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CLIMATE CHANGE ADAPTATION IN URBAN INDIA: THE INCLUSIVE FORMULATION OF LOCAL ADAPTATION STRATEGIES

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ABSTRACT

In Kota, the third largest city of Rajasthan, poverty levels are high in many areas and there is a great need to assess the vulnerability and adaptive capacity of different societal groups and sectors to the impacts of climatic variability and change, and to formulate sustainable planning strategies. The city is a large rapidly growing centre (but not a megacity), facing a varied and challenging water situation and anticipated harmful effects of climate change. The methodological approach involves participatory workshops with key stakeholders in urban administration to identify vulnerabilities, and discuss concrete strategies for increasing the adaptive capacity of the most vulnerable areas and sectors. The paper focuses on water resource planning (storm, potable, and wastewater), since it is already a challenging societal issue and one which will become even more critical in the future with climate change. We aim to contribute to improved urban water management for sustainable climate change adaptation in developing countries through an improved methodology of vulnerability assessments, capacity building and social learning, and a deeper empirical understanding of an urban context in Central India.

Keywords: climate change adaptation, urban planning, participatory assessment, India, slum populations, wastewater drainage, heat wave, flash flood, solid waste management

1. Introduction

The effects of climate change will be intensely felt by both rural and urban communities throughout India. Although the vulnerability of rural populations is important due to their sensitivity to any changes in precipitation patterns or temperature changes (Panda, 2009), urban populations must not be ignored (Panda, 2011). In general, the poor are particularly vulnerable to the effects of climate change (Somathan and Somanathan, 2009; Sett and Sahu, 2014). In urban areas, the risk of flooding, heat-trapping, water shortages and air quality deterioration is expected to increase (Revi, 2008). Climate change is an important stressor in relation to water management, so urban administrators and inhabitants need to consider it in decision-making and planning processes. Urban water management is closely related to human health, and therefore, important in urban planning (Bates *et al.*, 2008). Indian cities are already struggling with

limited access to water, sewage systems, drainage and solid waste management facilities, and the situation will be even worse by 2060 when approximately 500 million additional people will be residing in 7,000-12,000 urban centers (Sharma and Tomar, 2010). A large proportion of the Indian urban population lives in slums, in hazardous places and in very poor housing; hence this poor group is vulnerable to the health and environmental risks posed by climate change. Thus, specific actions are and will increasingly be needed to reduce the vulnerability of poor groups and give them further an opportunity for inclusion in the national economic development (Dubash *et al.*, 2013); more attention should be specifically given to slum areas when addressing climate change in urban development (DoE, 2010).

Cities, however, are also uniquely equipped to deal with pressing challenges. As centers of cultural, political, and economic leadership, cities can proactively deal with climate change by implementing mitigation and adaptation measures to reduce vulnerability and contribute to sustainable development. Empowerment and capacity-building, especially of the most vulnerable groups are, however, vital if such goals are to be realised. Hitherto, most studies in India have focused on mega-cities, such as Delhi, Mumbai, Kolkata and Chennai (Butterworth *et al.*, 2007; WWF, 2009; Panda, 2011). Less attention has been given to medium-sized cities, of which some play an important role as so called counter-magnets to the mega-cities. Kota is the third largest city in Rajasthan, and a declared counter-magnet city to Delhi[1]. The city is a rapidly growing urban center and it faces a varied and challenging water situation and anticipated harmful effects of climate change. As in many other cities, there is a great need to assess the vulnerability and adaptive capacity of different societal groups and sectors to the impacts of climatic change and to formulate sustainable strategies for the future.

This paper uses a methodological approach for inclusive vulnerability assessment and formulation of adaptation strategies at the local level, which involves participatory workshops with key stakeholders in urban administration (Wilk *et al.*, 2013). During the workshops, exercises are carried out to identify various aspects of vulnerability and discuss concrete strategies for reducing exposure and sensitivity, and increasing the adaptive capacity of the most vulnerable areas and sectors. The paper presents the methodological approach and results from the Kota case focusing on water resource planning (storm, potable, and wastewater). The aim is to contribute to improved urban water management for sustainable climate change adaptation in South Asia through a deeper empirical understanding of an urban context in Central India. Section 2 introduces the study area, whereas the methodology is presented in Section 3. Section 4 presents the results from the two workshops, followed by Discussion in Section 5. Finally, Section 6 states the Conclusions.

2. Study area: The Kota case

In semi-arid Rajasthan, climate change has resulted in an average rise in temperature of 0.60 °C over the last 100 years (GoI, 2006) and the state experiences intensified rains during the summer monsoon, recurring droughts and extreme temperatures. The projected climate change scenario by the United Nations Framework Convention on Climate Change (UNFCCC) for the period of 2041-2060, indicates that the major rivers in Rajasthan (Kutch, Saurastra and Luni), which account for almost 60% of the total water in the entire state, will experience acute water shortages (GoR, 2012). The gradual increase in temperature due to climate change is also a major contributor to water shortages due to also increased evapotranspiration (DoE, 2010). The average increase in temperature in Rajasthan is projected to be between 1.8 and 2.1 °C for the 2041-2060 period, with the highest increases in the south-east (GoR, 2011).

Kota has experienced an urbanisation growth rate of 30% during recent decades (GoI, 2006:17). Kota's climate ranges from semi-arid to arid and is characterised by low precipitation and high temperatures (mean annual precipitation 660 mm; average daily (24h) temperature per month ranging from 17-36 °C). The region also hosts a variety of industries, which results in economic growth, but also environmental impacts such as water pollution (GoI, 2006:277). As in most other industrial centres in India, this

[1] Alternative centres of growth to discourage migration to the national capital, decided by the National Capital Region Planning Board of India. See more in Times of India (2013).

development affects vulnerability both positively, by increasing adaptive capacity through wealth creation, but also negatively, by double exposure to climate change and water pollution. Increased population and rapid urbanisation and industrialisation have contributed to water shortages.

Figure 1. The city of Kota, Rajasthan, India

Kota city mainly depends on the Chambal River for its water supply. While the river is not one of the most polluted in Rajasthan, industrial and sewage water effluent is significant in Kota city (GoR, 2011; DoE, 2010; RPCB, 2007). There are two sewage treatment plants in operation, but additional effort is required to keep the water clean (Gupta *et al.*, 2011). According to Gangawala (2011), some of Kota city's water reservoirs and *nallahs* (streamlets) are becoming increasingly polluted, in particular certain slums and newly developed settlements without proper sewage and sanitation facilities. Along with these settlements, some small-scale industries have been established and contaminants from these sources directly pollute the Chambal River draining through the *nallahs*. In 2011, around 37% of the entire city's population lived in areas categorised as slums, and the annual growth rate of the slum population is more than 11% (Urban Improvement Trust 2011). About 80% of this slum population lives in small to large clusters on the bank of various water reservoirs, *nallahs* and the Chambal. In early 2000s, around 70% of people in the slums of Kota city were without access to safe sanitation and left with no other option than open defecation (ADB, 2007). Thus, the situation in Kota resembles that of many other medium-sized cities throughout Rajasthan and India, possibly with the exception of Kota's abundant water supply from the perennial Chambal coupled with extreme temperatures above 48 °C during heat wave events.

3. Methods: Participatory assessment of vulnerability and formulation of adaptation plans

Vulnerability assessments are currently being carried out in many areas of the world to assess the exposure and sensitivity of different areas, sectors and societal groups to the effects of climate change, as well as the adaptive capacity to deal with the potential impacts (Füssel and Klein, 2006). Double exposure, or multiple stressors, is a concept devised to include changes other than climatic, e.g., economic globalisation in the assessment of vulnerability at the regional and local scale (O'Brien *et al.*, 2009). The IPPC has called for participatory vulnerability assessments based on the premise that stakeholders at the scale in focus know and can map their current state of affairs in respect to major challenges, and that concrete action plans, based on strengthening and utilising their adaptive capacity, should be promoted (Füssel and Klein, 2006). Only through participation with stakeholders at the relevant scale can complex relationships, lack of synchronisation between actors, policies, planning and implementation, and cultural

and local traditions be identified. These circumstances may hinder good responsive management and need to be understood and addressed (André, 2013; Pahl-Wostl, 2009).

Although vulnerability to climate change in India is currently being addressed at different scales and locations, studies at the local level are limited; hence only little information on different groups of people among the poor and their needs is available (Panda, 2009). There is also little concrete data to guide actions in ways that address root problems (Hardoy and Pandiella, 2009). Moreover, experience from several participatory research processes emphasises the importance of a structured but flexible process design containing intermediary objects for successful implementation (Alkan-Olsson *et al.*, 2011; Andersson *et al.*, 2010; Jonsson and Wilk, 2014; Steyart *et al.*, 2007).

Stakeholder dialogue is a much applied method to: a) generate scientifically valid empirical material; and b) increase knowledge, perspectiveness and capacity of the involved stakeholders (Janakarayan *et al.*, 2007; Jonsson *et al.*, 2005). Success in participatory processes is very much linked to an open and democratic process including mutual respect and willingness to communicate with and learn from one another in order to address and solve real problems (e.g., Butterworth, 2007). In many instances, the major problem is not the lack of knowledge of how to adapt, but rather the lack of ability to access and mobilise resources and knowledge shared between stakeholder groups (Andersson *et al.*, 2009). Socio-economic issues must be probed so that the experiences of both middle income and low income residents are better understood. These experiences may involve both common and varying issues such as the different infrastructural contexts and formal and informal water access.

The current stakeholder dialogue is based on the progressive development of a guide for participatory vulnerability assessments (Wilk *et al.*, 2013). The guide provides fifteen participatory exercises to facilitate a structured analysis of vulnerability and adaptation for the particular object of study. The exercises cover future societal scenarios, climatic stressor mapping, sensitivity analysis, identification of key actors and barriers to adaptation. The guide was developed through interaction with local and regional stakeholders around the Baltic Sea (www.balticclimate.org) and in South Africa, and applied in Kota during the finalisation stage. A smaller number of exercises were selected and adjusted to fit the specific context of Kota's urban water management and climate adaptation. Representatives from different governmental and non-governmental organisations, education and research institutes participated in two workshops and progressed through the vulnerability assessments according to the guide. The issues covered by the workshops held so far include:

- Workshop 1: Challenges and Chances

- Workshop 2: Handling climate impacts and identifying vulnerable groups

The final assessment Workshop, which is still to be carried out, will guide the group in initiating a concrete action plan to outline the prioritised steps, and how different actors can move forward to address the challenges ahead. The situation in slums has been targeted in a literature review and will be further addressed in forthcoming field research. In addition, 25 semi-structured interviews were held with representatives from the local government in health, housing and water supply, informal water committees and community representatives from low and high income areas in order to: a) discuss water-related challenges within each city, and b) assess the willingness of the interviewees to participate in the vulnerability assessments. Between workshops, literature searches were conducted to find additional information on the magnitude and side-effects of these challenges. The workshops were also complemented by data from a detailed slum survey carried out in December 2010 by Rajiv Awas Yojana (under the Ministry of Housing & Urban Poverty Alleviation, India) aiming to investigate particular challenges affecting slum areas.

4. Results

4.1. Workshop 1: Challenges and chances in Kota City

During the first workshop with representatives from different governmental departments, participants carried out two exercises from the guide designed to identify the major challenges that Kota is experiencing in relation to climate change. The opportunities were identified on a general level, including political and public will, the role of Kota as a counter-magnet to New Delhi, strengthened public transportation, and more conscious urban planning and resource allocation. Over fifteen specific challenges were identified that could be related to five major themes (see major and specific challenges in Table 1).

Table 1. Identified challenges in Kota.

Major challenges	Specific challenges
groundwater	depletion, distribution system, groundwater harvesting
uncontrolled urbanisation	increasing slums, open defecation, vehicle pollution
deforestation	conversion of forests and agricultural land into urban use, decreased rainfall
water quality	sewage treatment, drinking water pollution
management and implementation issues	Problem of implementation, integrated approach and involvement of community
other	vector borne diseases, solid waste management, heat islands

The challenges were then ranked according to importance and urgency. The group ranked groundwater depletion as the most important and likely to deteriorate in the near future. The second most significant challenges were sewage management and deforestation. However, sewage management is currently being improved assuming that it will be under control for the next 10 years. In addition, it was assumed that deforestation, as well as unplanned urbanisation and the conversion of agricultural land to urban areas will increase in the future. Concern was also raised about open defecation, solid waste management and, more generally, pollution. To a lesser extent, heat wave effects and hot water from thermal power plants were regarded as problematic.

The average groundwater level depletion in Rajasthan varied from 0.18 m to 10.3 m during the years 1984-2003, and in the case of Kota, it was 6.39 m during this period (Narain *et al.*, 2005). In particular, during the dry season, groundwater is used both in the agricultural and industrial sectors, causing rapid water level depletion. Within the city limits, groundwater is also used as a source of household water, as many households remain without connection to a piped water supply. Kota belongs to the moderate category in the classification of districts for groundwater depletion in Rajasthan, indicating that the groundwater level is being depleted by 0.10-0.20 meters annually (SPRI, 2004). The unauthorised installation of wells, without reference to groundwater recharge, is a key explanation for the rapid depletion of the water supply in Kota city. In the years 1999-2000, the density of wells in Kota was 3,530 per 1,000 km^2; whereas it was 2,717 per 1,000 km^2 in the years 1981-82 (Rathore, 2005). The city has available space for groundwater recharge, but this is not straightforward because of its hard rock geological formation; artificial recharge would require huge investments and effort. The impact of climate change on water level depletion has been added to the excessive use of groundwater in this city. The trend of decreasing annual rainfall on fewer rainy days will directly impact groundwater, changing its volume and recharge. As groundwater is a major water resource for this industrial city, it should receive more attention in order to ensure the continued economic development of the city.

Due to changes in climate and rapid urbanisation processes, the effects of increasing temperatures and heat waves are already posing health challenges in many South-Asian cities (Hajat *et al.*, 2010). During 1978-1999, Rajasthan experienced the highest loss of human life due to heat waves, followed by Uttar Pradesh, Bihar and Orissa (Singh *et al.*, 2010). The present mortality rate, i.e. due to heart diseases, in

Rajasthan is expected to increase due to an increase in the frequency and intensity of extreme temperatures and heat waves (DoE, 2010; Gov. of Rajasthan, 2011). Moreover, loss of productivity and health effects, such as those previously mentioned, in the manual brick-making sector, which employees millions of workers all over India, will increase with climate change (Sett and Sahu, 2014).

Of the challenges identified during Workshop 1, three were directly related to climate change: groundwater depletion, pollution and heat wave effects. Groundwater depletion and heat wave effects were, therefore, selected in the second workshop for the exercise to formulate adaptation measures. The workshop ended with a brief discussion to identify potential stakeholders who should be involved in future development planning and a discussion on ongoing development projects and the need to modify available policies and planning.

4.2. Workshop 2: Handling climate impacts and identifying vulnerable groups

In the second workshop, participants carried out an exercise to identify and discuss measures that may help to mitigate the adverse effects of climate change. This was conducted with reference to the most significant challenges identified during the first workshop: groundwater depletion and heat wave effects. For each challenge, ongoing and suggested future activities were listed (Table 2).

For most of the suggestions related to water management, formal schemes and programs are already in place. These include schemes in the State Water Policy (GoR, 2010), projects to enhance water harvesting structures, various initiatives by the Ground Water Department, the Rajasthan Water Sector Restructuring Project, the Jal Chetana Abhiyaan and the Water Resource Vision 2045 (GoR, 2011). The participants also commented on this fact, but pointed to poor implementation as factor which is preventing these projects from reaching their potential.

Furthermore, participants in the second workshop were asked to identify current and future measures to counteract problems related to heat waves (Table 3). Fewer alternatives were mentioned in comparison to the issue of groundwater, and those that were, to a large extent, concerned the strengthening of current measures.

Table 2. Challenge: Groundwater depletion.

Ongoing measures	**Additional measures needed in the future in the light of climate change impacts**
Conservation of surface water through ponds and check dams Conducting repairs to old water tanks and removing accumulation of silt Rainwater conservation/harvesting	Encourage traditional methods of water storage, e.g., small underground storage ponds (*tanka*, *khadin*) Increase the number of local groundwater recharge projects
Ensure non-hard surfaces when extending city Increasing size of plantations/forests/urban green areas (increasing percolation)	Introduce by-laws for compulsory recharge arrangements on every rooftop
Avoiding water guzzling crops like paddy and sugarcane Stop the misuse of water	Initiate serious discussion on surface water and dam capacity
Sewage treatment and management Managing groundwater quality Establishing soakage pits (collection of sewage)	Expand the use of sewage collection, e.g. through soakage pits
Managing the drilling of bore wells Regulate groundwater use Abolishing free or subsidised electricity to farmers	Make a sustainable policy for the digging of bore/tube wells Establish a framework to regulate the drilling of boreholes Introduce volumetric charging on tube well pumps Remove subsidies on electricity

Apart from projects within the water sector that also have a positive bearing on heat issues, a few schemes have the potential to make a positive contribution to the reduction of impacts and adaptation to high temperatures and urban heat islands, i.e. the Integrated Housing and Slum Development Programme and local Disaster Management Plans (GoR, 2011). Workshop participants and interviewees highlighted that these two schemes were having a more significant effect on local urban management than most other schemes. The Rajasthan Climate Action Plan (GoR, 2011) does not mention any of the greening policies except under the forestry sectors, although several schemes were in place including planting and greenbelt policies of UIT and the free distribution of seedlings by the Forestry Department. Again, the issue of implementation gaps was raised.

Table 3. Challenge: Heat waves.

Ongoing measures	**Additional measures needed in the future in the light of climate change impacts**
Developing urban green zones (in reality the trend is the opposite) Developing shelter belts/tree plantations	Further develop green areas – mixed green and urban; also greening corridor in city to stop heat from certain directions Plant heat tolerant plants/trees that can absorb heat from the air Encourage roof-top horticulture Reduce the concretisation of the city
Encouraging surface water percolation into groundwater to cool the environment	*(no additional measures suggested)*
Establishing shelters/homes for displaced or migrant people	Increase and improve the temporary shelters/homes for displaced/migrant/homeless people (also good for cold waves)

4.3. Vulnerable groups and slum areas

All urban populations are not equally vulnerable to the impacts of climate change (Revi, 2008; Panda, 2011). In the second workshop, participants carried out an exercise to identify the most vulnerable groups and the reasons for their vulnerability (see Table 4). The ways in which the vulnerability of these groups could be reduced was discussed during the final project workshop.

Table 4. Identifying vulnerable groups.

Vulnerability factor	**Vulnerable group**
Age	Children (under 5 years) – they have lower immunity Elderly
Health	Physically handicapped - they are not always mobile Diseased and physically weak because of leukemia, malnutrition, etc.
Socio-economy	People below poverty line (deprived) Jobless persons Marginal farmers – depend on climate Landless Illiterate and poor women (often responsible for earning and caring for children and elderly) Bad habits (drinking, gambling, drugs)[2]
Dwelling	Slum inhabitants Migrating population – they do not have proper shelter, also unhygienic conditions

The factors and indicators used to describe social vulnerability on the individual scale, i.e. gender, health status, age, low income and poor education, correspond well to the scientific literature and are considered

[2]These factors were particularly emphasised by workshop participants as contributing to vulnerability.

to contribute to either higher sensitivity or lower adaptive capacity of groups such as women, people with illnesses or disabilities, elderly and children, unemployed and people with low income or education (Cutter *et al.*, 2008; Dwyer *et al.*, 2004; Heltberg *et al.*, 2009; Wilhelmi and Hayden, 2010). It is evident that these vulnerability factors, except from age, are overrepresented in slum populations. Most of the challenges identified for the slum population are also major challenges of Kota city as discussed above. However, the severity of the challenges differs between slum areas and the city in general. Most of the identified challenges are associated with infrastructure development. According to Holand *et al.* (2011), the characteristics of the built environment or infrastructure related issues are important to consider in vulnerability assessments. The slum inhabitants are receiving partial services regarding water supply and drainage compared to other city dwellers, while with regard to sewage they are almost totally isolated from the city network. The poor drainage system also makes the slums more prone to flooding. These challenges make the slum inhabitants more vulnerable to climate change and natural hazards.

5. Discussion

The outcomes from the two workshops with governmental representatives and the survey among slum inhabitants indicate that the most severe climate change impacts are related to increasing heat waves and groundwater stress. In particular, slum inhabitants are at risk when it comes to water supply and sanitation, as well as poor drainage during floods. Water pollution was somehow related to climate change, although it mainly relates to inadequate sewage treatment and industrial effluent control. To a certain extent, climate change may intensify sewage problems if intensive rainfall becomes more frequent, increasing the risk of the sewage contaminated flooding of low-lying land areas. The value of the workshop's approach is that perspectives from different departments and government agencies are expressed in a common platform, and that discussions between participants with several different perspectives result in a common picture of the main problems and priorities. By following the approach, a systematic analysis of climate vulnerability is achieved, where the guidebook tools also help the workshop participants to look for aspects that they would otherwise perhaps overlook. An example is the exercise focusing on vulnerable groups, which raises the issue of socio-economic differences and differences in the capacity to handle climate change impacts. This inspired investigations into health impacts related to climate change variables, the analysis of data from an ongoing slum-questionnaire, separate workshops in two slum areas, and the invitation of ward members to the third workshop.

Clearly, the approach is dependent on who participates and the absence of representatives from certain departments may result in incomplete discussions and the omission of highly significant issues. Thus, the workshops need to be complemented by interviews and an analysis of associated documents and scientific literature to ensure that all important actors are somehow included. One example is the issue of flash floods. During the workshops, participants claimed that the risk of flooding had been averted due to the construction of a diversion channel in 2007 (see also ADB, 2007). However, with growing urban populations even on river banks and low-lying areas, the problems related to flash floods are likely to increase according to the Government of Rajasthan (GoR, 2011). Moreover, climate change will also increase the occurrence and intensity of extreme rainfall events, which will probably render the first diversion channel insufficient. Flash floods may, therefore, add to the climate change related water problems which need to be addressed in Kota in the near future. Plans for a second diversion channel are underway, but knowledge of the growing significance of the problem, and the new plans were clearly limited among the workshop participants. A connected issue is the solid waste challenge which was identified during the first workshop. At first sight, this may seem of little relevance to climate change; however in connection to the problem of flash floods, it suddenly becomes an extremely important factor that aggravates the adverse effects of climate change. When sudden heavy rain occurs, *nallahs* become routinely blocked by solid waste, which contributes to the flooding of low elevated areas in the city.

As noted above, it was evident that the knowledge of climate related water issues was widespread among the invited organisations and departments, and that several measures to adapt were already in place. Relevant legislation and recommendations were also available, although some were not practiced

sufficiently. Certain state sponsored relief and development schemes, i.e. the Mahatma Gandhi National Rural Employment Generation Act and the Public Distribution System, have proven rather weak in assisting the worst hit target groups after flood incidences, while others, i.e. state emergency relief programmes, have been more successful in this respect (Somanathan and Somanathan, 2009). According to workshop participants, increased political will and more conscious planning (which were identified as chances/opportunities for Kota during Workshop 1), have the potential to play an important part in increasing adaptive capacity on a municipal level by enhancing implementation of already existing schemes. The purpose of the workshops was to increase the awareness and integration of these different understandings and suggestions, in order to facilitate collaboration between municipal departments. However, this can only do part of the job, and we see a clear need to directly link climate adaptation issues to a lead actor or initiative who will take on the responsibility. One such may be the District Disaster Management Plans (DDMP), initiated by the District government (Collectorate), which in the Kota case includes the events of drought, flood and extreme cold and heat events (DDMP Kota 2010). The DDMP identifies how these extreme phenomena may affect the city and also provides an emergency action plan giving different actors responsibility for mitigating the effects. However, the DDMP is per definition a rather reactive strategy, and there is a need to complement it in a more proactive perspective.

6. Conclusion

In spite of advancements at the national and state levels with Climate Change Action Plans, climate change and adaptation issues are not on the agenda of local government bodies. Many current schemes are also having a positive impact on climate adaptation; however these plans tend to have a large number of objectives and instruments without any order of priority. Moreover, implementation at the local level remains problematic. Tools that can enhance a broader policy dialogue, and translate national and state problem formulations into locally relevant and justified priorities are needed. In here, we urge the need for urban climate change adaptation plans that also include the most vulnerable societal groups and highlight the important role that the governments need to play. The disaster management plans which are currently under development only represent the first step in moving from a reactive to a proactive approach. We believe that the presented approach to stakeholder involvement in vulnerability assessment and adaptation plans, will help actualise pressing issues due to climate change and indicate a workable way forward.

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