical wastes
7	Rayermahal	- Water logging - Scarcity of irrigational water - Salinity in ground water - Poor service of water distribution authority
8	Sachibunia	- River grabbing (Mayur, Kajibacha, Hatia) - River drying - Water logging - Surface water pollution
9	Fultala	- KCC-local people conflict for ground water extraction - Lowering of ground water level - Irrigational water problem
10	Maheswarpasha	- Scarce ground water - KCC is planning to treat surface water in supplying water for communities.

Figure 1: Initial Theory of Change for the project



Climate policy, conflicts and cooperation in peri-urban south Asia: Towards resilient and water secure communities

The research project aims to improve mutual learning, strengthen institutional & community capacities to optimally manage water insecurity, and bolster resilience in periurban south Asia. It endeavors to support and empower communities to effectively use, manage and govern their water resources against a backdrop of water insecurity caused by climate change and urbanization. A consortium of north-south institutions brings together experience, skills and know-how in research, capacity-building and knowledge generation. This four-year collaborative endeavor will cover four cities:

- Khulna, Bangladesh
- Kathmandu, Nepal
- Gurgaon and Hyderabad, India

Partners

WAGENINGEN UR
For quality of life

Wageningen University (WUR), The Netherlands

SaciWATERs

South Asian Consortium for Interdisciplinary Water Resources Studies, India

ICIMOD

International Centre for Integrated Mountain Development, Nepal

Bangladesh University of Engineering & Technology (BUET), Bangladesh

JJS Jagrata Juba Shangha

Jagrata Juba Shangha, Bangladesh

META META

MetaMeta, The Netherlands