Asian Cities Climate Resilience

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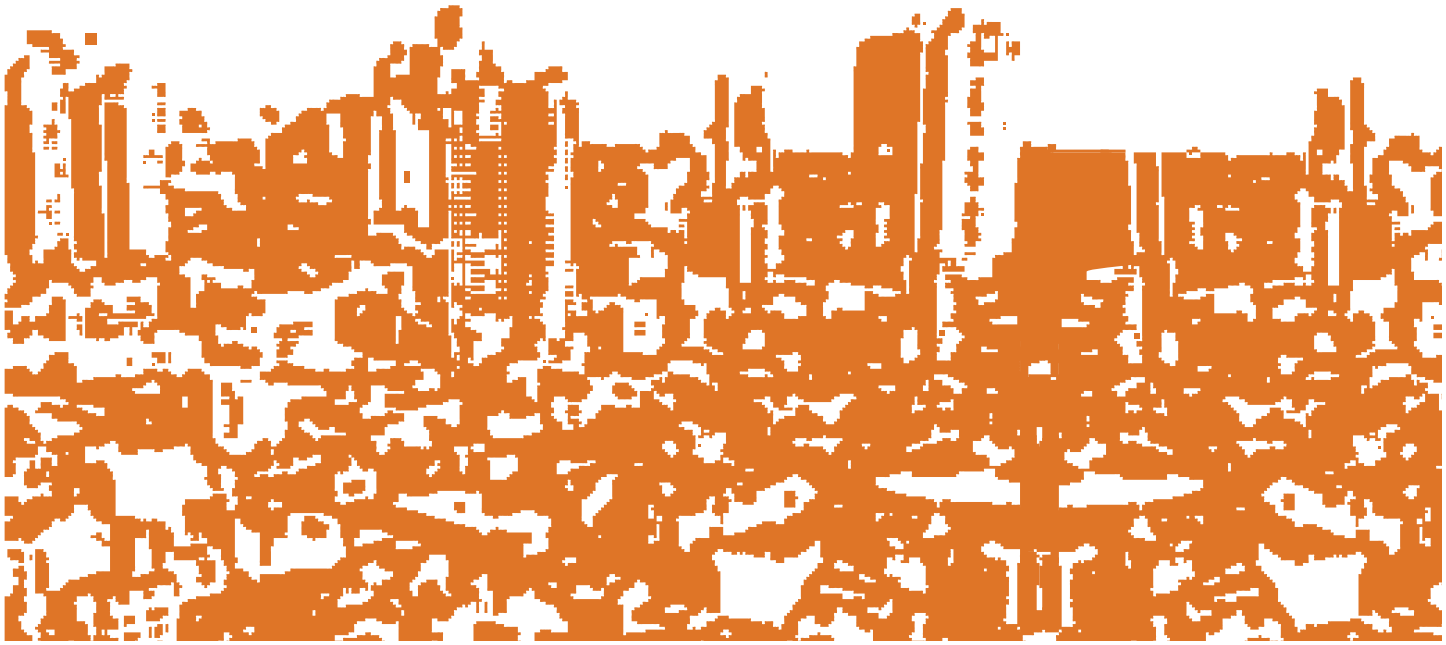
Wheezing ecosystems, livelihood services and climate change resilience in Uttar Pradesh

BY AMIT MITRA, SHIRAZ WAJIH AND BIJAY SINGH



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Acronyms

ACCCRN	Asian Cities Climate Change Resilience Network
FAO	Food and Agriculture Organization of the United Nations
FGDs	Focus group discussions
GDA	Gorakhpur Development Authority
GEAG	Gorakhpur Environmental Action Group
GMC	Gorakhpur Municipal Corporation
LEISA	Low external input sustainable agriculture
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
SLDs	Shared learning dialogues

Abstract

Increasing urbanisation and the accompanying changes in land-use patterns are leading to a silent crisis through the destruction of ecosystems and the services they provide to support the poor, as well as affecting the resilience of urban areas. Using the example of Gorakhpur City in India's Uttar Pradesh, this paper argues that not following basic ecosystem-based approaches to development – including understanding urban, peri-urban and rural areas and their associated systems – can be detrimental for both populations and the ecosystem itself. Critical to such approaches is a better understanding of the linkages between urban and peri-urban areas, going beyond mere spatial conceptualisations. The supporting, provisioning, regulating and cultural services provided by ecosystems are vital for the livelihoods of people as well as for resilience to climate shocks. Measures to restore ecosystems need unconventional approaches involving multiple disciplines. They must involve the people who are the actual keepers of the ecosystems at all levels. Central to such approaches would be preventing haphazard land conversion for construction and urban construction which have a tremendous cost for both people and the ecosystem and which affect the city's resilience. Reviving ecosystems also means attending to people's development needs, especially health and education.

1. Introduction

This paper seeks to examine the links between ecosystem services, urbanisation and resilience to climate change, using the case of Gorakhpur City in eastern Uttar Pradesh. This includes understanding the notion of an ecosystem and how urban transformations, unless carefully planned and implemented, can impact such ecosystems adversely. It argues that not adhering to certain basic principles of an ecosystem-based approach to development, including in the understanding of urban, peri-urban and rural areas and their associated systems, can be detrimental for both populations and the ecosystem itself. For instance, in the process of urban sprawl at the peri-urban interface, areas such as greenbelts, open spaces and floodplains are threatened and rendered fragile. This affects livelihoods which draw on ecosystem services, and are possibly more at risk in a situation of uncertainty surrounding climate change. Thus, by understanding the roles and services provided by these spaces and their ecosystems more generally, one can understand their role in contributing to urban resilience to climate change.

India's urban growth rates in most major metropolitan areas show no signs of decelerating. Significant structural changes in the economy, an agrarian crisis typified by falling agricultural growth rates and share of agriculture in the GDP, as well as depeasantisation and the increasing feminisation of agriculture, have enhanced urban expansion in the latest decade.

Overall, such urbanisation processes, as the Gorakhpur example demonstrates, are transforming agrarian ecosystems. This paper examines the changes in Gorakhpur in supporting, provisioning, regulating and cultural services provided by ecosystems, and the impacts of such changes on vulnerable populations. Critically, such services help small and women farmers build resilience to climate change and their decline accentuates not only the vulnerability of people but also of the city itself. Understanding the role of ecosystem services, the hierarchy of ecosystems and how they relate to the lives and livelihoods of small, marginal and landless and women farmers is critical to understanding the linkage between ecosystem services and urban resilience. As there is little research examining the role of ecosystem services in contributing to urban climate resilience, this paper seeks to understand and demonstrate how ecosystem services can build resilience in urban settings, enabling cities to function properly, and also secure the well-being of its residents. The paper examines government programmes and schemes that potentially can improve ecosystem services and suggests the necessary policy changes.

1.1 Research objectives

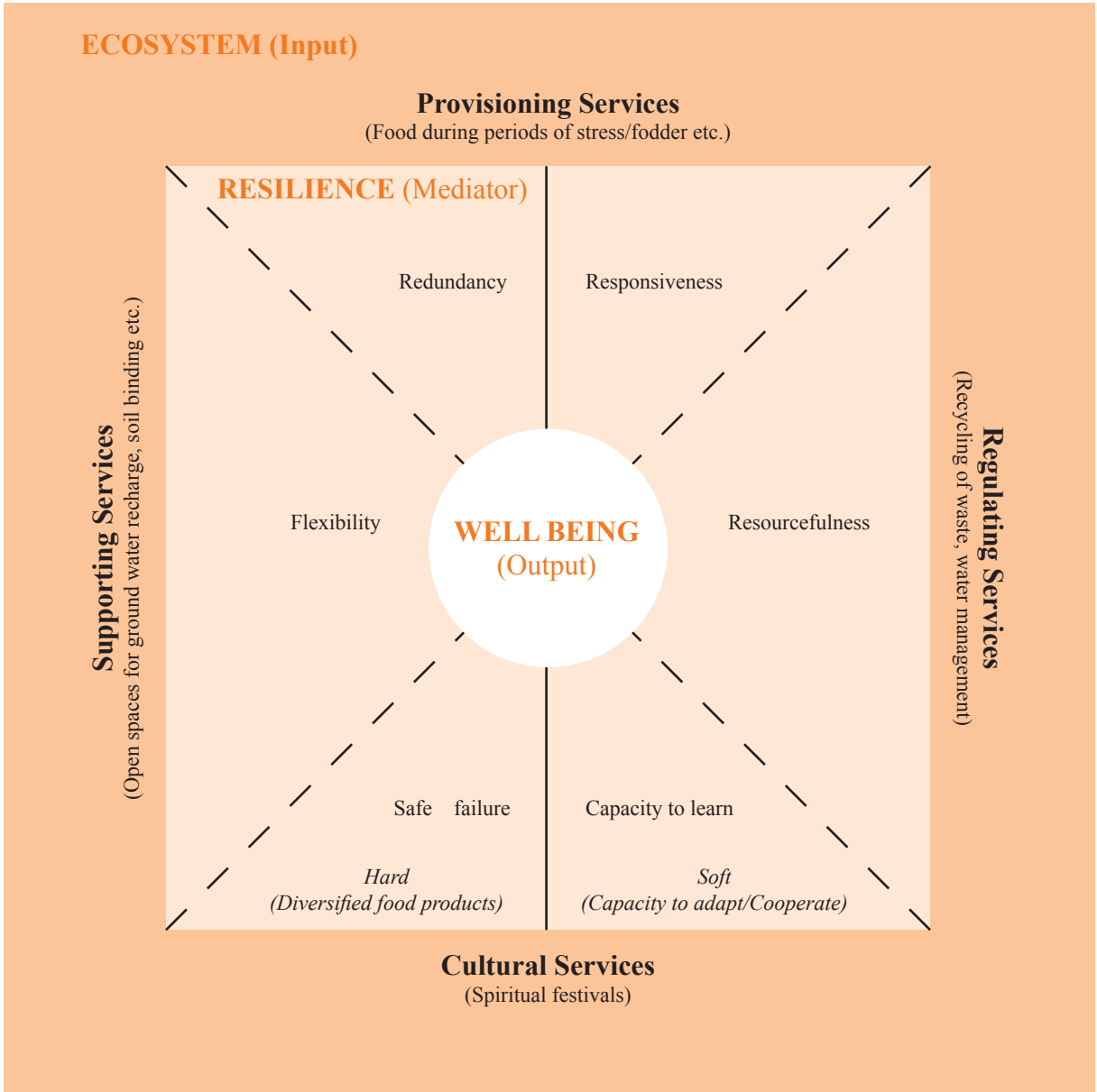
This paper seeks to understand the linkages between the peri-urban and ecosystems and the role of ecosystem services in building resilience to climate change. The key focus is on the role of ecosystem services in the lives and livelihoods of small, marginal and landless and women farmers and what happens when the ecosystem breaks down, for example due to urbanisation pressures. Included in ecosystem services are:

- **Supporting services:** ecosystem services 'that are necessary for the production of all other ecosystem services' (MEA, 2005: 40) such as nutrient dispersal and cycling, seed dispersal, primary production.
- **Provisioning services:** products obtained from the ecosystems such as food, fuel and water, fodder, fibres, genetic resources, medicines, energy or ornamental products.

- **Regulating services:** 'benefits obtained from the regulation of ecosystem processes' (ibid) such as carbon sequestration and climate regulation, waste decomposition and detoxification, water and air purification, natural hazard mitigation, pest and disease control or erosion control.
- **Cultural services:** 'nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences' (ibid).

Overall, the different ecosystem services enhance the redundancy and flexibility of urban systems, and can help ensure that any failures are 'safe failures' so as to minimise damages (Figure 1). The paper identifies examples of different kinds of ecosystem services in Gorakhpur city and their role in building the city's resilience.

Figure 1. Diagram of the resilience concept



Ecosystem for Resilience

Not only do these services ensure the well-being of the people, but they also play a role in regulating migration of people to urban areas as 'footloose' labour (Breman, 1996). This is because ecosystem services can play a role in influencing the various components of human well-being which include providing the basic materials for a good life, health, good social relations, security and freedom of choice and actions (MEA, 2005: v)

People are integral parts of ecosystems. A dynamic interaction exists between humans and ecosystems, with the changing human condition driving, both directly and indirectly, changes in ecosystems and thereby causing changes in human well-being (MEA, 2005: vii.) At the same time, social, economic and cultural factors unrelated to ecosystems alter the human condition, and many natural forces influence ecosystems (ibid).

The paper argues for an ecosystem-based approach to urban climate change adaptation and resilience, particularly the role that ecosystem services in peri-urban areas can play in core urban areas. It is increasingly recognised that ecosystem-based adaptation has the potential to overcome maladaptation and the inadequate consideration of biodiversity while giving the social components of adaptation more consideration, helping to avoid social inequality and disempowerment (Doswald and Osti 2011; Fitter *et al.,* 2010; Everard, 2009; Girot *et al.,* 2012, Huq *et al.,* 2013). The role of ecosystem services is critical to ecosystem-based adaptation strategies.

It is only when people are rooted in their original habitat, but with total access to their development rights as well as basic needs, that they are able to preserve the ecosystem, so vital to the health and also the resilience of the city. This paper seeks to analyse the changes in such services over a period of time and the impacts on vulnerable communities in terms of:

- The potential for developing climate resilience through ecosystem services which help small-scale and women farmers, and inversely how shrinking ecosystem services are adding to vulnerability of people living in peri-urban areas and the city,
- Government programmes and schemes helpful in improving or maintaining ecosystem services, and
- Recommended policy changes to preserve ecosystems and their role in supporting climate resilience.

1.2 Urbanisation in India

By 2050, almost three-quarters of the world's population will live in cities and towns, with most of this increase occurring in developing countries in the global south (United Nations, 2009; Martinez *et al.,* 2008; Nijman, 2008; UN-HABITAT, 2006).

The 2011 provisional census of India reported an annual growth rate of urban population of 2.76 per cent, close to the 2.73 per cent reported in 2001 (Census 2011). The urban population of India in 2011 was 377 million, or 31.16 per cent of the total population. The decadal urban population growth rate during 2001–2011 was 31.8 per cent, which was 1.8 times that of combined urban and rural growth, and 2.6 times the rural population growth. Thus for the first time since independence in 1947, the absolute increase in population was higher in urban areas than in rural areas (Census, 2011). The proportion of rural populations declined from 72.19 per cent in 2001 to 68.84 per cent in 2011 (Chandramouli, 2011). The number of towns increased from 5,161 in 2001 to 7,935 in 2011 adding 2,774 'new' towns (ibid). The latest figures corroborate the fact that due to various socio-economic factors including population pressure and poverty, urban regions have seen a large influx of population from rural areas and this has led to the rapid growth of new urban centres.

This has crucial implications for infrastructure and other civic amenities in urban areas (Dutta, 2012; Bhagat, 2011; Ahluwalia, 2011; Kundu, 2011). Rapid residential and commercial development is replacing agriculture and other undeveloped land, including common property resources and water bodies, around urban areas, severely impacting the ecosystems and the lives of the people dependent on them. Urbanisation brings about changes in land-use patterns by transforming urban-rural linkages, and leads to loss of open vegetation, decline in environmental quality, as 'increasing population concentrating more people on less land, even as total land devoted to urbanisation expands' (Dutta, 2012:2). This expansion and ensuing land-use change is a direct driver of damage or destruction of ecosystems in peri-urban areas, leading to a host of problems with few short-term solutions. These impacts are exacerbated by archaic policies that do not go beyond considering the differences between urban and rural areas as a question of numbers of people and geographical

spaces. Once the consequences of altering peri-urban ecosystems and the potential loss of resilience-building opportunities become apparent, it may be too late to bring about a reversal. This paper focuses on some of these factors in the case of Gorakhpur City.

1.3 The case study locale

Gorakhpur is located in the Terai belt of Eastern Uttar Pradesh, India, in the foothills of the Himalayas and thus floods annually by swollen ice melt. For the British in the colonial period it was an idyllic holiday resort due to the pleasant climate, numerous lakes and abundant greenery. Since the 1970s, with the establishment of the North Eastern Railway Headquarters and other infrastructural developments, radical changes have taken place. Currently the second largest city after Varanasi in Eastern Uttar Pradesh, it has a population of 671,048 (Census, 2011), up from 300,000 in 1981. Geographically, the city is situated at the confluence of the rivers Rapti and Rohini. The city has 70 administrative wards (Wajih *et al*., 2009: 8) and has an average density of about 4,559 people/km, which is lower than other faster growing municipal corporations like Varanasi, Kanpur and Allahabad. The small 39km^2 town of 1981 had become a city of 147km^2 by 2011, 'absorbing' 47 villages into the Gorakhpur Municipal Corporation (GMC). This growth in area was the cause for a surge in the city's population during 1981–1991 by 64.1 per cent (ibid).

The population is spread unevenly in the city, with a lower population density in the newer wards in the north. The rapid influx of population from nearby rural areas (as well as from outside the state) has exerted tremendous pressure on the city's infrastructural capacity. This has led to the development of numerous slums, with deteriorating living conditions within the city. Currently, there are about 110 slums, accommodating around 33 per cent of the population (Wajih *et al*., 2009: 13). Gorakhpur is considered the largest commercial centre of the region, with both retail and wholesale markets of commodities ranging from agricultural products to home-based cottage industries (ibid: 16).

Historically, Gorakhpur experienced low levels of flooding each year during the summer monsoon and depended upon such floods to replenish soil fertility, which is a direct example of an ecosystem service. Yet the depth and duration of floods in certain wards of the city has been increasing, as the city has expanded to encompass sections of both the Rapti and Rohini rivers. Some factors that exacerbate flooding and waterlogging include (Singh, 2014; Mitra and Singh, 2011; Wajih *et al.,* 2010):

- Loss of water bodies and permeable areas that once absorbed monsoon rains,
- Construction in the floodplain zones of the Rapti and Rohini rivers,
- Inability of the city to provide services that reduce flooding, such as solid waste management and wastewater/storm water networks,
- Inappropriately placed embankments that trap flood water for 2–3 months, causing waterlogging, and
- Informal and irregularly maintained canals, check dams and barrage systems upstream of and within urban areas.

These urbanisation processes have changed the nature of flooding and waterlogging hazards for the city and, as they accelerate, further alter the hazardscape of the city. Climate change has already become a reality in the Gorakhpur region (Mani and Wajih, 2014). The earlier continuous low-intensity rain, with the River Rohini doubling or tripling in volume due to heavy rains in Nepal, has given way to incessant rains during the monsoons, bringing flash floods followed by long dry spells. The monsoons typically began in June and ended in September but now start often in the last week of May with floods occurring in June. Flooding and waterlogging are triggered by rainfall events either in the city or upstream of the city in Nepal's Terai and Middle Hills regions.

In rural areas, the floodwaters previously receded within a week; now the land remains waterlogged for a month, destroying the *kharif* (monsoon) crops. In parts of Gorakhpur, the waterlogging remains for three months or longer. In contrast to earlier years, when 70 per cent of the average annual precipitation fell over an 80-day period, the same amount now falls in just 50 days (Sule, 2010; *Opitz-Stapleton and Hawley, 2013)*. Summers are hotter and winters are colder, and over the last few years winter has arrived later (Sule, 2010). In the near future, the frequency and intensity of

rainfall events that contribute to Gorakhpur's flooding is projected to increase (Hawley *et al.,* 2013; *Opitz-Stapleton and Hawley, 2013), complicating weather predictions*. The shifts in extreme rainfall due to climate change, coupled with the current city development trajectory, will continue to increase the flood and waterlogging risk (Hawley *et al.,* 2013; *Opitz-Stapleton and Hawley, 2013).* All these lower the resilience of the city and its people to climate change.

Box 1. Gorakhpur's civic challenges

Waterlogging

Most of the city, being below the river bed, faces waterlogging. The southern and western parts are severely affected, but the entire city's drainage system is stressed. Waterlogging is increasing due to rising sedimentation of local water bodies.

Solid waste management

Gorakhpur generates 300 tonnes of solid waste daily but lacks an organised solid waste management system. The Gorakhpur Municipal Corporation (GMC) supposedly collects 240 tonnes daily. The rest accumulates on the roadside and is supposed to be removed by the GMC weekly. However, the accumulated waste tends to flow into open drains creating blockages.

Sewage

Only 22 per cent of the city (30km^2) is covered by the 55km underground sewer network. The 50-year old pipes have collapsed in many places, contaminating the drinking water, and the system is overloaded. The city's six pumping stations dispose of the untreated sewage into the drains and subsequently into the Ramgarh Lake and the Rapti River, severely polluting these water bodies. There is no sewage treatment plant in Gorakhpur. Just 20 per cent of the population have access to proper sanitation.

Drinking water

Water quality is a major concern due to waterlogging and poor solid waste management. GMC provides water to 65 per cent of the city while the rest is served by hand pumps. People drink contaminated water from shallow hand pumps leading to bacterial and gastrointestinal disorders.

Health

Waterlogging and insanitary conditions lead to malaria and encephalitis. Jaundice, diarrhoea, amoebiasis, gastrointestinal disorders and cholera are common. However, the public healthcare infrastructure is weak.

Energy

The city faces 10–12 hours of power cuts daily. Polluting diesel generators are the common alternative energy source. During the monsoons, 50 electric pumps drain waterlogged areas, further draining the city's energy.

Institutional challenges

- Lack of interdepartmental convergence
- Mainstreaming climate change in the city's master plan
- Sensitising policymakers and planners
- Lack of data

Sources: Wajih et al (2009)

1.4 Research methodology

This paper is based on secondary sources as well as primary data collected through fieldwork in the peri-urban areas of Gorakhpur City.[1] The Gorakhpur Environmental Action Group (GEAG), a local environmental NGO, is implementing an action research project in the city to promote ecosystem-based low external input sustainable agriculture (LEISA) in eight peri-urban villages, divided into two clusters. Promoting good governance through democratic institutions and gender equity are integral aspects of the intervention, which focuses on marginal and small-scale as well as women farmers. GEAG has built up a quantitative database through a detailed survey of 485 households, out of the 1,474 total households in these villages. This paper relies partly on the data collected for this project in both of the clusters. Additionally, some localities outside these clusters, including those just outside the border of the city (not demarcated in the 2021 master plan) were visited as they represent peri-urban areas.

The substantive part of the data was collected through eight focus group discussions (FGDs) and shared learning dialogues (SLDs), three of which were exclusively with women. Care was taken to ensure that everyone got a chance to speak. The participants were mostly small-scale and marginal farmers as well as some landless labourers. From the outset, it was emphasised that at least five people be in each FGD. However, as often happens in Indian villages, the numbers would gradually swell, and then some, especially younger women, would have to leave due to household or other work. Additionally, two FGDs were held with youth.

Fifteen key respondents were interviewed. These included women health workers, traditional birth attendants, one local (untrained) medical practitioner, several school teachers and two model farmers[2]. Government representatives included health workers, one *sarpanch* (headman) and some members of the *Panchayat* (local governing body). GEAG's staff, many of whom are local youth, were also interviewed in depth.

The interviews were semi-structured, sometimes open-ended. The focus was on understanding the present living conditions, livelihoods and aspirations as well as changes in the last two decades. Every care was taken to ensure that the respondents did not exaggerate the past – either positively or negatively – though in the FGDs the participants ensured that this did not happen. If anyone presented an extreme picture, the others would present a counter view. The information provided by the key respondents was crosschecked with others, including in the FGDs and SLDs.

1 *The names of the participants/respondents have been changed in this paper to protect their identities. The village names have not been changed.*

2 *Model farmers refer to those who, facilitated by GEAG, adopt low external input climate resilient farming systems on small land holdings. This is based on enhancing diversity, complexity and recycling through integration of agriculture-horticulture-aquaculture-livestock rearing; common property resources management (including forest, water and land); and linking with appropriate government schemes by leveraging available funds and technologies.*

2. Literature review: the conceptual framework

2.1 The resilience of a city

A resilient city is one that is able to respond positively to numerous emerging challenges that interact with each other to exacerbate the overall impact, such as climate change, disaster events, rapid urbanisation and poverty. Bahadur *et al.* (2013) reviewed the literature to distil ten key characteristics of resilience, including: high diversity; effective governance and institutions; the ability to work with uncertainty and change; community involvement and the appropriation of local knowledge; preparedness and planning for disturbances; high social and economic equity; robust social values and structures; acknowledging non equilibrium dynamics; continual and effective learning; and the adoption of a cross-scalar perspective. In the context of Gorakhpur, despite the attempts being made by NGOs like GEAG through initiatives such as the Asian Cities Climate Change Resilience Network (ACCCRN), these characteristics are by and large yet to be established (Bahadur and Tanner, 2014). Building or enhancing urban resilience involves multiple and multisectoral interventions at different scales and has many different professional and practical entry points (Arup, 2012) and is a continual process. Climate change is an evolving process, occurring alongside rapid urbanisation, existing infrastructure systems and established institutions, and hence cannot be addressed through isolated interventions.

Cities are complex socio-technical systems which makes it difficult to predict or assess their level of resilience. The experiences of the ACCCRN initiative, which spans 10 cities in four countries and includes Gorakhpur, shows that four key components of a city (knowledge, enabling policies and plans, engaged stakeholders, access to finance) collectively determine well-being where different attributes can be used to observe or assess these four components (da Silva *et al.,* 2012; Kernaghan and da Silva, 2014). These attributes distinguish between characteristics that are applicable to infrastructure and institutions (hard systems) such as redundancy, flexibility and safe failure; and the capacities of social agents (soft systems), including resourcefulness, responsiveness and the ability to learn (da Silva *et al.,* 2012).

The provisioning, regulating, supporting and cultural services provided by ecosystems for a city support both the hard and soft urban systems (Figure 1).The soft systems are equally if not more important than the hard systems and ignoring them jeopardises the functioning of the former. Predominant hard adaptation measures such as large-scale infrastructure investments can be costly, resource intensive and obstruct natural flow. They can also:

- Lead to maladaptation (IPCC, 2012; Jones *et al.,* 2012; Klein *et al.,* 2007; Huq *et al.,* 2003)
- Promote ‘negative development’ (Pérez *et al.,* 2010; Tschakert and Dietrich, 2010)
- Threaten biodiversity and ecosystems (Campbell *et al*., 2009; CBD, 2009; EEA, 2009), and
- Potentially fail to address future climate change challenges (Jones *et al.,* 2012; Pérez *et al.,* 2010).

The resilience of Gorakhpur is threatened with the decline of ecosystem services. With rapid land-use changes and an economic shift from agriculture to urban development, small-scale and marginal farmers in peri-urban areas, whose practices provided redundancy to urban food production, are on the brink of collapse. The diversity of peri-urban agriculture, including its ability to provide food in periods of floods and waterlogging, is an example of how the provisioning services of ecosystems help in developing the flexibility of hard systems. The villagers are mostly vegetable growers, with small landholdings of under an acre. They practise peri-urban agriculture, formally defined as:

[*A]gricultural (including livestock) production, processing, and distribution activities within and around cities and towns, whose main motivation is personal consumption and/or income generation, and which compete for scarce urban resources of land, water, energy, and labour that are in demand for other urban activities* (Gundel, 2006).

This diversity-based farming helps in providing open spaces for groundwater recharge, soil binding, recycling and soil fertility. Additionally, this farming supports the large low-income populations living along the city fringes which are highly dependent on primary production. The existence of these farmers is under threat and many have joined the ranks of the city's urban poor casual labour workforce (Mitra and Singh, 2011).

Gorakhpur's peri-urban ecosystem is fractured, particularly in the regulation of services such as the maintenance of water bodies, leading to weakened resilience in terms of ecosystem flexibility and safe failure (Figure 1). Most importantly, with the breakdown of ecosystems and ecosystem-based services, the social institutions that held the people together and enabled localised participatory governance are on the verge of collapse. Water bodies in the city are important to the citizens for various cultural and spiritual needs like marriages, festivals and worship, and which contribute to their protection. GEAG and other organisations working to rebuild urban resilience today therefore seek to build participatory community institutions and work through them (Mani and Wajih, 2014; see also Bahadur and Tanner, 2014).

2.2 Conceptualising the peri-urban as an ecosystem

'Peri-urban' is conceptualised in multiple ways in the literature. It is viewed as the transitional zone between a sprawling city and its rural surroundings (Dutta, 2012), 'neither rural nor urban in its outlook and characteristics' (Prakash, 2012 : 2). Not clearly definable, given the contextual and situational specificities involved, in most parts of the world peri-urban spaces are rapidly expanding and being occupied by increasing numbers of people (Dutta, 2012; McGregor *et al.,* 2005; Kayser, 1990). Peri-urban areas face uncertain land tenures accompanied by inferior infrastructure, low incomes and lack of recognition by formal governments (Prakash, 2012). They are typified by mixed agricultural and non-agricultural land uses and flows of goods, services and resources between villages and urban centres and a perpetually changing heterogeneous social population. This leads to specific environmental and natural resource problems beyond the scope of urban or rural governments individually: peri-urban areas need innovative approaches (Prakash, 2012, Narain, 2010; Allen, 2003). The people and the landscape interact dynamically with the associated land uses and livelihoods based on flows of agricultural goods and ecological services both within peri-urban zones and between them and urban core areas (Prakash, 2012; Lerner and Eakin, 2011). The 'rural is not only defined relative to its urban counterpart, but also relative to the specific political-economic, ecological and social-cultural context in which such spaces emerge,' (Prakash, 2012:2; see also Lerner and Eakin, 2011).

Therefore, the peri-urban is a fast-changing, semi-natural ecosystem which provides natural resources for growing cities while depending on the urban markets for sales and employment. This two-way interaction changes even the lifestyles and mentalities of peri-urban inhabitants. The 'extractive' nature of urbanisation places a low premium on preserving the ecosystem, affecting not only the livelihoods of those directly dependent on it but also the city itself. Peri-urbanisation leads to usurpation of ecologically sensitive lands for housing and other construction activities. These change the face of agriculture, reduce open spaces, enhance pressure on natural resources like water. These areas are marked by a lack of hygiene and sanitation infrastructure, industrial effluence, air pollution and inadequate provision of basic services. Often, the solid waste of a city is dumped in peri-urban areas (Marshall *et al.,* 2009:7).

Changing peri-urban boundaries due to rapid urban growth leads to multiple transformations – physical, morphological, socio-demographic, cultural, economic and functional in the city periphery (Dupont, 2004; Brook and Davila, 2000). The high spatial uncertainty necessitates the protection of land-use patterns and reclamation of common property resources for other purposes (Narain, 2009; Narain and Nischal, 2007). These transformations sometimes irreversibly change ecosystems and the services they provide.

Environmental management of peri-urban areas is critical to the sustainability of urban and rural development as the ecological, economic and social functions performed by and in them impact on both the city and the countryside (Dutta, 2012: 4; Narain, 2009; Allen, 2003). Contemporary land acquisition policies in developing cities disregard social equity and environmental integrity, undermining a city's capacity to adapt to climate change and rendering the peri-urban areas and poorer populations very vulnerable. Environmental degradation, natural resource conflicts, health concerns and social injustice are particularly acute in the peri-urban areas that are excluded in formal planning processes (Prakash, 2012; Marshall *et al.,* 2009). The lack of basic knowledge and timely information of the urbanisation process and its long-term ecological impacts constrains development planning authorities in analysing, managing and restoring peri-urban ecosystems (Dutta, 2012; Narain, 2007). Left unaddressed, the process leads to rural-urban synergies breaking down, environmental degradation and rising urban inequities and poverty (Prakash, 2012) which could be worsened by the impact of climate change (Mitra and Singh, 2011).

2.3 Environmental services provided by ecosystems in urban areas

Ecosystems provide a multitude of physical and environmental services to cities and their residents. Regulating services play an important role in reducing the magnitude of natural disasters in two ways. First, for example, water bodies or wetlands can reduce physical exposure by serving as natural protective barriers or buffers, thus mitigating hazard impacts (IUCN, 2008; Barbier, 2006). A well-managed ecosystem can provide natural protection against common natural hazards such as flood and storm surges, fire and drought. Secondly, it lessens disaster risk by reducing socio-economic vulnerability to hazard impacts by providing essential goods such as food, fibre, medicines and construction materials for strengthening human security and resilience against disaster (Abramovitz *et al.,* 2002).

In the northern, western and southern parts of Gorakhpur several stagnant water bodies such as lakes, pond and other depressions locally called *tals* were an integral part of the inland drainage system of the area. These natural reservoirs play a vital role in minimising floods. They not only collect excess water, but also act as a detention basin for flood water during the monsoon and provide a good source of livelihood to fisherfolk. But the depletion of water bodies and fish has affected the fisherfolk, the Nishads and the Kewats. Only 40 per cent now depend on the lakes for a livelihood, the rest having been forced to leave their traditional occupation and work as casual wage labour (Mitra, 2010).

Supporting services, which differ from other services because their impacts are indirect and play out over the long term, are necessary for the production of all other ecosystem services. Some services, like erosion control, can be categorised as both a supporting and a regulating service, depending on the timescale and immediacy of their impact on people. For example, humans do not directly use soil formation services, although changes in this would indirectly affect people through the impact on the provisioning service of food production. In an urban context, like Gorakhpur, the food production systems of small-scale and marginal farmers, including livestock rearing, horticulture and aquaculture, have provided redundancy to urban food production especially during floods and waterlogging periods. However, with the current rapid changes in land- and water-use patterns, the soil formation is changing, impacting the remaining farmers in the region. They say that agricultural productivity is declining, and with that the profits from agriculture, acting as an impetus to leave farming.

Rapid urbanisation is further destroying agricultural land and natural resources in general, enhancing the vulnerability of the poor as well as the city itself. These factors all add up to further reduce the redundancy of the shrinking peri-urban agricultural base of Gorakhpur and also diminish the scope for safe failures. The flexibility of the system, critical to building up resilience to climate change shocks and citizen well-being, is rapidly declining and the communities are becoming increasingly vulnerable.

2.4 Drivers of change in water-based ecosystem services

2.4.1 Climate change

The ecological and environmental challenges discussed in Section 2.2 are multi-dimensional in Gorakhpur's context (see also Box 1). Climate change is a major threat to the sustainable production and management of water-based ecosystem services. Climate predictions for the region suggest that air temperature and rainfall patterns will change (Opitz-Stapleton, 2011), which could affect nutrient turnover time and leaching into water bodies. Summer surface temperatures in water bodies are predicted to rise.

The ecosystem services provided by river catchment areas are the formation of groundwater, regulation of hydrology, and nutrient retention capability of catchment areas. In future, groundwater formation will be less than at present if hot and dry summers become more common. Also, groundwater quality can decline, involving the increase in iron concentration in groundwater if water tables fall dramatically because of drought, among other things. If extreme weather conditions become common, as predicted, the regulation of hydrology will be affected. As a consequence, floods and drought periods will become more common. This could affect the nutrient retention capability of vegetation and soil in catchment areas.

2.4.2 Eutrophication

Ecosystem services provided by water bodies include clear water, fish stocks and recreation. As climate change advances, the greatest threat to the ecosystem services of water bodies is their eutrophication. If the annual cycle of hydrology changes, with spring arriving earlier and autumn being delayed, the nutrient retention capacity of water bodies may decline (Samuli *et al.,* 2011). This intensifies eutrophication. With an overgrowth of vegetation, the water quality, recreational accessibility and aesthetic values of aquatic nature in water bodies decline. In Gorakhpur, shrinking water bodies and pollution has severely affected the flora and fauna of the city and its peri-urban zone. For example, Ramgarh Lake had considerable diversity in its flora and fauna until the 1980s. Its fish were in great demand in Gorakhpur. But human interference and eutrophication has affected the fish stock, the fish trade and those dependent on fishing for a living. The deterioration of the waters and the absence of food have also affected the bird population. Previously abundant birds like the Sarus crane, several species of storks and egrets, wild ducks and pheasants are rarely seen (Mitra, 2010).

The ecosystem services provided by water bodies are especially vulnerable in shallow lakes with a small surface area. Most of the crucial impacts on water quality are related to excessive nutrient loading and harmful effects of eutrophication (blue-green algae blooms and overgrowth by vegetation). For fish stocks, the crucial impact is the excessive increase of summer temperatures in water bodies to a point where species adapted to cold water may disappear.

Catchment areas and water bodies are affected by changes in land use as well as climate change, but it can be challenging to distinguish the effects of climate change or land use from each other (Bergström *et al.,* 2011), particularly as land use is controlled by policy and economy, factors with poor long-term predictability.

2.4.3 Land-use change

Land use is a major driver of change, directly impacting the soil formation process and the accumulation or loss of soil organic matter. Due to rapid change in land cover in urban areas the demand for soil from the fringe areas has increased manifold. In the last five decades, with the changes in cropping patterns, increased mechanisation, use of agrochemicals and synthetic fertilisers, and the introduction of new crop varieties, the quality of soil has markedly changed and the nutrient content has deteriorated. The natural ability of the soil to recharge nutrients has also been adversely affected, impacting overall food production. This decline in supporting services can ultimately affect the resilience of the city to climate change.

Changes in land use and land cover also affect timing and magnitude of runoff, flooding and aquifer recharge, including alterations that change the water-storage potential of the system. For example, the construction of embankments, roads and railways has modified the flood characteristics of the Rapti catchment basin. Building embankments not only provided a false sense of security, thereby promoting land encroachment up to the most exposed region, but also severely altered the basin morphology.

The vegetative cover plays an important role in soil retention and reducing soil erosion. Well-compacted soil helps to filter out the impurities in fresh water and prevent organic contamination. The removal of natural vegetation cover and canopy tends to reduce evapotranspiration losses and expose the soil surface to the full kinetic energy of the falling rain, causing breakup of the soil, clogging pores, reducing infiltration capacity and possibly even forming impermeable hardpans (Rana, 2005). Historically, a large part of the area was covered with a forest of *sal* (Shorea robusta) and other trees but under British rule, this gave place to cultivation. This deforestation has led to tremendous soil losses and increased flood events in the lower part of the basin.

2.5 Water and sanitation in peri-urban contexts

The close relationship between land and water use means that any alteration between land uses has direct implications for water and other environmental resources. In Saharanpur City in Uttar Pradesh urban expansion destroyed fertile agricultural land which could not be recovered, and the area began losing its agrarian characteristics (Prakash, 2012; Fazal, 2000). Filling up water bodies for urban acquisition is a common phenomenon across South Asian countries (see also Narain, 2010; Janakrajan *et al.,* 2006).

Understanding the peri-urbanisation process necessitates analysing the impacts on environmental resources and ecosystem services due to urban expansion (see also Prakash, 2010). A review of practices in accessing water and sanitation by peri-urban poor in five metropolitan areas including Chennai (Allen *et al.,* 2006) shows the failure of centralised supply policies and the market in meeting their water needs (Prakash, 2012). The peri-urban poor have no option but to pay market prices for water and often for sanitation. It appears that access to water and sanitation is mainly needs-driven and informal rather than the result of formal policies (Prakash, 2012).

Thus peri-urban issues can be analysed from the conceptual framework of the flow of environmental services from urban to peri-urban areas and vice versa (Prakash, 2012). Most Indian cities have expanded without sufficient water and sanitation infrastructure and have appropriated the environmental resources of peripheral areas. Drinking water is ‘sourced from the peri-urban areas through public or private tanker supply while urban waste (sewage and waste water) is directed to the peri-urban areas’ (Prakash, 2012: 3). These practices, as in Gorakhpur, adversely impact the poor living in these areas. Additionally, solid waste management is a major challenge in the Indian peri-urban context, underscoring the importance of governance and local initiatives in minimising adverse impacts (Prakash, 2012: 4; Shaw, 2005).

2.6 Governance considerations

In the Indian administrative context, there is a lack of clarity about the notion of the 'peri-urban.' The problem arises partly due to definitional issues. Important in this is the distinction between a 'statutory town and a census town.' Statutory' towns are towns with municipalities or corporations. Whereas, 'census' towns are agglomerations that grow in rural and peri-urban areas, with densification of population that do not have an effective urban governance structure or requisite urban infrastructure, for example, sanitation, roads and so on in place. Between 2001 and 2011 the statutory towns increased by just 242.[3] In many official documents, like the the master plan 2021 of the GDA the word peri-urban is not mentioned, though in day to day discourse many officials use the term. In general, howeve, despite calling them 'rural' a peri-urban area is defined administratively according to whether the locality falls within the boundaries of the city's master plan. This leads to many administrative issues. A major challenge to better environmental governance in urban and peri-urban contexts is the lack of coordination between various line departments (Prakash, 2012). Forest, land and water bodies are managed by different departments; cities are managed by municipalities and peri-urban areas by *panchayats* (ibid). In India there is no separate department for urban or peri-urban agriculture or provisioning of extension services. There is no coordination between different departments in sharing data, nor does a common platform for discussing issues or a coordinated action plan for governance exist (ibid).

In a process of sustainable ecosystem-based urbanisation, democratic good governance that is based on the principles of equity becomes critical. The weak and the marginalised need a voice and have to be heard. However, despite legislation to the contrary this rarely happens. In 1992, following the 74th Amendment to the Constitution, India sanctioned the involvement of its urban citizens in planning their future and improving their present. But in real terms it meant the citizens voted in elections once every five years, and citizens' rights, development needs, priorities and goals were forgotten until the next elections. In effect, a top-down approach to development masquerades as a 'bottom-up' approach, further alienating and marginalising the excluded. Good governance and all that goes with it (accountability, transparency and process ownership) is little more than a formality in the hands of the elected elite and participation, at best, is passive.

Yet the state does recognise the importance of good governance for urbanisation, as reflected in the Indian 12th national five-year plan statement. Urban planning in India is a state subject and under the 12th schedule of the 74th Amendment Act, it has been mandated to municipal corporations and municipalities, while regional planning is to be done by state governments. As per the constitutional mandate, district and metropolitan development plans have to ensure coordinated spatial planning, sharing of natural and other resources, integrated provision of infrastructure and environmental conservation (Prakash,2012 . These areas need guidelines to synchronise bottom-up and top-down approaches (Government of India, 2011: 6–7).

The importance of good localised participatory governance and equitable people's institutions cannot be emphasised enough in building urban resilience. The process represented in Figure 1, despite global and regional dimensions, manifests itself locally. It is at the local level that imbalances are created that must be restored and resilience must be built up otherwise the system breaks down irreversibly. GEAG's intervention so far, supported by the ACCCRN initiative and other international programmes, has been to create community institutions that take their own decisions in all aspects of the dynamic linkages between ecosystem services and the components of resilience (see also Singh, 2014; Mani and Wajih, 2014; Bahadur and Tanner, 2014). Resilience at the macro level cannot be built unless the micro level is adequately addressed, reiterating the fact that local communities are the best managers of the environments that their livelihoods depend on. This requires institutions that adequately empower the local and not the supra local, which is not presently the case in Gorakhpur.

3 *http://planningcommission.nic.in/hackathon/Urban_Development.pdf*

3. Characteristics of GEAG's intervention area

The intervention area comprises of two clusters of peri-urban villages. The first consists of five villages: Semra Devi Prasad, Chakra II, Khatwatia, Pipra and Jharwa. The second has three villages: Sanjhai, Nuruddhin Chak, and Jangle Bahadur Ali. The first cluster falls in the Khorabar Block in Gorakhpur District and is located in southwest part of the city's master plan area. The second cluster is located in the northwest part of the master plan in Chargawan Block. Both sites are demarcated for agricultural land use in the city's 2021 master plan.

A survey conducted by GEAG reveals that the total population and area of both the clusters is approximately 18,000 and 450 hectares, respectively. Both are low-lying areas located about 1.5km from the left-hand bank of the River Rapti. Hence, the clusters are prone to recurring floods and waterlogging for two to three months every year. Seventy five per cent of the population in both clusters are of the Nishad community, while the rest (25 per cent) are a mix of Lonia, Nau, Kahar and Muslim.[4] These clusters are primarily dependent on agriculture and casual labour for their livelihoods. At the moment, agricultural activities in both clusters are only possible for nine months of the year. Input-intensive and high-cost agriculture is practised in the area. For the remaining three months, during floods, the community relies solely on income from casual labour, particularly in the second, northwest cluster.

Both areas are known for their vegetable and horticulture produce, and livestock practices. Food produced here is sold in key *mandis* (markets) of Gorakhpur. Wheat is also grown but generally for self-consumption. A small number of households practise flood- and waterlogging-resistant agriculture by growing guava, Indian blackberries and mango, which supports their livelihoods during the three-month flood period.

A significant proportion of both clusters can be classified as low income. About 80 per cent of households are small-scale and marginal farmers with an average landholding size of less than one acre, while a few own about five acres each. The landless households generally lease land from others for a fixed share or for cash (locally known as *hunda*) or a sharecropping basis (locally known as *adhiya*, receiving half the share after deducting non-labour input costs). About 50 households in the southwest cluster own tube wells. Groundwater is the primary source of irrigation in this cluster. By comparison, the northwest cluster has very few tube wells. As across India, in the last couple of decades, in the wake of the Green Revolution, agriculture has been mechanised, with the tractor and hand-held power tillers replacing the plough.

4 *Traditionally, the Nishad were boatpeople and fisherfolk, the Lonia saltmakers, the Kahar palanquin bearers and water carriers and the Nau dancers/entertainers. The Nishad and Kahar have been included in the list of scheduled castes (SCs) in UP and are entitled to benefit from positive discrimination like reservation in government jobs and educational institutions. The Lonia and Nau are included in the list of other backward castes (OBCs) who receive some benefits of positive discrimination but not on a par with the SCs. All these castes were considered 'untouchable'. The Nishad numerically dominate the area and own most of the land. There is substantive internal differentiation. With their traditional occupations no longer in vogue, the other three castes work as casual labourers. Muslims also mostly belong to the lower castes such as the Ashraf.*

Irrigation with the help of bullock-driven water-wheels and other traditional devices has given way to deep electric tube wells. Synthetic fertilisers and pesticides have replaced farmyard manures. There are deep ecological repercussions for these cost-intensive practices on small-scale and marginal farmers, whether they are rural, urban or peri-urban, throughout the country. What is of specific concern here is how changing agricultural practices have contributed to changing agrarian, rural cultures and the impacts of this on ecosystem services as well as climate change resilience.

3.1 The agrarian ecosystem

In the agriculture of eastern Uttar Pradesh characterised by small landholdings, the farmer's field is not an entity that exists in isolation. It has a farm system which also comprises livestock and homesteads as well. The various farm sub-systems are interconnected and also depend on the external environment (physical, social and political): the neighbourhood farmers' fields, land, water, drainage and inputs from nearby ponds (in the form of silt, fish, aquatic products for food and fodder or water for irrigation in the dry season), forests, orchards and open grassland (in the form of fuel, dung for manure wood, straw for housing and cattle shelters). Water, forests, grasslands, orchards and open land ecosystems play an important role in agriculture and the productivity of small-scale farmers (compared to bigger farmers who have a more controlled farming system where inputs are generally derived from the market and products are sent to market). It is important that such ecosystems are conserved and maintained for the sustainability of small-scale farmers and to reduce dependence on external inputs in the farm system.

In flood-affected areas, these ecosystems play an important role in enhancing the water-holding capacity of land during the rainy season and in the management of water, including groundwater recharging. If open areas and water bodies are maintained, the natural flow of water is easier, which is necessary in the Terai where the slope gradient is very low and there is tendency for water holding. The duration of waterlogging can be reduced and hence farmers can harvest the next *rabi* (post-monsoon) crop in good time with the help of natural drainage and water-holding capacity of the area at a micro level (which also affects the macro-level situation). Such ecosystems also conserve soil which tends to be washed away quickly during intense rainfall.

The criticality of such ecosystem-based analyses and understanding highlights that merely considering the peri-urban as a geographical–administrative entity can imperil the lives and livelihoods of hundreds of small and marginal agriculturalists as well as the urban poor and can ultimately affect the very existence of the city. This is explored further with various examples from the field.

4. Research findings

4.1 The land question

Box 2. Changing land use: developers versus farmers

It is all about the land. The land is our maker or our destroyer. Outsiders care for the land only, not for us. City dwellers want our land to build houses on plots and pay a fancy price. But we don't get al.,l the money. The dalals *(agents) take it away. In any case, how long does money last?*

Sonora Devi, aged 65, is a woman farmer from Chakra Doyam village. According to Sonora, her husband Sukku was duped by some realtors of 1.7 acres of land some years ago. The realtors said that they would loan Sukku money for excavating a bore well. Apparently, in lieu of the money, the realtors got the land registered in their own names. The realtors then came to threaten Sukku one day, after which he lodged a police complaint. Nothing else happened after that and Sonora and Sukku continue to occupy the land. However, the villagers give a different version. According to them, Sukku sold the land some years ago for a pittance, and the realtors allowed the couple to occupy the land on sympathetic grounds. Perhaps the realtors were only waiting for land prices to rise. But now that land prices have gone up, the old couple do not want to vacate the land as they want to be compensated.

A major issue in the peri-urban context is changing land-use patterns, which is at the core of the transformation of rural ecosystems to peri-urban and urban ones. This section explores different factors relating to land-use changes.

4.1.1 From agriculture to real estate

As rural/urban fringe areas are included in peri-urban areas (here used in the administrative sense, such as being included in a city's master plan) a speculative land market grows. Realtors and middle-men purchase land for conversion into real estate. However, in the context of Gorakhpur, hard data on land sales and registration is difficult to come by given that the registration is not often done immediately and most land bought by realtors is in small amounts from multiple marginal and small-scale farmers. Selling land is not illegal but the conversion of land to real estate is not allowed in the Gorakhpur master plan. However, most conversion takes place a few years after the initial purchase. In a situation of weak implementation of the master plan and poor monitoring, it is difficult to track the changing land-use patterns. In all probability in the records, much land still remains classified as agricultural, but in reality has become housing, although illegal. This is true even in metropolitan areas like Delhi. When the city authorities try to clamp down on illegal structures, the occupants get stay orders from courts and after a few years, due to political pressures, the colony is 'regularised.'

In almost all of the villages visited for this study, many people mentioned incidents of land being sold to speculators ostensibly for the money (see Box 2). This anecdotal evidence will be examined alongside qualitative evidence. GEAG's 2013 survey of 485 households across the eight villages found that 27.3 per cent had sold land in the last five years. In the present study, in some cases, it was pointed out that with the proceeds the sellers purchased agricultural land elsewhere, in areas that were not flood prone. However, very few sellers actually continued in cultivation, due to the feeling (especially amongst men) that agriculture was no longer a viable operation, a feeling expressed often in other peri-urban contexts. Thus, in peri-urban Ahmedabad and Baroda, only 14 per cent households who sold land reported purchasing more land (Shah and Kumar, 2011: 27; Shah, 2000). Reasons for selling land varied from low viability to a lack of interest among the future generation in farming as a profession. In most cases land was sold to intermediaries, who would eventually sell the land to actual users – including land developers. As a result, a substantial amount of land remained unused for a fairly long time (ibid).[5]

Rampur-Moharipur village is just outside the boundary of the Gorakhpur Development Authority (GDA) master plan. As 43-year-old Binda Prasad remarked, 'Traditionally I am a farmer. But one cannot survive on farming nowadays. Our lifestyles have changed. I had to spend Rs500,000[6] on my daughter's wedding. I could not have spent so much if I were not a railway employee.' Binda Prasad also notes the consequences of his village not being included in the master plan: 'We would have got so many facilities from the government. The land prices would have gone up. I favour plotting [conversion of agricultural land for housing]. If that happens people will move close to the embankment and get better communication and transportation facilities.'

However, Binda Prasad has not given up agriculture, saying that the basic food needs of his household are met from the fields. His example points to the interlinkage of the various sub-ecosystems discussed earlier.

Over the last few years, land prices have risen. Land within the GDA boundary on which houses can be built costs Rs250,000 or US$4000 per *dismil*[7] in the village of Semradevi Prasad. In the village of JangalBahadur Ali it varies from Rs200,000 to Rs250,000. Even in villages prone to waterlogging or flooding, it is Rs50,000–60,000. In villages outside the boundary, even as far as 5km from the city, land averages around Rs50,000 (e.g. in the village of Badni). A decade ago, land within the boundary sold for Rs10,000–15,000 per *dismil*.

4.1.2 Women and land

On the other hand, women are less likely to want to sell their land. Almost all of them vehemently said that agriculture is very viable as long as one is flexible and adapts to the changing situation. Most of them grow vegetables and sell the produce themselves at markets. In the village of Sanjhai for instance, it was found that even marginal women farmers, like widowed Gitadevi (aged 40), makes Rs15,000 a year in profits by cultivating and selling vegetables from her 0.3 acre plot. Enterprising women like Shobhadevi (aged 60), a GEAG model farmer with 2.5 acres land, have combined vegetable cultivation with dairying. This has enabled her to buy consumer durables like a fridge and washing machine, and to convert her mud hut into a brick and masonry two-storey home with marble flooring. She has motivated her husband to collect on an average 70 litres of milk daily from other households and sell it in the city at a profit of Rs15 per litre. Having taken advantage of the new opportunities arising from urbanisation, she says she will never sell her land. Experience from other countries also demonstrates how women can perceive land differently to men – in the periphery

5 *As such, tracking land-use conversion is a complex task. A CEPT study (1997) reported that in some villages about 60 per cent of agricultural land was converted for non-agricultural purposes. However, it was pointed out that the estimates represent significant under-reporting because: a) farmers sell land to other farmers who have the right to use it for non-agricultural purposes – permission is usually a formality in such cases and if not accorded within three months of the application, is deemed to have been granted. Both lead to actual conversion without necessarily being recorded as non-agricultural land use on the official records (Shah and Kumar, 2011:27).*

6 *Equivalent to US$8065 (US$1= Rs62 in March 2015).*

7 *100 dismils = 1 acre.*

of Bamako in Mali, men complained of the loss of agricultural land to residential use with no benefits, while women, for whom access to land had traditionally been difficult but who had a long tradition of independent small-scale trade, saw greater opportunities from higher demand for horticultural products and their strategic location between rural producers and urban consumers (Bah *et al.,* 2003).

In Gorakhpur, none of the women spoken to owned land in their own names: only 10 per cent of Indian women do (Mitra, 2008; Brule, 2012) and even amongst those women, many do not know that they have land titles. The women interviewed traditionally did most of the work in agriculture, but have seen their workloads increase after switching to vegetable cultivation. It is worth investigating in more detail the reluctance of women to dispose of their land, particularly as there is a dearth of literature on changing gender relations in peri-urban transitions. In an era of globalisation and falling returns from conventional agriculture, men from small or marginal farmer households migrate to cities to work, leaving the women behind. In villages around Varanasi, Rao (2012) found that for the women, working on the family farm had become an extension of the household work, but it gave them a sense of identity. Unlike the Bamako women, the Gorakhpur women have no prior experience of engaging in trade or with the market, which is conventionally the role of men. As Shobhadevi pointed out, 'I got married as a child. Earlier like all other women, I also worked in the fields. I do so even now. None of us went to the market. It was the job of men. But now negotiating with the traders, going to the market, gives us a sense of identity and recognition.' Similarly, women in Chakra Doyam go to Gorakhpur to sell guavas, which was unheard of even 10 years ago. All these women said that this was possible due to urbanisation and the urban demand for vegetables and fruits. This has been a positive gain of inclusion in the GDA boundary.

4.1.3 The decline of state support for agriculture

However, inclusion has brought in its wake some negative issues. Nationally, agriculture is going through a critical period with the withdrawal of the state post-1991, through the neoliberal 'new economic policy' era. Indian agriculture has not followed international trends which favour export over domestic markets. However, changes in orientation, the partial removal of state support and the promotion of free private enterprise and markets in an era of globalisation and liberalisation have led to rising income and regional disparities, deceleration and rural distress embedded in an agrarian crisis (Reddy and Mishra, 2009: 3). A key area of withdrawal of the state has been budgetary allocations for the agricultural sector. Agriculture had a 14 per cent share in the central government's budget during India's first five-year plan (1951–56) – this fell to 4.9 per cent during the ninth plan (1997–2000). Average state-level expenditure on agricultural infrastructure has also declined since 1997 and was only five per cent of the average state allocation in 2001–2 (Vasavi, 2012: 77). Institutionally, this has meant the virtual withdrawal of the state and its commitment to land reform or resource distribution (ibid). In underdeveloped districts, it is common for state agricultural policy support to be defined more by its absence that presence. Weak local institutions become complicit in the capture of community resources by the elite (Pritchard *et al.,* 2013:75).

Perhaps the best example of these processes is the current inadequate and inequitable provision of agricultural extension. Only five per cent of small-scale and marginal farmers have access to agricultural extension services (about half the level of access that medium- and large-scale farmers have). Forty per cent of agricultural extension posts remain unfilled (Agarwal, 2011:10) and probably most are in poorer areas, where the marginal and/or tribal farmers live (Pritchard *et al.,* 2013). Agents of seed, fertiliser and pesticide companies often act as 'extension workers' instead (Vasavi, 2012).

4.1.4 The decline of ecosystem services

In the villages visited in Gorakhpur's peri-urban areas, most land that has been sold has or will be converted into housing. These spaces had provided vital ecosystem services such as recharging water bodies and acting as buffers. These services, and their contribution to the city's resilience, are being lost. Supporting services, including nutrient dispersal and cycling, seed dispersal, and primary production have been altered, changing the nature of all other services. The people in Gorakhpur's peri-urban villages now increasingly rely on the market for food and medicines and other goods. There is an acute fuel shortage, leading to reliance on expensive bottled natural gas and electricity.

Conserving these ecosystems is important. However, given the escalating land prices for urban construction and the declining returns to agriculture, concerted action might be necessary involving both urban and rural governments and the people. Stricter implementation of laws to prevent land conversion is necessary. But the people involved – the actual 'keepers' of the ecosystem – also need to be incentivised and compensated to stay in agriculture.

In Gorakhpur, water bodies that were important for recycling waste, water management and flexibility and which created opportunities for safe failures are being reduced due to real estate development. While this is due to a decline in the regulating services of the ecosystem, it also is an example of the loss of control and governance that local people have over their environment. Ultimately, the resilience of the city is affected as a whole. Water bodies are important for various cultural and spiritual needs like marriages, festivals and worship (Mitra, 2010). Such cultural services of ecosystems simultaneously help to protect water bodies and therefore support resilience in terms of flexibility and safe failure.

4.2 Peri-urban agriculture in Gorakhpur

Densely populated intensive smallholder agriculture is the dominant norm in peri-urban areas. Marginal local farmers and poor inner-city as well as rural migrants live side by side and may all be engaged in agriculture in peri-urban areas. With the urban poor spending the majority of their income on food and with limited transport infrastructure, peri-urban production plays a crucial role in supplying fresh and affordable food for growing urban populations which have relatively easily accessible markets (Marshall *et al.,* 2003).

For poor peri-urban communities, agriculture forms a key part of often-diverse livelihood strategies – meeting basic food requirements, as a source of income from selling produce, or as employment e.g. as farm labourers. However, the obstacles to producing safe and affordable food that preserves environmental integrity are immense.

The role of urban and peri-urban agriculture in improving food security and enhancing livelihoods is increasingly recognised (Bakker *et al.,* 2000). But there remains a lack of widespread recognition in policy and practice, and despite the increasing demand for affordable fresh produce for urban populations, the peri-urban interface is often perceived as a temporary 'belt' on the city fringes, and the decline of agriculture is often seen as inevitable to make way for urban development (Marshall *et al.,* 2009).

Peri-urban agriculture generally occurs outside the jurisdictional boundaries of municipal authorities but close to the urban core and are excluded from rural agricultural development programmes, as seen in the peri-urban villages of Gorakhpur. This means peri-urban farmers are excluded from government extension services as well as municipal service provision (ibid: 29) and their vulnerability is enhanced by this exclusion.

The role of peri-urban agriculture in both the urban and rural hinterlands point to potential pathways towards peri-urban sustainability, 'building on better conceptualisation of the multiple and diverse ways in which agriculture intersects with social, economic, environmental and health issues and the diverse perspectives involved' (ibid) and peri-urban agriculture is already part of the Gorakhpur master plan.

However, farmers in these areas do not receive remunerative prices for their produce from the urban vegetable markets due to their poor quality. The short shelf life of vegetables in waterlogged areas makes the distress sale of vegetables necessary. Yet this vulnerable group has no alternative stable source of income. Shared learning dialogues conducted with vegetable wholesalers in the city by GEAG provided clear evidence that a large number of important food items such as vegetables, food grains and dairy products are sourced from peri-urban agricultural lands. But in the peri-urban villages included in the GDA master plan, extension workers were not visible. The villagers said that they received no extension support. The GDA does not seem to have any provision for agriculture, let alone extension services. One villager just outside the boundary affirmed that the extension worker sometimes did come, but they were trained only in cereal crop production, not vegetable cultivation. These deficiencies in extension services are a serious problem for a city seeking to promote sustainable peri-urban agriculture and need immediate attention.

Another major deficit is the provisioning of institutional credit. The government of India provides small-scale and marginal farmers (individually or as groups) with cheap credit through public sector banks by issuing Kisan credit cards.[8] In the villages involved in this study, the dominant form of credit appeared to be from informal sources. Big usurious money lenders-cum-landlords are a thing of the past and farmers borrow from relatives, friends and sometimes local money lenders. Some reportedly take advances from traders. No one reported having a Kisan credit card. The website of the relevant agencies emphasise rural farmers and do not mention urban farmers, which suggests they may not be eligible for these cards and credit. This needs further probing and policy changes if necessary.

While much is made of the government's rural employment guarantee programme (the Mahatma Gandhi National Rural Employment Guarantee Act or MGNREGA)[9] most respondents in the field were rather vague about it and said they did not receive any benefits. GEAG's survey data shows that about 12 per cent of households had no knowledge of MGNREGA. Of the 88 per cent of households that did, only 12.4 per cent were registered under the scheme and had job cards. In the last year, MGNREGA could not provide one day of employment to households in the eight project villages. This is partly because of the low demand for work under MGNREGA given that the workers get at the most Rs 100 to 120 per day working on road construction or other 'public works' (the scheme does not allow work on private lands) while by going to the city or working on other's farms the daily wages range from Rs 250 to 300 per day.

These villagers and farmers are neither 'rural' nor 'urban'. Combined with rapidly changing ecosystems and declining ecosystem services, they receive little or no support from either the state or development programmes. This is partly because governments, policy makers and academics often do not recognise that even in peri-urban contexts agriculture is a part of an ecosystem, thanks to the farmers' ingenuity and inherent adaptive capacities. However, such ecosystems are eroding rapidly due to short-sighted policies and poor implementation of existing policies, underlining the importance of regulatory services such as natural hazard mitigation, erosion control and water management.

4.3 Livelihoods and well-being

Over the last several decades, changes in the nature and extent of floods in Gorakhpur have had an adverse effect on agriculture, health and livelihoods. Marginal farmers are increasingly dependent on surrounding common resources, as well as regional and even global ecosystems.

In Gorakhpur, the ecosystem has been severely damaged and the dependent populations de-linked from their roots. Health, a function of good nutrition, used to rely on locally available herbs and medicinal products. Now junk foods and carbonated drinks are seen as prestige symbols. However, despite modernisation, peri-urban populations are mostly deprived of modern healthcare facilities, often affecting their ability to work. Like the urban poor in many cities across the world, their ability to cope with climate change shocks is restrained by their lack of access to basic infrastructure such as potable water, drainage, sanitation and health services, education and employment opportunities (da Silva *et al.,* 2012; Moser and Satterthwaite, 2008). These are some of the most basic requirements for human well-being and poverty reduction (MEA, 2005: vii) and the lack of them reveals poor or weak regulating systems.

Addressing the deterioration of ecosystem services is directly linked to the MDG goals of eliminating hunger, disease and poverty, and providing universal primary education (MEA, 2005). Both health and education are critical for building resilience to climate change, enhancing the scope of redundancy and safe failures: sick people cannot work efficiently and lack of education leads to failure to acquire the necessary skills to maintain the ecosystem in contemporary times. Socio-economic challenges exacerbate these issues.

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8 A Kisan credit card is intended to provide affordable credit for farmers in India without going through time-consuming bank credit screening processes. Repayment can be rescheduled if there is a bad crop season, and extensions are offered for up to four years. The card is valid for three years and subject to annual renewals.

9 MGNREGA is an Indian law that aims to guarantee the 'right to work' and ensure livelihood security in rural areas by providing at least 100 days of guaranteed wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work.

4.3.1 Sanitation and health

In peri-urban areas in developing countries diseases associated with poverty such as dysentery and cholera are prevalent alongside 'modern' diseases associated with affluence, such as heart disease and stress (Douglas, 2008). In the Gorakhpur villages visited, diabetes and heart disease were reported by some of the more affluent respondents. Given the high levels of alcohol consumed by the men (not just limited to the affluent) this was not unnatural. However, for the poorer people, especially women and children, diarrhoea, stomach disorders and fever (in the absence of blood tests often diagnosed as malaria) were rife, especially during monsoons. Diverse economic and political barriers prevent poor people from accessing healthcare (Marshal *et al.,* 2009). Inadequate living conditions and limited livelihood strategies in peri-urban areas expose residents to risks of injury and ill health (ibid). Poorer groups are also pushed into hazardous, polluted work and living environments. These factors make peri-urban populations extremely vulnerable (ibid; Ompad, *et al.,* 2007), particularly the very young, the immuno-compromised and those of lower caste such as the Dalits.

In the three villages in the Chakra Doyam cluster, effluents and sewage contaminate the ground water and cause health problems. While specific health and environment studies have not been conducted in the Gorakhpur area, waterlogging encourages the spread of vector-borne diseases. Poor sanitary conditions lead to gastrointestinal diseases, which can have consequences of malnutrition (Clasen *et al.,* 2007). Other diseases such as malaria and dengue are also common. Health problems are compounded by open defecation, poor personal hygiene, inadequate sewerage and clean water, and few or no formal systems for managing domestic or industrial water.

In villages like Chakra Doyam and Harijan Basti, home to about 50 poor Dalit households and where the city's waste water, sewage and silage is syphoned, skin diseases are rampant. An embankment constructed in the pre-Independence period to keep floodwater out of the urban wards causes waterlogging. A syphon was constructed in 2004 at a cost of Rs13.40 million, despite local protests and petitions. It drains the waste water from three adjacent urban wards into Chakra Doyam. The discharge has made Chakra Doyam a virtual pond of stagnant water, impacting 100 acres of guava orchards and 50 acres of agricultural lands. Two neighbouring villages have also been impacted and in 2008, five children of Chakra Doyam drowned in the cesspond, leading to clashes between villagers and urban ward residents. The case lies dormant at the *Panchayat* level.

In Harijan Basti, flooding causes health problems affecting both livestock and people – and also impacts agricultural yields. The River Rapti flows close below Chakra Doyam. Villagers explained that previously during monsoons, the waters would cover the fields and fish were abundant. Nowadays, instead of nutrient-rich silt, the waters bring sewage. The fish have disappeared and many fields have been permanently abandoned. Some Harijan Basti residents also allege that the owner of the guava orchards, which provides many people with a livelihood, is planning to sell the land to a housing society due to poor fruit yields.

For poor daily wage labourers living outside the GDA boundary in camps beside the polluted water body, the lack of sanitation is a pressing issue. During monsoons the camps are inundated, so they have used rubbish to raise their huts, adding to the health issues. Commuting is problematic during the rains so many stay on the embankment. As in most other peri-urban villages, the majority defecate in the open. But as one resident asked, 'How does one build toilets when the whole area gets submerged? And where will the money come from?'

These health problems have been displaced from urban areas to marginalised communities living on the periphery of the cities, eroding their resilience. Short-sighted policies have ignored the ecosystem, destroying the services it provides, creating disasters and perpetuating vulnerability.

4.3.2 Socio-economic challenges to health services in peri-urban areas

Health services in Gorakhpur are provided by both the public and the private sector. In addition, some charitable hospitals provide subsidised health services to the poor. Central government also provides some healthcare services such as hospitals and dispensaries. Primary healthcare is provided by 21 first-tier centres.

However, in peri-urban areas, barring the few groups who receive medical benefits, the majority seek informal sector healthcare except during emergencies. As Premadevi, a government health worker of Chakra Doyam explained, 'Even if the government hospital gives free treatment, it costs money and loss of wages to go there for treatment. Very often the prescribed medicines have to be bought from the open market.'

Focus group discussions, shared learning dialogues and individual interviews found a very weak contemporary health infrastructure. This is compounded by the destruction of the ecosystem services that provided preventive health measures, such as better nutrition by collecting greens, tubers and fruits from the common property resources including the banks of the water bodies. The present day curative provisioning, through uncultivated natural foods (from the commons) is weak or inaccessible to the poor.

Many people in these areas use home remedies or visit informal medical practitioners like Ramchand, aged 60, in Chakra Doyam. However, soiled bandages, syringes and needles are not disposed of properly. The spread of infection is not something neither he nor the villagers take into consideration. Ramchand claims that in 'serious cases' he recommends the patients seek treatment in Gorakhpur. Urmila, 40, from Harijan Basti, said that going to Gorakhpur for treatment costs at least Rs30–40,000 and that 'in any case, the patient dies and the money is wasted. So many just choose to stay at home and die.'

The lack of education of both medical staff and patients puts the poor seeking treatment at greater risk. Overriding this are local perceptions of diseases and their causes. There are strong supernatural associations with disease, such as the 'evil-eye.' Traditional faith healers are consulted simultaneously with modern doctors. Most babies are born at home, as described by women in FGDs and health workers. Indigenous childbirth practices have long been forgotten by untrained birth attendants. However, the literature on ecosystem services does not discuss gender issues, even in the area of health provisioning. Women are more vulnerable than men, even in the poorer communities, and a special focus is needed to build climate change resilience by addressing gender issues upfront.

High illiteracy rates are also a challenge, according to a GEAG survey, accounting for at least 45.6 per cent of the population in all project villages. Focus group discussions suggested that children attend school regularly but more for the free midday meal statutorily provided in government schools. Girls are usually withdrawn from school when they reach secondary level. For the peri-urban poor the lack of education and safe, accessible healthcare coupled with economic challenges and the increasing loss of ecosystem provisioning and supporting services are significant challenges to both climate resilience and development.

4.4 Changing cultures

Ecosystem services were once the centre of community life, with employment, education, traditions and gender roles revolving around the land that sustained them. And as peri-urban ecosystems change and degrade, so do the cultures of the area.

For many young people, education and status is associated with urban employment and not agriculture. More importantly, not all households in peri-urban areas have land. For those such as carpenters and smiths that manufactured and maintained ploughs and ploughshares, their livelihoods are redundant. Without romanticising the past (many of these occupations have deep caste-based inequalities) these services providers also maintained the ecosystem and helped regulate it. Fisherfolk not only reared and sold fish (an important source of food) but also maintained the health of the water bodies by regularly cleaning and removing aquatic plants. With the decline of ecosystems due to urbanisation, many such livelihoods have been lost forever, contributing to rapid migration. This in turn leads to shortage of manpower. Most villagers complained of acute labour shortages in agriculture, maintaining common property resources and cleaning roads and drains. With the breakdown of the ecosystem comes the loss of the associated community cultural services and 'collective spirit'.

Being close to the city, few peri-urban residents remain unemployed or without work, with the caveat of caste and gender affecting remuneration and working conditions. Caste (and religious) discrimination leads many young men to seek work in Chennai or Delhi. Pravesh, a Dalit of Rampur Moharipur, works in Chennai as a house painter. Akhilesh works in Delhi as a carpenter. Both said that because of their low caste status, they could not find employment in Gorakhpur and when they did, the payment was low.

For women, urbanisation has brought many freedoms and a sense of identity and recognition. But there are also associated problems such alcohol abuse and domestic violence, even amongst the poorest. Women's education and health are accorded a low priority. For example, Kiran, aged 33, of Jangal Bahadur, lost her husband three years ago. She is from the upper-caste trader community and owns 0.3 acres of land but rather than farm it herself, she has a tenant sharecropper. She says, 'I am not a farmer so how can I manage the land?' She receives no government benefits and survives by selling petty goods, such as ribbons, from a stall in front of her house.

Going by the accounts of the women and girls spoken to, in most social matters there has been a retrogression of their status. This perception could be due to frustration at continuing inequality in gender relations. Urbanisation does not automatically lead to higher levels of literacy and mobility and hence higher status of women (Marshall *et al.,* 2009: 9; Kielman and Bentley, 2003). Emerging new and unfulfilled expectations might lead to new tensions and stresses between and within genders. 'As women experience some aspects of modern life and as they are exposed to ideas of gendered emancipation, so their own "failure" to do so becomes apparent,' (Marshall *et al.,* 2009).

One form of 'emancipation' can lead to new forms of oppression. For instance, women who withdraw from manual labour increasingly are being subjected to elite patriarchal values (ibid). Improved health awareness in urban areas often sees women redefining their experiences of 'natural' women's diseases. Politically, this makes 'poor and marginalised women more aware of their exclusion from health facilities and treatment' (Marshall *et al.,* 2009: 9).

5. Conclusions and recommendations

Using Gorakhpur City as a case study, this paper has attempted to demonstrate how climate resilience can be built sustainably. Protecting ecosystems and ecosystem services in peri-urban areas is essential to the survival of the poor. These services also enhance the city's resilience. For instance, a critical ecosystem service provided by 'open spaces' like orchards and fields that act as buffers can enhance Gorakhpur's resilience to flooding. Construction that usurps these spaces reduces the resilience of the city.

Overall supporting, provisioning, regulating, and cultural ecosystem services enhance the redundancy and flexibility of urban systems. They can help ensure that any failures are 'safe failures' to minimise damage. Critical to the building of resilience is the distinction between hard and soft systems. Most administrators and policy makers focus on hard systems (infrastructure and institutions). But soft systems which enhance the capacities of social agents, including resourcefulness, responsiveness and the ability to learn, are critical to the functioning of the former.

Integral to soft systems are the understanding and use of an ecosystem approach and the systematic development and protection of ecosystem services. However, part of the problem lies in the very conceptualisation of peri-urban areas, which are often only seen as a space between urban and rural areas by policy makers and administrators. For example in Gorakhpur, peri-urban areas are conceptualised as just those villages that are included in the city's master plan, but without using the term peri-urban. In effect, this means that the social, economic, ecological and administrative changes occurring in these villages, as distinct from those villages that are strictly rural (that is in the hinterland) or the villages just outside the master plan boundaries are ignored. Combined with a failure to understand urban and peri-urban areas as ecosystems, this has led to many changes.

In the context of Gorakhpur, the driver of changed has been changing land-use patterns. As the city expands, a speculative land market has emerged and agricultural land is being lost to housing. The shrinkage in agricultural production impacts the redundancy of food production that plays a critical role in augmenting Gorakhpur's food supplies. Water bodies are being increasingly encroached on or polluted, impacting on the lives and livelihoods of many. Provisioning services are critically affected as the poor become more dependent on non-cultivated foods obtained from the commons and domestic animal stocks are declining. Water pollution and soil contamination are increasing as Gorakhpur's solid wastes and sewage are dumped in the peri-urban areas while infrastructure measures to reduce urban flooding are creating waterlogging. Taken together, all these factors impact on the well-being of the people.

Major efforts by policy makers, administrators and residents are required to tackle the crisis. This requires an explicit recognition that an ecosystems approach and realising the importance of ecosystem services is needed if both urban and peri-urban areas are to be developed sustainably and inclusively. Current practices pose a tremendous threat to both the ecosystem and vulnerable populations and are exacerbated by climate change.

Central to a systems approach is the protection of urban and peri-urban agriculture. Peri-urban areas are not 'waiting rooms' for entry to urban areas. A fundamental change in mindsets is needed, to prevent further land-use changes and unregulated construction activities. While international agencies like FAO and CGIAR articulate the need to for supporting policies and practices for peri-urban agriculture (Marshall *et al.,* 2009; FAO 2007), they do not seem to consider agriculture as part of an integrated system within ecological settings which contributes to the overall resilience of the city. Multidisciplinary and integrated administrative land-use planning that recognises the agricultural ecosystem as a core component of the urban and peri-urban natural resources system is essential for this initiative (Marshall *et al.,* 2009; Pothukuchi and Kaufman, 1999).

At the core of redefining 'peri-urban' in the context of Gorakhpur should be a multipronged ecosystem-based strategy that includes:

- Enforcing legislation to prevent the conversion of agricultural land and water bodies
- Recognising peri-urban agriculture as a distinct category, with support in the form of extension services, marketing facilities and institutional credit
- Increasing ecosystem support, such as enhancing soil nutrition and protecting water quality.
- Providing better transportation infrastructure
- Implementing new waste management policies and rules
- Recognising and supporting the role of women in peri-urban agriculture
- Improving education, healthcare and access to existing facilities
- Tackling issues such as chronic malnutrition and disease with better environmental management.
- Ensuring effective citizens' participation in implementing such measures through appropriately formed people's institutions

Importantly, implementing such measures requires good governance coupled with planning 'from below'. The financial requirements for this would have to be met primarily through state funding. Apart from higher budgetary allocations and improved efficiency in government spending, prevention of leakages has to be instituted through greater transparency and accountability to the people. The role of the private sector, through public–private partnerships also needs to be explored.

All of the above would require major policy changes and effective implementation. The authorities tend to overlook or ignore infringements of the existing polices, especially those related to land-use conversion. Yet international examples show that restoring ecosystem services is not only more sustainable but cheaper too.[10]

Short-term profits of converting agricultural and common lands and water bodies for urban housing need to be contrasted with the benefits of long-term planning. In this context, it might become necessary to compensate the keepers of the ecosystem, given the wider benefits that are derived from the services from such systems. Such initiatives might require money upfront – and in sums larger than the present Gorakhpur city authorities have. Without abdicating its responsibilities to its citizens, the government could explore public–private partnerships to maintain ecosystems and the services derived from them in Gorakhpur.

10 *In New York City, where the quality of drinking water had fallen below standards required by the US Environmental Protection Agency (EPA), authorities opted to restore the polluted Catskill watershed that had previously provided the city with the ecosystem service of water purification. The cost of this investment in natural capital was estimated between US$1–1.5 billion, much less than the estimated US$6–8 billion cost of constructing a water filtration plant plus the US$300 million annual running costs. Source: http://en.wikipedia.org/wiki/Ecosystem_services.*

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