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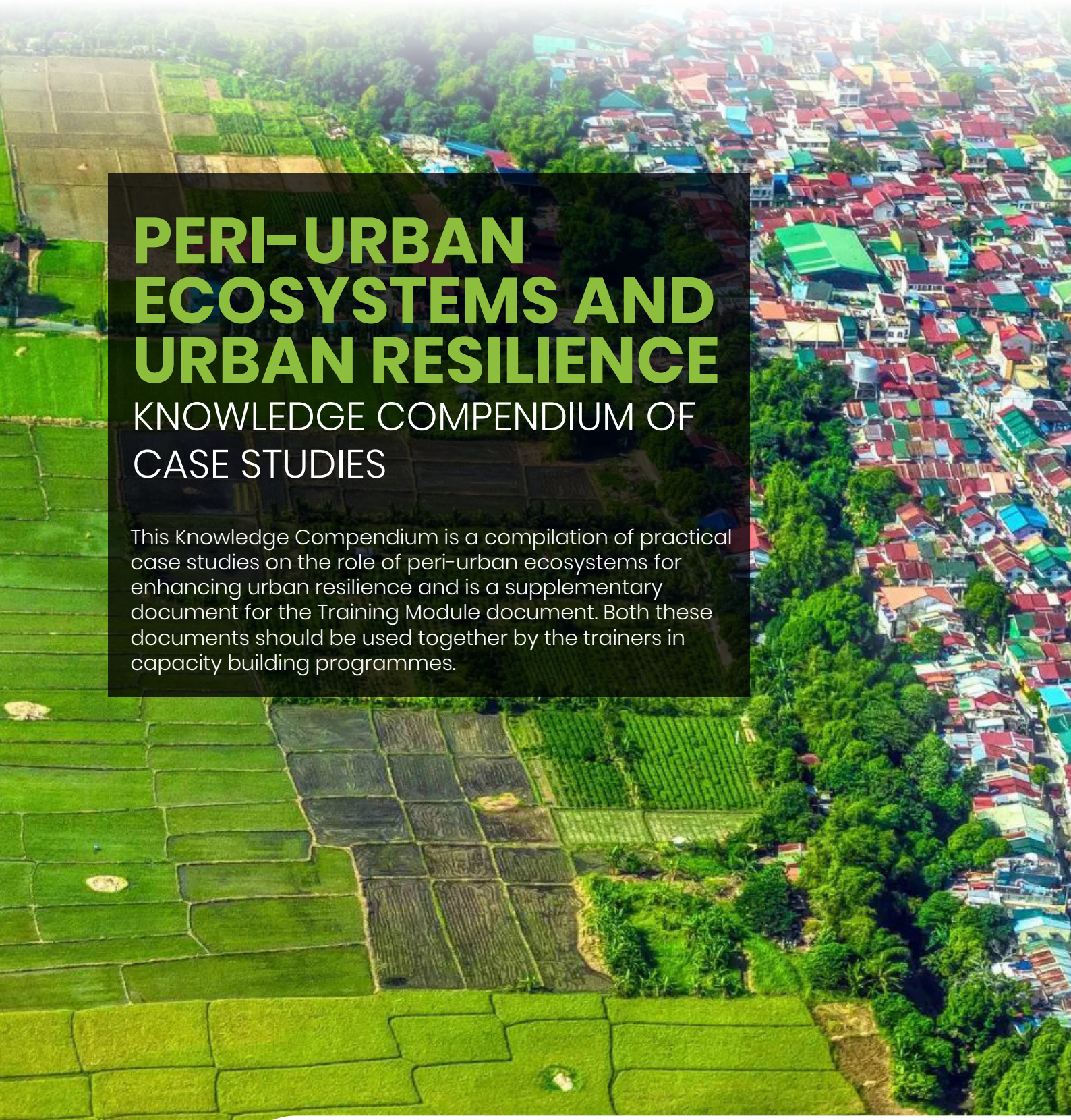

PERI-URBAN ECOSYSTEMS AND URBAN RESILIENCE

KNOWLEDGE COMPENDIUM OF CASE STUDIES

This Knowledge Compendium is a compilation of practical case studies on the role of peri-urban ecosystems for enhancing urban resilience and is a supplementary document for the Training Module document. Both these documents should be used together by the trainers in capacity building programmes.

CDKN Climate & Development Knowledge Network

ICLEI Local Governments for Sustainability SOUTH ASIA

nidm Towards a disaster free India....

GEAG Gorakhpur Environmental Action Group

SPA School of Planning and Architecture

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PERI-URBAN ECOSYSTEMS AND URBAN RESILIENCE

KNOWLEDGE COMPENDIUM OF CASE STUDIES

FOREWORD

Major Gen. Manoj Kumar Bindal
Executive Director
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The present urban dynamics are changing robustly under the disaster risk drivers to environmental changes encompassing climate change, changing land use pattern and natural resource degradation. Cities are likely to take the hit as it is predicted that more than two-third of the global population will live in cities by 2050. Urban resilience encompasses adaptation to risk dynamics and business continuity coupled with sustained improvement towards meeting the developmental needs. Peri-Urban areas serve cities through supporting capacities-ecosystem services, rural-urban connect and input-output systems etc.

Ensuring city and urban developmental dynamics, ecosystem integrity and service flows are essential. Peri-Urban ecosystems are key providers of social, economic and health vulnerabilities by providing resources, buffers and capacities that help in reducing vulnerabilities.

NIDM and GEAG have collaborated in many endeavors supporting research and on ground action projects in the thematic areas of urban resilience and peri-urban ecosystems. The “Peri-Urban Ecosystem and Urban Resilience” is a collective documentation of case studies form various cities pan-India and highlights the connect between the role of urban resilience and peri-urban ecosystems.

This Knowledge Compendium of Case Studies is developed to support the training manual on ‘Peri-Urban Ecosystems and Urban Resilience’. This compendium is developed under the CDKN initiative and is a compilation of practical case studies undertaken in field under various pilot studies. We hope that this compendium will turn out to be a good resource material for researchers, practitioners, academicians and other professionals.

Manoj Kumar Bindal

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INTRODUCTION

The peri-urban is a fast-changing, semi-natural ecosystem which provides natural resources for growing cities in terms of water bodies, open and green lands, and orchards. 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.

The resilience of most of the secondary cities in India 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 provide 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.

Peri-urban ecosystems are increasingly at risk of degradation and loss as natural resource consumption and waste in peri-urban areas increase due to rapid urbanization and increasing human activity. Cities do not operate in isolation but within a “sphere of dependence” on surrounding areas and their ecosystems. As such, the degradation of these ecosystems results in loss of ecosystem services that support urban and peri-urban populations.

This Knowledge Compendium is a collection of case studies from different cities in India which establishes the important connect between the role of peri urban ecosystems and urban resilience.

Institutional Coordination for Water Supply in Shimla

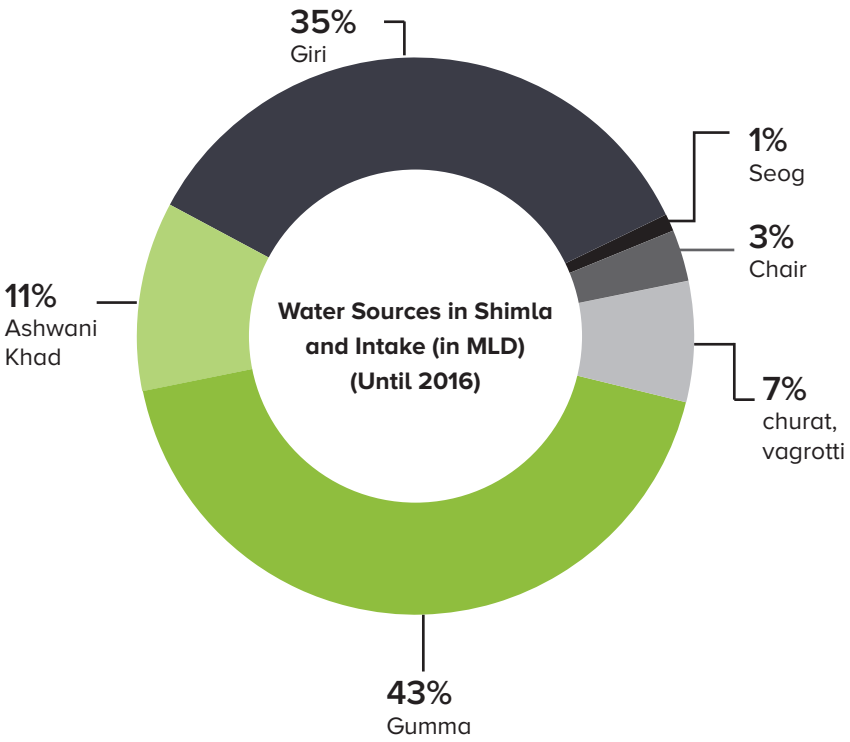
The Crucial Peri Urban-Urban Connect

Shiraz A Wajih and Nivedita Mani

The city of Shimla is located on a ridge. Water has always been a scarce resource in Shimla. After Himachal Pradesh was granted full statehood in 1971, the population of Shimla, being the state capital, increased manifold. The water sources present at that time were the only ones set up by the British supplying 22 MLD of water where the demand was 24 MLD, creating a deficit of 2 MLD. Over the years, this deficit increased with growing population and little augmentation to the water supply.

Until 2016, Shimla had a total of seven water sources of which the two main sources of water, Ashwani Khad and the Nauti Khad (of which Gumma is a part), have witnessed significant reduction in water levels. These existing water sources are tributaries and sub-tributaries of river Sutlej and river Yamuna and lie in the peri-urban areas of Shimla. The entire water sources of the State are managed by the Irrigation and Public Health Department, while the distribution of water to the town is handled by the Municipal Corporation.

The various water sources in Shimla from where water was sourced until 2016 along with the intake in MLD is shown as below:



Sewage Contaminated Water Stream leads to Jaundice Outbreak

A major water-contamination episode struck Shimla between December 2015 and March 2016. There was a Hepatitis epidemic caused by contaminated water from Ashwani Khad – a spring from where Shimla used to get its largest share of water. Unclean water from a sewage treatment plant contaminated the streams in Ashwani Khad, resulting in an outbreak of jaundice that affected more than 500 people in the Shimla city, including residents of the IAS Officers' colony. The sludge from a treatment plant at Malyana, which had a faulty sewage treatment system, was flowing into the Ashwani Khad.

The 3 Sewage Treatment Plants (STPs) were located upstream of the Ashwani Khad water scheme and had not been working since the time they were set up. When the STPs were being set up, the health experts and virologists had warned that hepatitis outbreak may compound in the years to come when the 3 STPs – Malyana STP (4.44 MLD capacity), Lalpani STP (19.35 MLD) and Dhalli STP (0.76 MLD) would run to their maximum capacity in the years to come (as the whole city was not connected to STPs until then) which could discharge upto 24.55 MLD treated or untreated sewage into the Ashwani Khad located downstream.

Despite this warning, the IPH department which happens to be a state-run department did not take much cognizance of this issue and without any discussions with the Shimla Municipal Corporation (ULB responsible for provision of water in the city) went ahead to install the STPs right above the mouth of the drinking water sources. This was labelled as a complete "planning failure" as the 3 STPs were installed upstream of the Ashwani Khad water stream. The Ashwani Khad water source was established in 1995-96 and the STP which came much later, overlooked the placement. And as an added disadvantage, the STPs never worked!

The experts analysed that in winter months, the condition for the Hepatitis virus became more conducive due to low dissolution of sewage in the natural streams due to lean discharge of water in the catchments. During rains, the sewage flow is diluted due to increased water discharge in the Ashwani Khad. So the repetitive Hepatitis outbreaks were taking place only in the winter months. In 2016, the city reported 1620 jaundice cases out of which 9 people were dead. This was a shocking situation for the Shimla Municipal Corporation which immediately shut down the Ashwani Khad water source after the initial investigations.

This entire episode led to the arrest of a junior engineer and a supervisor from the IPH Department for their negligence in preventing the contamination of the drinking water source at Ashwani Khad, which supplied water to several localities in the city.

The governance gap

Shimla is a classic example of unique as well as natural ecosystems, most of which lies in the peri urban areas of Shimla. It is also one of the largest inhabitations on the hills. The urban forests add value to Shimla by providing environmental buffer for the city, absorbing storm water, improving air quality and adding to water supply. The famous Mall Road of the city is situated on a watershed, the drainage from which, on the one side flows into the Sutlej and so into Arabian Sea, and on the other into the Yamuna


Weather Himachal Elections

NEWS / CITY NEWS / SHIMLA NEWS / JAUNDICE OUTBREAK IN SHIMLA DUE TO YEARS OF APATHY

THIS STORY IS FROM FEBRUARY 1, 2016

Jaundice outbreak in Shimla due to years of apathy

City Shimla Mumbai Delhi Bengaluru Hyderabad Kolkata Chennai Agartala Agra Ajmer

TOI

SHIMLA: Once summer capital of British India, Shimla has now become jaundice capital of Himachal Pradesh with a large number of cases reported each year. However, all these years, authorities in Shimla seem to have never bothered to check whether all areas are connected with sewerage lines or have residents been directing sewerage waste into the nullahs. And with sewerage still mixing with drinking water in certain areas, residents still have reason to worry


Sewage treatment plant failure leads to jaundice outbreak in Shimla

More than 1,000 people get jaundice as city's sewage mixes with the drinking water supply

NEXT NEWS ›

By Anupam Chakravartty
Last Updated: Monday 25 January 2016

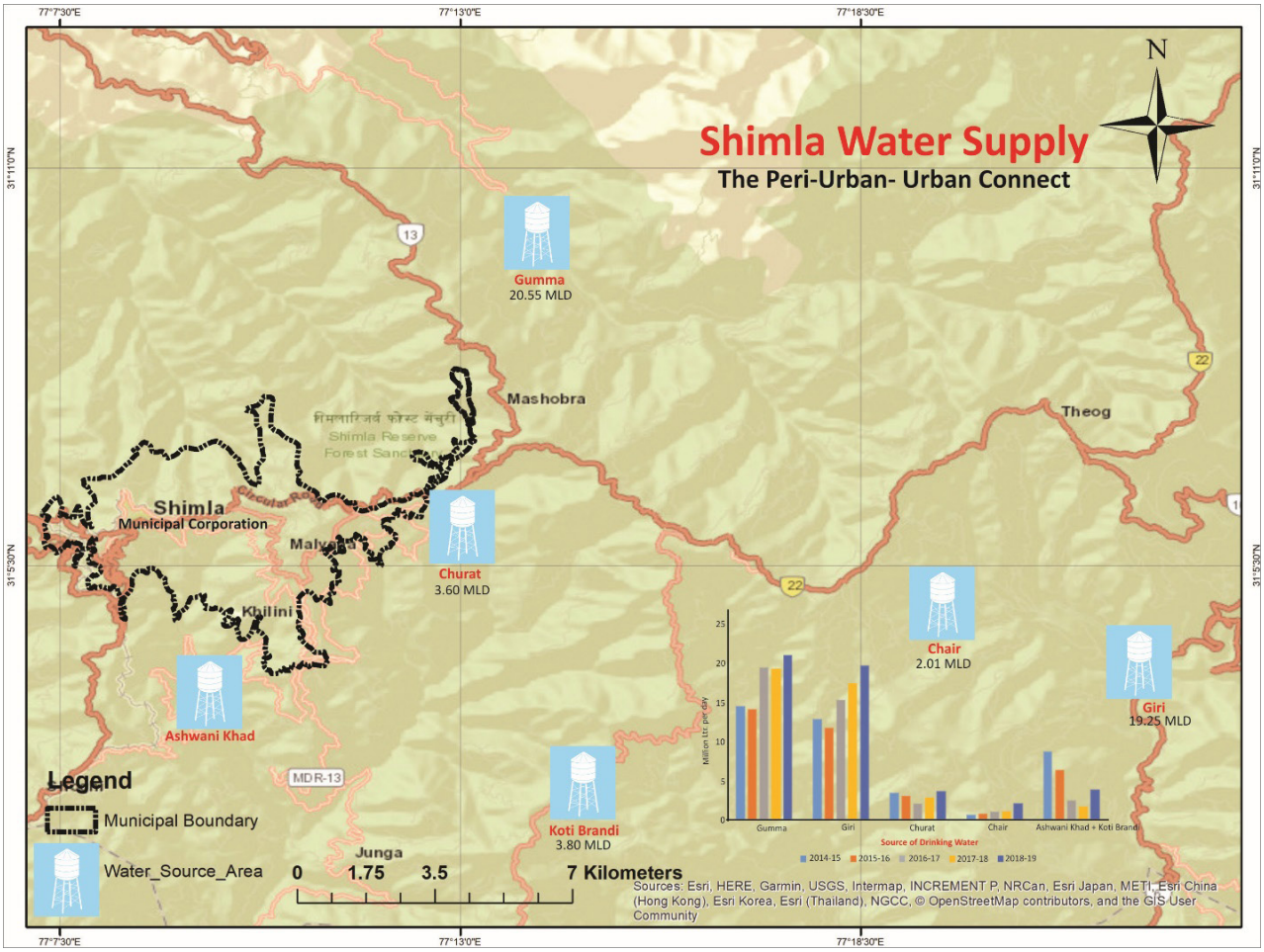
Five people have died and more than 1,000 have been affected in a jaundice outbreak in Shimla. Officials from the city's municipal corporation have confirmed that sewage from two sewage treatment plants (STPs) contaminated a drinking water source, causing the outbreak of the disease.

Shimla police have arrested a junior engineer and a supervisor from the Irrigation and Public Health (IPH) Department for their negligence in preventing the contamination of the drinking water source at Ashwani Kund, which supplies water to several localities in the city. A criminal complaint has also been filed against the private contractor managing the two STPs. But the contractor is absconding, according to local police. Following allegations by various political sections, the Himachal Pradesh government has formed a special investigation team to probe the outbreak.

Deputy Mayor Tikendra Panwar has alleged that despite several complaints to the IPH department, no action was taken against the mismanagement of the STPs. "The STPs have been having problems for the last few years. There are problems with clarifiers and power generators attached to these STPs, which appears to have impacted their functioning," he added. Clarifiers are mechanical settling tanks for continuous removal of solids being deposited by sedimentation before the filtration of sewage.

Health officials say that most of the victims are from Vikas Nagar and New Shimla. A team from National Centre for Disease Control (NCDC) is already in the city to examine the cause of the outbreak. A health official told *Down To Earth* that an average of 50-60 fresh cases are being reported every day ever since the outbreak started in mid-January. Meanwhile, the Municipal Corporation of Shimla has issued advisories against consuming water from Ashwani Kund and has also stopped the supply of drinking water.

The Shimla chapter of Bharat Gyan Vigyan Samiti, a non-profit working in the field of health and science, has raised questions over the functioning of the STPs. "There are six STPs, whose management has been



on its way to the Bay of Bengal. Inhabitants of Shimla depend on these ecosystem services for a decent, healthy, and secure life as these provide for most of the resources like water, food, fibre, and genetic resources.

The water supply system is one of the most fragile urban systems in Shimla. With most of the water sources lying in the peri urban areas of Shimla (as shown in the map below), the cost of fetching and supplying good quality water to its inhabitants comes at a very high cost.

In 2005, a Sewage Treatment Plant was set up above the drinking water source in Ashwani Khad. The experts opined that lifting water to a huge height was not cost effective. They must have ensured that sewage does not get mixed with water through decentralised sewage treatment plants. Unfortunately, IPH department never paid heed to this and the mixing of raw sewage water with the drinking water started happening quite frequently leading to outbreak of Hepatitis E and Jaundice and several deaths every year.

The **lack of effective coordination and convergence** between the IPH Department and the Shimla Municipal Corporation led to the Hepatitis disaster year on year and unfortunately, became a serious one in 2016 causing huge number of deaths.

The Policy and Institutional Reforms in Shimla's Water Sector

There is opportunity in every crisis and the repeated Jaundice outbreaks built momentum for major reforms in the water supply sector in Shimla, 2016 onwards.

As the first step, the state government, jointly with the Shimla Municipal Corporation, set up a dedicated Utility which aims to take over Water Supply and Sewerage (WSS) services for the city. Earlier, these responsibilities were fragmented between different agencies and departments, leading to blurred accountability and suffered from lack of proper coordination. This Utility - the **Shimla Jal Prabandhan Nigam Ltd (SJPNL)** now runs the city's WSS system. Policy decisions such as setting water tariffs and subsidies are done by the state government and the city municipality. This initiative which is supported by the World Bank through a Development Policy Loan

(DPL) is supporting the GoHP's program of policy and institutional reforms needed in (i) bringing bulk water to Shimla from a new source on the Sutlej River after the close down of Ashwani Khad; (ii) 24x7 water supply and sewage management for Shimla City and; (iii) sewage services for peri-urban areas. It will also support capacity building for the Shimla Municipal Corporation to take on its new role of oversight.

With the current reforms in the policy and institutional structures, SJPNL is now able to source 54 MLD of water on a daily basis while the demand is just for about 49 MLD. The peri urban areas upto 300 metres of city's periphery are also being served with water supply. The water quality monitoring system established in the Utility is ensuring water testing at three levels – Water Treatment Plant level, Indira Gandhi Medical College has also been roped in for testing samples and Eco Labs, Chandigarh is also engaged in water quality monitoring.

By doing this, the Government of Himachal has taken a bold step to make the supply of WSS services directly accountable to citizens by devolving responsibilities to an autonomous, professional company that answers to the urban local body. The customer-focused utility has the technical capacity, governance framework, and performance-based management policies needed to provide reliable water and efficient sanitation to the citizens of Shimla.

Shri. Dharmendra Gill, the Managing Director-cum-CEO of SJPNL rightly points out that the two main reasons for this paradigm shift in the water supply sector in Shimla are the much needed policy and institutional reforms. For other cities to learn from this model, it is not necessary that the Shimla model needs to be replicated. Rather, certain principles of good governance, if followed, will be sufficient to bring about a positive change in the water sector. These include:

- Ring-fencing of accounts for which the SJPNL has notified a new policy called as Cost Recovery, Tariff and Subsidy Policy under which all the stakeholders have proper commitment towards their duties. This means that the customers are responsible for cost recovery, government is accountable for subsidies and the tariff structures are made as per the local situation
- Strong institutional structure which includes a powerful Board of Directors and professional staff including qualified technical engineers, customer relations people, communications specialists, managers and so on.

This case shows that Shimla and many other cities in India do not exist in silos and are dependent on their peripheral/peri-urban areas for supply of food, water, goods and services. The Urban-Peri Urban connect and the related governance mechanisms are very crucial for the holistic resilience of cities and the peri urban areas as well. Specifically, water needs to be looked at as an eco-system and not a commodity in a decentralised manner and hence the urban-peri urban governance becomes very important for the provision of adequate and safe water supply to the cities.

Peri-urban crisis in Visakhapatnam as a result of CRZ violations

Amit Mitra, Bijay Kumar Singh, Ajay Singh

Visakhapatnam is a coastal city situated in the state of Andhra Pradesh. It has a land area of 620 sq.km and an overall population of 18, 81,952 with an average density of approximately 3,320 people per sq.km (Visakhapatnam Smart City Proposal). Agriculture was the main primary sector activity in the last two decades that contributed to Visakhapatnam's' growth. Irrigation was mostly through small rainwater harvesting structures. The sub-urban pockets near Kapuluppada, Mehadrigedda and Gambheeram grew vegetables and commercial crops.

The problem

Encroachment of peri-urban regions: Today peri-urban agriculture in Visakhapatnam is vanishing rapidly due to land diversions for industrial and commercial purposes. Private builders have purchased many acres of lands from smallholder farmers in the vicinity of industries like the NTPC and the Steel Plant. They have developed empty plots for housing on these farms. Consequently, the supply of fresh vegetables, fruits, flowers, milk, meat and eggs from nearby peri-urban areas is reducing. The entire Sagar Nagar colony and Singapore Society in the northern part of Visakhapatnam have developed by acquiring agricultural lands. Usurpation of common property resources like grazing lands has led to fodder shortages and subsequently of the farmers moving out of agriculture (Mitra et al, 2017).

Water crisis: Visakhapatnam's water situation is worsening despite its 23 streams and small lakes. With the municipal water supply unable to keep up with the rapid expansion of the city boundaries, many areas face shortages in summer. A recent study covering 936 sq.km (GVMC area and the catchment of the springs draining into it) found that between 1976 and to 2010, there was a 2.48% loss of water bodies. A decreasing trend of the surface area of freshwater bodies was observed at many places as freshwater lakes or small ponds were converted into the land and built-up area. Also, several studies on water quality found high levels of metals like aluminium, manganese, copper, zinc, selenium, rubidium, cadmium, lead and cobalt in the groundwater in the areas like Akkireddypalem, Balacheruvu and Lankelapalem which are in the vicinity of industries like Hindustan Zinc Limited and Visakhapatnam Steel Plant.

Solid waste management: Solid waste management is a serious issue in Visakhapatnam. The Greater Visakhapatnam Municipal Corporation (GVMC) is responsible for waste management. The municipal dumping yard is located at Kapuluppada, a peri-urban locality about 25 km from the city, in Zone 1 of GVMC. Around 920 tonnes of solid waste is generated within the

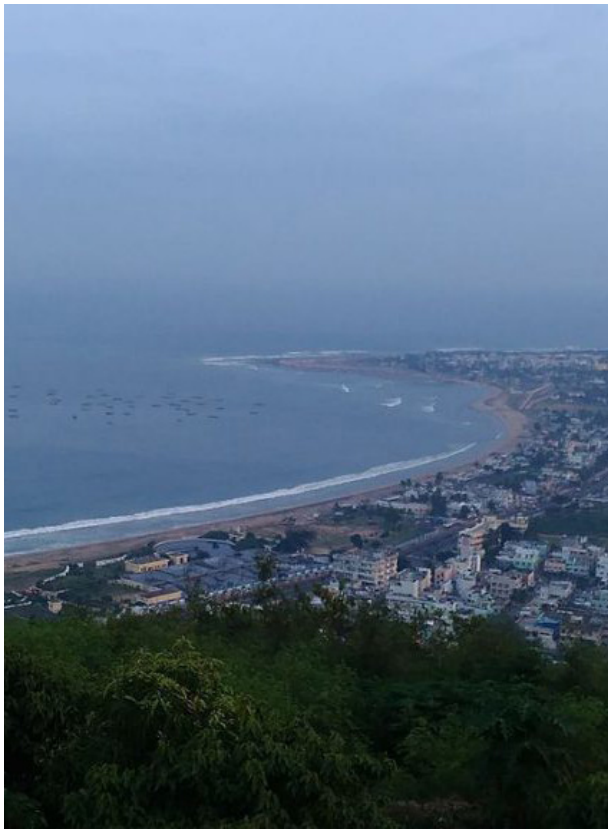
Impact of CRZ violation in Vishakhapatnam

Due to severe Coastal Regulation Zone (CRZ) violations within the city in terms of pumping of groundwater from borewells, groundwater wells especially near the Lawson's Bay area have turned saline. CRZ norms are mostly violated by the construction of hotels, like in the RK Beach area and apartments along the coast. In 2007, the Andhra Pradesh High Court ordered the removal of constructions violating the CRZ, but there has hardly been any action. Many big hotels are trying to regularise their properties. Efforts are on to relax the CRZ norms to facilitate beachfront construction. Aquaculture farms along the coast have put up concrete structures and electricity lines in the prohibited zone along the shore. Around 55 ha of mangrove habitat fall under the Visakhapatnam Port Trust (VPT) area, which extends up to the Visakhapatnam airport. Dredging by the VPT to stop the airport from flooding, the mangrove cover has depleted by 50%.

GVMC limits per day. In most wards of the city, door to door waste collection happens but the waste is not segregated at source. Recyclables like newspapers, plastics and metals are collected by rag pickers. There are no treatment plants and often the waste is openly burnt. Toxins leach into the soil and pollute the groundwater. Visakhapatnam and its peri-urban areas do not have adequate sanitation facilities. Only 48% of the city has closed drains and there is a shortage of sewage treatment plants.

The health issues: In Visakhapatnam, contaminated/ polluted water, lack of sanitation and heavy atmospheric pollution (the city is one of the most polluted ones in the country) due to industrialization is silently affecting thousands of its residents. Diseases like swine flu, chikungunya, dengue, malaria and anthrax have emerged as new diseases in the last 30 years in the city and peri-urban areas due to climate change, deterioration in sanitation conditions, dumping yard and industrial pollution. The human resources in the medical department are not proportional to the increasing population, which results in a lack of services in many areas. With this rapid pace of urbanization and the changing lifestyle of people, diseases like HIV and hepatitis are expected to increase (Mitra et al, 2017).

Marginalization: Peri-urban areas are marginalized in every possible way. This is best reflected in the growth of slums and squatter settlements. Visakhapatnam had around 793 slums according to the 2011 census that housed 44% of the city's households. Visakhapatnam has an additional aspect of marginalisation that is linked to land-use changes. In a blatant violation of CRZ rules, private and government agencies have built hotels and other entertainment sites along the coast.



Conclusion and way forward

Fundamental changes in mindset are needed to prevent further land-use changes and unregulated construction activities. This would require mapping the peri-urban areas and land-use patterns effectively through GIS tools instead of relying on masterplans in addition to strictly implementing the land and water use rules and regulations. It has to be recognised that in a city, the peri-urban need not be homogenous but the variety contributes to the overall resilience of the city in addition to the livelihoods of hundreds of people. The Visakhapatnam study shows this very clearly. Rapid urbanization or peri-urbanization displaces peoples livelihoods, forcing them to join the ranks of the urban informal labour force as casual labour. Fishers, both marine and inland, too need to be recognised and their rights protected. The CRZ rules are violated with impunity by private and state agencies alike, leading not only to loss of livelihoods but also potentially increasing the adverse impacts of disasters like cyclones.

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Urban and Periurban Water Flows

The Case of Gurgaon

Vishal Narain

This case describes urban-rural linkages, typically ignored in planning because of a dichotomous view of urban planning and rural development. The story relates to Gurgaon, located in the north-western Indian state of Haryana. It shows how studies of rural-urban water flows provide a mechanism to study urban and peri-urban linkages and the impact of urban expansion on the periurban areas.

Gurgaon was a sleepy village till the 1980s. After that, DLF, a real estate agency, started buying plots of land for residential and commercial uses. The transformation of Gurgaon was facilitated by three factors: namely, its proximity to the National Capital, New Delhi and the Indira Gandhi International Airport; policies pursued by the state government to promote private enterprise through the creation of Special Economic Zones and the growth of the outsourcing and real estate sectors (Narain 2009). Land use change is a major driver of periurbanization processes: the growth of Gurgaon took place through the conversion of private and common lands for building gated colonies, residential buildings, recreation and shopping centers. Thus the visual landscape of the city reveals a duality wherein the 'rural' co-exists with the 'urban'. Modern residential buildings, malls and shopping centres exist alongside village settlement areas, village ponds and small plots of agricultural land.

This growth of the city has impacted upon the peripheral villages in many ways. Competition for groundwater has increased, and the falling water tables mean that many small and marginal farmers are no longer able to access groundwater. In village Sadhraana, for instance, about 15 km away from the city, many farm-houses have come to be located (Narain 2014). Most of these farm-houses were located on lands overlying what locals call "*meetha paani* (water that is sweet or not saline)". Some farm-houses were built on the lands over the "*khaara paani* (saline groundwater)". The owners of these farm-houses responded by buying small plots of land overlying the sweet groundwater and transporting it to their farm-houses using underground pipes. This is the consequence of an institutional framework in which access to groundwater is tied to the ownership of land. To acquire access to groundwater, you have to be interested in the land lying above it.

Located a few kms away from Sadhraana village is village Budhera. Budhera shows another way in which the ecological foot-print of urbanization is borne by peri-urban areas (Narain 2014; Vij and Narain 2016). As the city of Gurgaon expanded, a need was felt to augment its infrastructure. A water treatment plant was built to augment the water being provided by the water treatment plant located at Basai. This water treatment plant, known as the Chandu-Budhera water treatment plant, was built by acquiring the grazing lands of the village. This is paradoxical as Budhera is a heavily livestock dependent village. Many households had to cut back on the livestock population. However, for several other households, this was not an option. These households responded by switching from grazing to stall-feeding. While taking livestock to graze is the responsibility of male family members or of professional grazers who engage in this activity as a hereditary or family occupation, collecting fodder grass for stall-feeding is the responsibility of women. Thus, this process led to a transformation of gender relations around livestock rearing activities, creating additional responsibilities for women. This

is an important way in which urban expansion impacts gender relations, adding to women's work burdens and responsibilities, over and above their responsibilities at home and on the farms.

These farm-houses serve the social and recreation needs of the urban elite. They are used for family get – togethers and as weekend get aways. It is common to find fruit orchards located in them. One consequence of the location of these farm-houses in Sadhraana village has been that many local farmers have lost access to groundwater, as they cannot compete with the farm-house owners in digging deep into the aquifers to extract groundwater. They are forced to leave their land fallow or take only one crop in a year. A common response to the scarcity of water is the increased use of sprinkler irrigation sets. The case of losing access to groundwater by the residents of Sadhraana shows the negative impacts of urban expansion and land use change on peri-urban residents who lose access to groundwater in the process. This has negative equity implications.

It is important to note that periurbanization processes can also impact gender relations in other ways (Ranjan and Narain 2012). In Sultanpur village, the tasks of collecting water for household purposes have traditionally not been done by women in the upper caste households such as the Rajputs. It is considered against a woman's dignity to go out to collect water. However, with land use change and occupational diversification characteristic of periurban spaces, men of these households started working in the city. The women would then not wait for the men to return home, but instead started going out to collect water. *'Purdaah phaat gaya hai...* (the veil has been removed)", as they would say. This shows another way in which rural-urban relationships and the movement of people between rural and urban areas impacts gender relations around water.

While there is an appropriation of fresh water from the rural areas in the to the city, there are also reverse flows of wastewater from the city into the periurban areas. Cutting through village Budhera is a wastewater runnel that carries the domestic wastewater of Gurgaon city. This wastewater is heavily relied upon for the cultivation of wheat and paddy. Waste water is appropriated from the wastewater runnel either by installing pipe outlets along the wastewater runnel after applying for the same from the Irrigation Department or by pumping it using diesel pump-sets or electric motors (Narain and Singh 2017). Wastewater flowing from the city being used in periurban agriculture serves two purposes: first, it provides a way of disposing the urban waste. Second, it plays an important role in supporting the resilience of periurban spaces to water insecurity induced by urbanization and climate change.

Many residents of Budhera had lost access to groundwater sources that were located on the lands that were acquired to build the GWS (Gurgaon Water Supply) Canal and the NCR (National Capital Region) Channel, that were constructed to transport water to the Basai and Chandu Budhera water treatment plants, respectively (Narain 2014). Further, the area is not served by an irrigation canal. For these reasons, wastewater remains an important means of irrigation. The reliance on wastewater has further increased because of changes in the precipitation patterns. The region no longer experiences what the locals call "*chaumasa* (the four-month monsoon period) ". Wastewater generated by the city serves as an irrigation choice of last resort. When asked by a wastewater irrigator why he used wastewater, he said "*lachaar hoon*...(I am helpless) (Narain and Singh 2017)".

For paddy irrigation, particularly, farmers wait for the rains. If there are no rains at the time that the crop needs water, they use wastewater. Wastewater irrigation thus serves as an important coping strategy in the wake of growing urbanization and changing rainfall patterns. It is important to note, however, that none of the wastewater irrigated produce is consumed directly by its growers; instead, it finds its way into the wholesale market.

The use of wastewater in periurban agriculture shows yet another way in which the rural and the urban are related through flows of water and agricultural produce: wastewater flows from the city into the peri-urban areas and there are reverse flows of the wastewater irrigated produce from the peri-urban to the urban areas. In the face of growing urbanization and climate change, wastewater generated by the city plays an important role in supporting periurban livelihoods.

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Diminishing Lifeline of Panjim's Resilience: The Khazaan lands

Tallulah D'Silva

Panjim was awarded as the capital of Goa in 1840's when the then Portuguese colonizers were forced to shift their trading base and then capital city of Velha Goa (Old Goa) after it was nearly obliterated by an epidemic. Panjim before this was largely a hillock with an orchard at its periphery and marshy lands. These are one of the oldest man made and built systems that exist in Goa which date back to more than 3500 years, aeons before the Kadambas ruled over Goa and the more recent colonization by the Portuguese roughly around 500 years ago. These are basically the flood plains along the river that were formally organized or built to harvest the natural resources from the river. These systems called Khazaans were built to support many traditional occupations. The local communities would harvest salt in the salt pans, fish, shrimps, crabs and oysters from the ponds interconnected by the backwaters and rice too. Goa has 9 rivers and all along these rivers, the Khazaan lands were built.

In the recent times, the climate change induced threats in Panjim has generally been sea level rise, flooding due to changes in rainfall patterns and intensity, and coastal erosion of beaches. Panjim is prone to sudden flooding due to heavy rains, leading to disruption in urban services power. Coastal communities, which depend on coastal ecosystems for resources and livelihoods, are especially vulnerable to the impacts of climate change involving: the loss of beach- space and coastal commons, loss of livelihoods, flooding of settlements, deteriorating health and living conditions, and eventually displacement. The watersheds of the Mondovi river basin around Panjim is both unique and highly vulnerable to climate impacts. Rapid urbanization has affected drainage in the unique, coastal, estuarine agro-system of *Khazaan* lands around Panjim and reduced resilience of communities.

The Peri Urban around Panjim

Panjim's peri urban areas largely have the *Khazaan* lands and also agrarian fields and wetlands all along its periphery contiguous to the adjacent villages of St Cruz, Taleigao and Merces. The *Khazaan* lands were built adjacent to the Mandovi river as well as its estuarine creeks of Ourem and St Inez. All rivers that flow into the sea are saline, having brackish water and are

Khazaan land structure

approximately around 40 kilometers from the coast. The rivers swell during rains and therefore, many of these have large floodplains that are rich in silt that gets washed down from the hills and mountains of the Western Ghats along the eastern length of Goa. The communities that lived around these flood plains built this network of raised embankments called dykes or bunds with sluice gates at strategic locations along the river and further inland within the backwaters of the *Khazaan* lands. These sluice gates allowed the river water during high tide to flow into the backwaters and into the series of shallow troughs or *poims*. The pressure of water would push the doors of the sluice gates allowing the river water to flow into the channels and along with it, fish spawn would also flow in. When the tide would change, the gates would automatically close allowing the water to stay within as it slowly trickled out and the fish spawn would thrive in these waters, safe from its predators. Since the sluice gates were the only points of entry and exit, fresh fish and shrimp would be caught at these points using small fishing nets. These were systems that allowed fishing in the *Khazaan* lands without the risk of going into the unpredictable waters of the sea.

The *Khazaan* lands stretched between 3.5 to 4 kms inland from the river edges lined with mangroves. Besides channels and sluice gates, there were salt pans within this stretch of the *Khazaan* lands. Here again, every year post monsoons, the water from the trough is pumped out while sealing the sluice gates with clayey soil mixed with dry hay/grass. The pans and channels are then repaired and firmed up over a period of nearly a month. Then the salt water from the river and backwaters which has less than 40% salinity is allowed to flow into the series of channels into the shallow pans. Over a period of a few days the water keeps evaporating leaving crystals of salt behind. The first few cycles of salt have lots of silt and therefore was traditionally used to nourish soils in coconut or fruit orchards. Traditionally, this solar salt was also used as an effective remedy for sore throats and colds. Beyond the stretch of this portion of the salt pans, the backwaters of the *Khazaan* lands have a series of troughs lined with mangroves rich with local fish like mullets to thrive in these shallow waters and then finally at the tail end beyond the dykes, these lands were used to grow rice. Goa and Kerala are the only 2 states where a particular species of red rice is grown that can tolerate salinity. In Goa it is called '*khorgut/ korungut*.

Panjim's peri urban areas also include a large stretch of agrarian lands that are also part of the Khazaan lands. The portion in the adjacent villages of Taleigao, St Cruz and Merces are still cultivated today for rice as well as local vegetables. Taleigao is historically known for its agrarian wealth. It has given its villagers food security. The Konsachem fest or the harvest feast was traditionally celebrated with Taleigao taking the lead. These low lying areas have high water table and help the rain water flowing down the Nagalli hills to percolate into the soil as well as the rest flows via channels into the St Inez Creek. The fields of Taleigao are well known for unique local vegetables like brinjal, amaranth, radish, sweet potatoes, etc. The wetlands along these fields are a living infrastructure allowing biodiversity to thrive and protecting the higher lands from flooding.

Salt Pans

Agrarian lands

The Ecosystem Biodiversity

Panjim is perhaps one of the few cities that has a mangrove forest all along its riverine or creek edges and *Khazaan* lands. There are roughly around 14 species of mangroves found in these peri urban areas. The mangroves support unique biodiversity like mud skippers, fiddler crabs, mud lobsters, fish like mullets, pearl spot, mutri, etc, shrimps, crabs, bivalves and oysters. These play a role in enriching and aerating soils, arresting erosion, etc. There are a number of local as well as migratory birds that often visit these areas teaming with snails and alga which are a rich source of food for birds like red shanks, black winged stilts, Asian open bills, painted storks and the lesser adjutant storks. Otters and the marsh crocodiles are often found in these areas too! The locals worship the crocodile as its protector in an annual ritual called '*mange thapnee*.'

Ecosystem services and benefits

The mangroves, wetlands and the agrarian fields in the peri urban areas of Panjim help in carbon sequestering, soil formation and soil retention, nutrient cycling, water cycling and filtering of water, production of atmospheric oxygen, generation of biomass, regulation of floods and checking soil erosion. These areas also provide relief to urban cities for recreation and opportunities for improving health and wellbeing. The *Khazaan* lands also aid with food production like salt, fish and rice which is Goa's staple. Therefore, they provide livelihood opportunities.

Disappearing Khazaans

The *Khazaan* lands and its systems were originally managed by the people of the community. During the Portuguese colonization, these thrived because they were systematically managed and in the absence of refrigeration, salt was used largely for preservation of food. So the salt pans also flourished. Post liberation, these lands fell into private ownership and management of these became very difficult. With local labour becoming difficult to find, today the few salt pans that are surviving have workers who come from nearby coastal villages of Gokarna in Karnataka. With refrigeration the use of salt for preservation has largely reduced. So from nearly 300 salt pans that existed in Goa at one time, there are barely 30-40 saltpans that are active today.

The fields are also under pressure from development. With land in the city becoming scarce, fields are seen as lucrative lands that can be converted for commercial and residential use. Fields that haven't been cultivated for a few years are seen as useless and its ecosystem benefits are ignored. Debris are often dumped in these areas hastening the degradation of these once cultivated lands. Over the years, the contiguous sections have been filled up and constructed upon impacting the larger seamless

connections. The fields adjacent to the *Khazaan* lands are often affected by salt water intrusion due to lack of maintenance of the bunds/dykes.

The key historic location of the '*Konsachem fest*' which used to be in a large section of the *Khazaan* lands is under threat from filling up of debris, garbage dumping and sewage pollution from the houses and colonies on its fringes.

Every year the water levels are rising with the increasing heat. The fields in the peri urban areas of Panjim as well as the *Khazaan* lands are unique infrastructure of the city for protecting it from the vagaries of climate, its climate resilient armour.

The mangroves along the coast and riverine areas is another buffer that in a way protects the coastal city. These therefore, need to be protected and conserved for posterity. Their role and ecosystem benefits and services need to be understood and retained as assets of the city in all the development and future plans for the city.

The development activities have significantly impacted the ecology and economy of the *Khazaans* and estuarine areas. The pace of degradation of the *Khazaan* ecology has increased in recent years due to short-sighted planning, public apathy, industrialization and urbanization.

Conclusion

Over the years, awareness about these peri urban areas has surely increased with regular walks being conducted for students, youth, citizens and stakeholders by many individuals as well as responsible tourism entities. A lot has been written about the wealth of the *Khazaans*, food security as well as its role as climate resilient infrastructure. Such citizen participation is the first step leading to conservation.

The local body as well as the Goa State Biodiversity Board acknowledges these areas as eco-sensitive hotspots and has recommended that all these be included in the People's Biodiversity Register that are currently being prepared by the respective Biodiversity Management Committees of the city and its suburbs.

Further to this effort, the Planning and Development Authority, Town and Country Planning Department too needs to integrate these areas as Special Zones and completely bar any development or land use conversions of these critical green and blue belts so that this age old climate resilience infrastructure is conserved in all the development plans for the region.

The government should help the creation of detailed ecosystem and site-specific protocols and guidelines based on global and national best practices. For this, they will need to incorporate cutting edge technologies and traditional knowledge systems for the restoration and conservation of marine ecosystems such as the mangroves, *Khazaans*, dune vegetation, and so on, using an ecosystem-based adaptation approach. Building bye-laws in coastal settlements should integrate ecological approaches with resilient infrastructure as a construction norm. Individuals, communities, NGOs, government and policymaking bodies can play a crucial role in combating future adverse impacts.

Changing land use and growing water insecurity in Mukteshwar

Vishal Narain

The case of Mukteshwar represents a case of amenity-led mingration, wherein the migration is led by aesthetic rather than economic reasons (Chipeniuk, 2004: Moss, 2006; Perlik 2011). In this case, we look at the changing flows of people between Mukteshwar and urban centres led by the region's pristine and scenic beauty and pleasant climate, and its implications for local water access.

In this case, we describe how land use change has impacted the access to water of the residents of villages in Mutkeshwar, in the Kumaon Hills of the North Indian state of Uttarakhand. We further show how the impacts of these changes are aggravated by climatic change and variability. The case shows how rural-urban links through the movement of urban residents into Mukteshwar bring about land use change, which in turn has implications for the water security of the local resident

Mukteshwar is the name of a sacred Shiva[1] temple in the Kumaon hills of the North Indian state of Uttarakhand. What is popularly referred to as Mukteshwar, however, is a cluster of villages around the temple. The region is known for its scenic and pristine beauty, pleasant climate, fruit orchards and breath taking views of the snow clad Himalaya. It is dotted with trees of pine, deodar, rhodedondron and oak. Writings on the region, such as those of the naturalist Jim Corbett, document its rich flora and fauna. Wheat has been the dominant crop in the region. In recent years, however, there has been a shift towards fruits and vegetables.

Mukteshwar is preferred over the surrounding tourist areas such as Nainital, Almora and Ranikhet as it is still relatively unspoilt. Land use change started in Mukteshwar in the 1980s and has accelerated over the last two decades. Land use change has taken place mainly for building tourist complexes, resorts and hotels, and to build private cottages that urban residents from as far as Delhi and Mumbai use for weekend breaks or short vacations. Prices for land vary, with the highest price attached to parcels of land attached to springs, followed by those with a good view of the snow clad Himalaya. Most of the up-market resorts are located in the upper reaches of the region, while in the lower reaches there is still much construction underway, which will result in the proliferation of new tourist resorts and complexes in the future.

Traditionally, water was sourced in the region by the local residents from Springs. Each spring had a catchment area of about 2-3 hectares. Local communities were seen as the custodian of these springs; their access to and appropriation of this water was institutionalized on the basis of religious values. These springs were managed collectively by them. Increasingly, the plots of land that are acquired for the above mentioned purposes are located adjacent to springs. The buyers of plots of land prefer to buy plots with springs attached to them; in fact, as noted above, plots of land with springs attached to them command the highest price. One of the owners of a coffee shop and tourist resort, in the course of this research pointed out, ''There is scarcity of water in the area, but I am blessed with a spring on my land".

1 In Hindu Mythology, Shiva is one of the trinity of popular Gods, representing the destroyer. He is the Hindu God of destruction.

When these plots of land are sold off, the local residents lose access to the springs. CHIRAG, a local NGO, used to conduct hydro-geological surveys of the region in the past; they used to identify the catchment area and monitor the discharge of springs. The sale of lands affected the local soil and water conservation activities; the NGO was unable to convince the locals to cease the sale of their lands. The NGO consequently withdrew from its efforts at monitoring and recharging the springs.

A second way in which the access of local communities to water is impacted through this process is that increased withdrawals of groundwater upstream by cottages, tourist resorts and hotels reduces the discharge in the springs downstream.

The occupants of the new cottages of the urban residents further compete with the local residents for the appropriation of piped water supply. As the residents of Letey Bhunga, one of the villages in the region, put it, " all the big houses located in Mukteshwar are of the outsiders, while the small houses are of local residents." The big cottages, located upstream of the piped water distribution network, appropriate the water supply, reducing its availability to the smaller houses of the local residents located downstream. Besides, the new settlers often bribe the lineman - in charge of water delivery from the piped network (that is, in turn, based on springs), to release water to serve them. The lineman therefore deliberately holds back the supply of water, and waits to be bribed. Local residents, unable to match the outsiders in their capacity to bribe, once again lose out in their access to water.

The movement of outsiders into the region, therefore, alters the pattern of water distribution away from local residents in their favour. Thus, we need to see issues of periurban water security not only in terms of the physical flows of water from the periurban or rural areas to the urban areas; but also as represented by the physical movement of urban residents into the periurban spaces, giving rise to land use change and are appropriation of water.

This process of re appropriation of water from the local residents to outsiders and the new settlers has increased the reliance of many locals on water brought in from the adjoining areas. This is the case especially during the summers, when water is brought in from the Kosi River or from perennial streams through water tankers. Water can be bought at prices varying from 3 to 5 Indian Rupees per litre.

The effects of changing access to water brought about through land use change are further aggravated by the impacts of climate change and variability. Narratives of locals point to climate change manifest in declining intensity of winters, reduced snowfall as well as a change in the seasonal distribution of rainfall. Locals also report a decline in the volume of rainfall over the years. This has resulted in a poor recharge of springs. Thus, both demand side and supply side factors have reduced the access of the local communities to springs. On the demand side, the stresses come from changing land use - which in turn, alters water use practices. On the supply side, the reduced precipitation reduces the recharge of springs. Together, urbanization and climate change impact the water security of the residents of Mukteshwar.

The change in the climate experienced by the local communities of Letey Bhunga has caused a shift in the cropping pattern away from grains to fruits and vegetables." Earlier there used to be 3-4 feet of snow, now it is difficult to see snow', as was heard in the fieldwork. This has translated into an increased burden for fodder collection for women, as earlier the crop residue from the harvest of wheat could serve as a valuable source of fodder. Women respond to this in two ways. First, they mobilise their social capital; using norms of reciprocity, they assist each other in fodder collection. Second, they walk one way, to the source of fodder, and return through a commute in a shared taxi.

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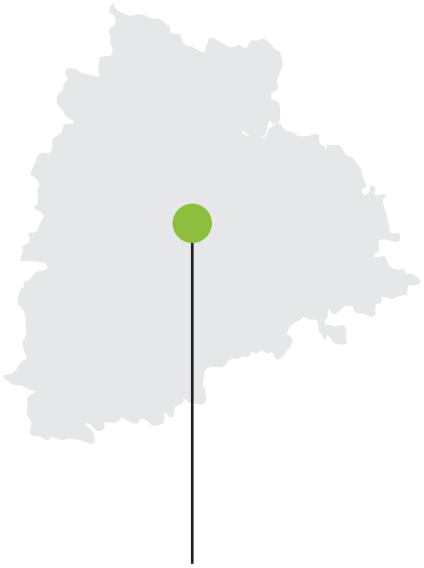
The urban-peri-urban water connect in Hyderabad: implications for resilience to climate change

Anjal Prakash

The urban-peri-urban water connect in Hyderabad

Hyderabad is the fourth most populous cities of India with a population of about 7.7 million as per 2011 census. The city is located on the bank of River Musi in the Deccan plateau in peninsular India. The city was founded by Qutub Shahi Sultans of Golkunda in 15th Century India. Post-independence, Hyderabad became the capital of Andhra Pradesh.



Hyderabad
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In the mid-1990s when India started to liberalise, Hyderabad started to be the major hub for pharmaceutical industries, Information Technology (IT) processing and services industry. Many global companies started its offices in Hyderabad as it became one of the major IT Hubs of India. As a result, Hyderabad started to expand rapidly. A larger district called Ranga Reddy (RR District) was culled out to accommodate this expansion. RR District became the most developed district of Andhra Pradesh in the late 1990s with a global hub of major IT companies. As the city grew in shape and size, the peri-urban areas of Hyderabad showed incremental growth. During 1981-91, this growth was to the tune of 158 per cent (Kamraju & Kamraju, 2018). In 2014, Hyderabad became part of Telangana state that comprised ten districts from north-western Andhra Pradesh. This was due to the bifurcation of former Andhra Pradesh into two states – Telangana and Andhra Pradesh. Hyderabad is the capital of Telangana since 2014.

The Hyderabad UA (HUA) consisted of the Municipal Corporation of Hyderabad (MCH) and several peripheral municipalities. These along with many gram panchayats were assimilated in 2007 and the Greater Hyderabad Municipal Corporation was formed. These areas, also recognised as periurban areas, have become nodes of development post-1990s when the city started growing and the real-estate sector has boomed covering the erstwhile adjoining rural areas. Between 1991-2001, the growth in the municipal corporation of Hyderabad was about 19% while the same was to the tune of 71 per cent in the surrounding areas (Prakash., Singh & Narain 2011; Prakash, 2014).

The rapid expansion of the city has affected its hydrological cycle. Wakode et al (2018) study the urban water balance of Hyderabad City. The study finds that due to rapid urbanisation, the natural hydrological cycle of the city has been disrupted following the water balance of the city. The city does not keep account of its

Photo: SaciWATERs

groundwater withdrawal which is impacting the water balance of the city. To meet the lack of water in newly developed areas in Hyderabad, water transferer from peri-urban areas through tankers have been recorded. An informal water market has been developed that feeds the new housing societies in IT hubs of Hyderabad drawing on water from peri-urban locations (Prakash, 2015; Narain et al 2013; Narain and Prakash, 2016).

This case study examines the nature of the relationship between peri-urban and urban Hyderabad through the water lens. It shows the importance of the practical urban-peri urban connect and how peri-urban areas of Hyderabad has lent resilience to the urban centres. It is divided into three sections. Following the introduction, I look at the issues of water insecurity in Hyderabad through a rise in groundwater markets. Section three looks at the destruction of surface water bodies in Hyderabad which is linked with the exploitation of peri-urban water resources. The last section concludes this case study with implications for resilience.

groundwater recharge and issues of water transfer from peri-urban to urban locations

As the city started to grow, the water supply was the main issue that the new societies and establishments were tackling. The sudden jump in demand was not able to match the supply and therefore elaborate drinking water markets started to develop in the new settlement areas in and around Hi-tech City in Hyderabad. The water need for newly developed housing societies, companies and business establishments were met by tanker companies which were fetching water from peri-urban locations.

In Mallampet, a peri-urban village in Hyderabad, several tanker companies are functioning. These tankers were owned in partnership with local powerful residents to exploit the rich groundwater resource. Most of them operated illegally and without any permission. These companies were operating because there were a demand and lack of enforcement of laws that ban the sale of water. Based on the data collected from individual pumps and selected tanker companies operating in the village, estimates were made for the amount of water extracted and the revenue earned by a few wealthy and powerful people in the village who are ignorant of the dire consequences of rapid aquifer discharge (Prakash, Singh and Brouwer, 2015). Similar markets exist in Kokapet, another peri-urban village in Hyderabad. This village was amongst the largest in terms of several people involved in informal water markets as per the study. In 2016, there were 14 water venders in Kokapet village which used to fetch water from the village to sell in the nearby housing societies in IT hubs as well as in the industrial areas. The Panchayat felt that the village is facing water issue due to increased water vending by individuals. The authors reported conflicts between individual sellers and village panchayat over the issue (Vij, John and Barua, 2019). Sen et al, 2019 studies the same set of villages (Malampet, Kokapet Adibatla and Malkaram) to report that the villages now have moved towards establishing water treatment plants to cater to the demands of this market also sell water outside the peri-urban space for double or four times the price. They also serve the villages they reside in, but larger clients are outside

the village and located in the new housing societies in the neo-rich urban locations. These places are populated by new professionals who are now working in the IT and pharmaceutical industries in Hyderabad. The authors point out that they fill an important gap created by a lack of public provisioning in peri-urban spaces to provide free and safe drinking water.

The larger question is – who is benefitted by the sale of water? It is largely the influential individuals who had money to invest in water extracting infrastructure. They violated the laws and sold water, which was common property, for private gains. These situations would not have arrived if there was no market. The market was created due to the new area which was developed to house new IT and pharma companies, but the new urban locations did not plan for water supply and sanitation infrastructure (Narain et al, 2014). The gaps were filled up by the local water markets at the cost of drawing their resource base. The fact that these markets keep moving interior as they drain the resource bases slowly, show the irreversibility of this phenomenon where groundwater bodies were not able to recharge themselves (Narain and Prakash, 2016). The drawdown has outnumbered the groundwater recharge rate and so the aquifer started to dry up soon (Cronin et al 2014).

From sponge city to a city of water crisis: The story of the destruction of the surface water system in Hyderabad

If the increased urbanization in the post-liberalization era is to be blamed for the water supply crisis of

Photo: SaciWATERs

Hyderabad, what lies beneath is a larger process. It involves systematic destruction of lakes and ponds of Hyderabad. The city was part of the unique system of rainwater harvesting that was created by earlier rulers not only in Telangana but almost entire south India and Sri Lanka. The system of water harvesting through cascades of tanks for irrigation and drinking water needs were first built during Kakatiya Dynasty (1163-1323) which were strengthened by the QutubShahi rulers (1534–1724 AD) and later by the Asaf Jahi rulers (1724–1948). During the latter part of the years, some of the large tanks built such as Hussain Sagar, Mir Alam, Afzal Sagar, Jalpalli, Ma-Sehaba, Talab Katta, Osman Sagar and Himayat Sagar. All these tanks are artificially built, and residents of Hyderabad are still dependent on some of these large tank systems (Rekha Rani, 1999, quoted in Ramachandraiah & Prasad, 2004).

Most of these lakes are now declining due to three main reasons. First, these lakes were built on a

Photo: SaciWATERs

Photo: SaciWATERs

cascade which was linked from one and another in a honeycomb style. All these lakes were connected through feeder channel that had diverted the excess rainwater from one lake to another across the plateau. The rampant infrastructure development and urban planning in Hyderabad have largely neglected these channels leading to encroachment and unauthorised constructions. Most of the feeder channels have disappeared or have been appropriated (Mishra, 2017). Second, once the lakes which were part of the larger system started to become independent, their catchment areas reduced, and they started to dry up. It became open to encroachments, transfer of lands for non-lake use and more for building infrastructures and grounds for waste collection (Vani & Kamraju, 2016). Third, some of these lakes were systematically encroached to build housing societies as the value of land increased manyfold (Prakash, 2014; Cronin et al 2014).

Most of the declines have happened in the post-independence period and much more when Hyderabad was declared as an IT hub and when companies started flocking to the city to set up systems for operation (Ahmed et al, 2016). In just 3 decades, Hyderabad, which was considered a sponge city has become a drier city with acute water problems For the neo-rich, this issue was not there as they could buy water and have 24X7 access to the same (Das and Skelton, 2019; Kuamr et al, 2020). The people who lost this race was the poor and marginalised who can not afford buying water and their wells started to dry due to increase selling of water from the peri-urban areas.

Water insecurity, climate change and the peri-urban question: implications for resilience

One of the major stressors which have marked the city is increased variability in climatic conditions. The city has experienced extreme heat as well as flood all in 6-7 months in recent years. Years after years, some areas of Hyderabad are getting flooded as a huge rainfall is occurring in a shorter period (Vemula et al, 2019). In 2020, also, major locations in Hyderabad got flooded. With major water channels being blocked, water had no ways to get out to the Musi river leading to many low-lying areas getting inundated. Thousands of people got affected especially from slums and housing societies which were built on dried tank beds, a natural water path. These issues brought in water insecurities and health complications for many people. The larger question is how a city like Hyderabad builds resilience to climate change? First and foremost, the city must protect its water bodies. Even after the destruction of many water bodies in Hyderabad, there are still many ponds and lakes which stands tall even today. Their feeder lines may have been disconnected and hence it requires a lager hydrological mapping of the present situation. These tanks which were part of the chain of tanks in the past, are now become independent and so started to dry up. One of how it could be recharged is to connect rooftop rainwater harvesting pipes to be drained into the nearby lakes, thus recharging the lake as well as water supply

bores in the areas. Most of Hyderabad still relies on individual bores and not on the water supply systems, these provisions will help in recharging their borewells. Second, all new and old housing societies must build rainwater harvesting systems. For the new societies, building permission should not be granted if the rainwater harvesting system is not planned. If not, then urban Hyderabad will continue to rely on peri-urban and rural locations for their water supply. In future, large conflicts may break out reported in the case studies.

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Circular Economy: Urban Resilience through Peri Urban Ecosystems

Shipra Singh, Ajay Singh

By adopting different practices, rapid urbanization at the peripheries of urban areas can be restructured into a more environmentally stable system. In recent times, urban expansion has led to creation of a new region called 'peri urban' with its own unique social, economic, environmental and institutional characteristic. Nevertheless, these regions are highly vulnerable due to a number of factors. Burdened by the growing cities, the natural resources such as land, water and air are greatly affected in peri urban regions. The increasing urban dependence on these regions makes them vital for planning and policy formulation. Under the interventions of Gorakhpur Environmental Action Group (GEAG), peri urban agriculture has been witnessing many innovative approaches to develop resilience. This case study documents the significance of peri urban regions in developing urban resilience and how these regions serve to be a bulwark for urban areas. The case study analyses different roles peri urban ecosystems play, the challenges they face and how a concept of circular economy will be helpful in becoming a way forward for these regions.

Rapid rate of urbanization in India, has led the cities to continue expanding their urban margins. The effect of urban sprawl can be witnessed more in developing countries and is expected to double by 2050. India, being a developing nation, can hence be predicted to face new concerns and challenges in future. The urban population in the world since 1970s was 40 percent which is currently expected to rise by 60 percent in 2025 (Anjal et.al., 2011). The changing land use pattern, rapid industrialization, migration and transformation in agricultural practices have led to an accentuated urbanisation. Increasing urban disasters, goods and services, urban governance challenges and other such factors have led to growing realization about the importance of 'peri urban' space around cities with its unique social, economic, environmental and institutional characteristics. As the peri urban regions are peripheral areas, they are quite hazy to distinguish from urban or rural regions (Manasi and Raju, 2020). Roughly understood, these regions are defined to be a subtle boundary between urban and rural areas, an urban fringe, a lacking area, a transition zone, new kind of rural-urban hybrid, a challenging periphery and so on (Varkey and Manasi, 2019).

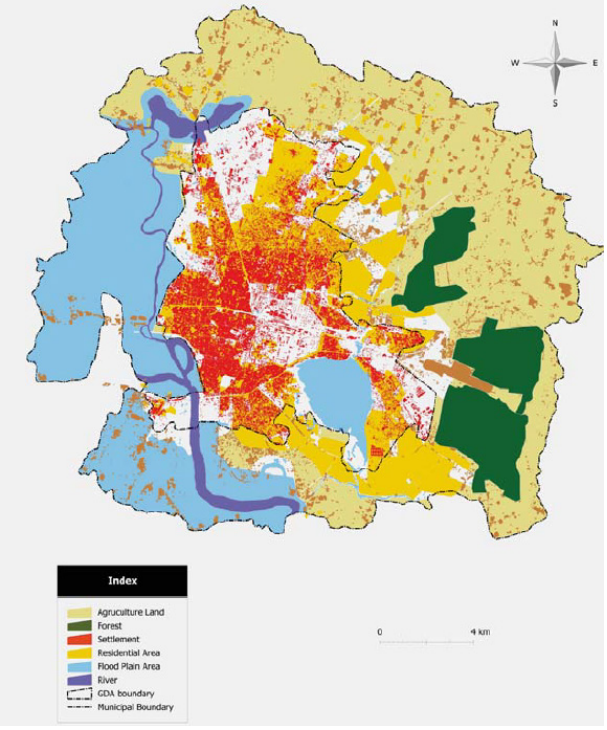
These regions are crucial for understanding as they are highly vulnerable due to a number of factors. Lack of infrastructure facilities and poor economic status of people form the core of these challenges. A significant amount of untreated solid and liquid waste ends up either in freshwater sources (rivers, lakes, ponds) or in empty land sites (Varkey and Manasi, 2019). The anthropogenic drivers of climate change in the form of land degradation, pollution, changing livelihood patterns, dumping industrial waste into surface and groundwater have further resulted in an intensified rainfall and temperatures (Ramasamy et.al., 2018). these regions are highly prone to illegal land acquisition and encroachment due to lack of any proper regulation or advocacy (Saxena and Sharma, 2015). All these factors pose a serious question mark on the meaning of a peri urban region narrowed down to just becoming a 'dumping ground region' for urban neighbourhoods.

The City of Gorakhpur

Gorakhpur is becoming one of the fastest growing urban economies in Uttar Pradesh. Located in the *Terai* region of Uttar Pradesh, the city has a total area of 147sq. km and divided into 70 administrative wards. It is a secondary city which is located at the confluence of rivers Rapti and Rohin. Having the potential of falling under the leading cities, Gorakhpur still faces a myriad of problems related to urban planning and natural disasters. The city has a natural inclination towards floods due to being located at a lower elevation than river Rohin along which it rests. The city collects excess water discharged from Nepal in its bowl-shaped topography. This is further aggravated by climate uncertainties which might further increase the rainfall intensity by 10 to 20 percent in future. This is a major factor due to which small and marginal farmers inhabited in the adjoining areas of city suffer from crop losses (Bhatt et.al., 2016). Despite flooding being a major calamity in this region, anthropogenic activities such as encroachment of land and illegal construction around the floodplain of river Rapti is being manifested in many parts. (Mani and Wajih, 2014). The farming community around Gorakhpur city includes 90 percent of small and marginalised farmers who often have very small land or high vulnerability to floods. Due to lack of a concrete policy and insufficient capital and resources, the young farmers easily fall into the cycle of "distress migration" (Mani and Wajih, 2014).

Peri urban-urban resilience connect in Gorakhpur can be understood in terms of the ecosystem services peri urban regions bring to the urban regions. Gorakhpur's northern, western and southern areas have water bodies such as lakes, ponds, *tals* (depressions) that provide regulating services in the form of collection of excess flood water, acting as natural reservoirs and carbon sequestration Supporting services in the form of soil erosion control, nutrient enrichment etc. indirectly benefits the local population and nearby urban areas through food security, livestock rearing, horticulture and aquaculture (Mitra et.al, 2015). Owing to their significance, the peri urban regions therefore, need to be acknowledged properly through technical, local and administrative interventions through a framework of circular economy.

Figure: Gorakhpur and its Periphery (Bhatt et.al., 2016)



Girard and Nocca (2019) have described circular economy to be based on the principle that in nature nothing is "waste" and everything can become a "resource", and is proposed to operationalize sustainable development principles. By adopting different practices, rapid industrialisation at the peripheries of urban areas can be restructured into a more environmentally stable system. The concept of circular economy is focused on minimizing untreated waste and harmful emissions and stressing more on recycling and reuse. Adoption of this framework helps in generating benefits in terms of social, economic and environmental and to recover lost natural resources (Kakwani and Kalbar, 2020).

Recognizing the connection between peri-urban ecosystems and rban resilience, efforts were made to strengthen the circularity of economy amongst these spaces resulting in a win-win situation. Conservation of natural infrastructure and ecosystems and re-cycling and re-use mechanisms in peri-urban areas on one hand helped the livelihoods and production system of communities in peri-urban spaces and this also helped in enhancing the buffering capacity providing resilience to city.

1. ***Wastewater Treatment:***

   Dumping of wastewater in the outskirts of city is a common phenomenon causing damages to crops, affecting health and hygiene and enhancing pollution load. Through introduction of Decentralised Wastewater Treatment System (DEWATS), as a pilot initiative in village Semradevi Prasad located in the southwest peri-urban part of Gorakhpur. The basic principle behind DEWATS is treatment of organic wastewater generated from households, and reusing it in irrigation. Semradevi Prasad is majorly engaged in agriculture and allied activities (cattle rearing). Due to being in close vicinity with urban Gorakhpur, this village is highly influenced by the goods and services offered or

received by the city. However, this village often serves as a mere dumping ground for urban waste (solid and liquid). This disturbs the balance of urban-peri urban relationship and urban areas become parasites to peri urban regions, leaching off their shores. Therefore, installation of DEWATS in Semradevi Prasad village has helped a total of 106 households (544 persons) by treating approx. 65000 litres of wastewater per annum through a simple and low operation and maintenance technology. This has helped increase the volume of land used for irrigation by 4 hectares and replaced almost 8 agricultural pump sets (average capacity 7.5 HP). The farmers in the village now have access to clean irrigation water for irrigating their crop fields, especially vegetables. Farmers continue to lobby for access to clean water and the treatment of sewage water from Gorakhpur. Along with the economic benefits, the installation of DEWATS has eased the access of local population to clean water, increase in toilet construction, ensured safety of women and children from social bias and water-borne diseases, behavioural shift from open defecation to using toilets, provision of manure etc.

2. ***Solid Waste Management:***

The increasing volume of solid waste in Gorakhpur and the reduction of disposal options are creating serious environmental problems in the peri-urban villages. This led to a violent clash between municipal authorities and peri urban communities in Mahewa. Gorakhpur Municipal Corporation records claim that the city engenders 601 metric tons of municipal waste circadian.

Records show that almost 90 to 92 percent of city's solid waste is accumulated. But garbage management practices contravene the Municipal Solid Waste (management and handling) Rules, (Municipal Solid Waste) 2000. Gorakhpur's solid waste is either utilized as land fill material (peri-urban villages like Chakradoyam, Mahewa, Baharampur) or is dumped in some of the demarcated locations especially in the low-lying areas in the outskirts (Mahewa, Nausadh and Mahesara) (Mitra et.al., 2017).

A pilot initiative to manage solid waste in Mahewa area of Gorakhpur city was undertaken. It was assessed that the 951 households in Mahewa generate about 700 kgs of solid waste on a daily basis out of which almost 50% was kitchen waste which could be decomposed to produce organic manure. The waste collection area was divided into 3 zones and waste collectors were deployed to collect and segregate waste into bio-degradable and non-biodegradable. The bio-degradable waste was collected in a drum and compost culture was added to it (250 gms of culture/75 kgs of waste). The compost was prepared in 20 days which is used by the peri-urban farmers in their field crops. Additionally, the leachate (liquid substrate) obtained as part of the composting process is also being used as liquid manure in the crops.

A good example of circular economy that composting resulted into, the bio-waste was well managed, not landfilled and incinerated. Instead, it formed a resource for improving soil quality and promoting sustainable farming practices in the peri urban areas.

Vegetable farming in thermokol boxes in waterlogged areas

3. ***Climate Resilient Peri-Urban Agriculture:***

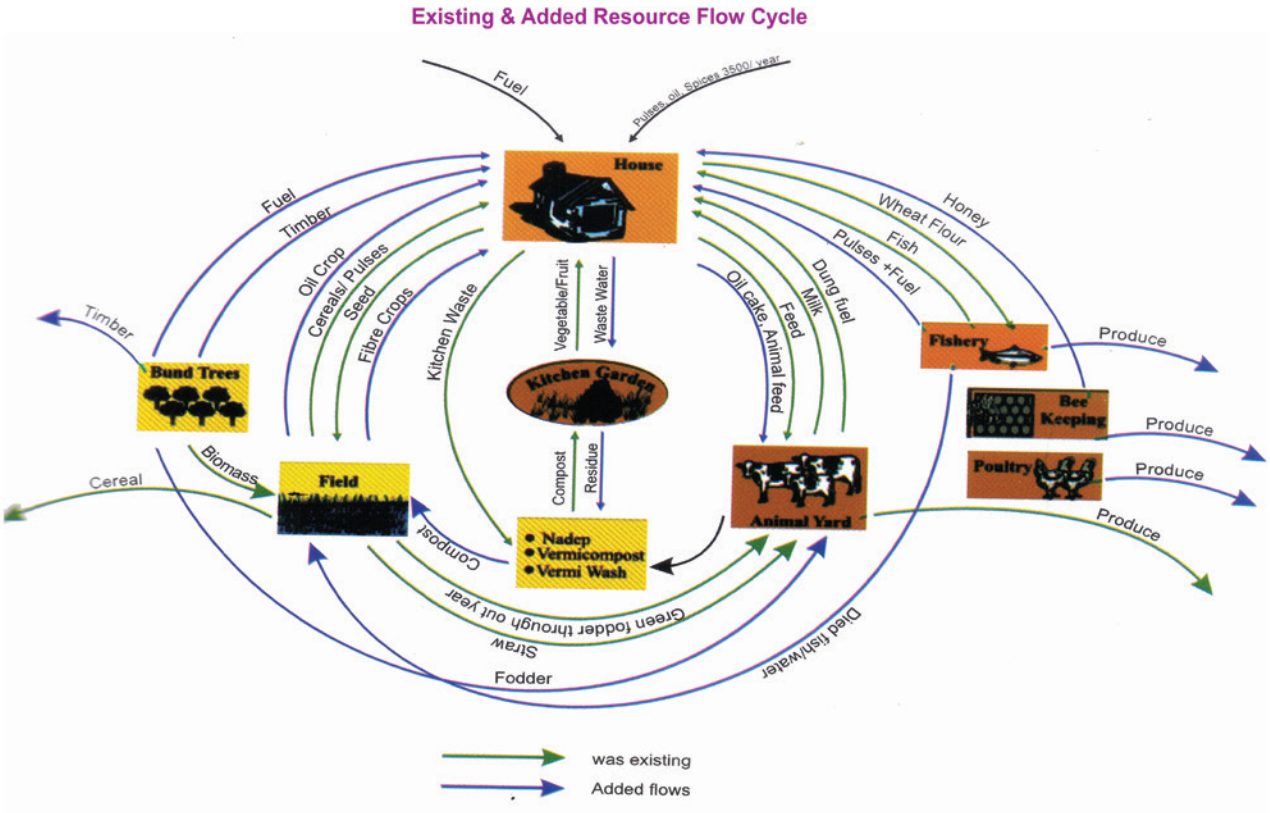
Peri-urban agriculture, adopted as a strategy in the flood prone areas of Gorakhpur, is serving as a means to keep areas that are vulnerable to flooding, free from construction and to maintain their natural functions (enhancing water storage and infiltration; reducing run off) resulting in less floods and reduced impacts of high rainfall. It has worked in reducing vulnerabilities of the urban poor and enhanced their coping capacity to deal with impacts of floods. It has also helped in enhancing the food and income sources of peri-urban agricultural communities. Since most of the agricultural activities are done by the women members of the family, nutritional security has also been an important outcome of peri-urban farming. Peri-urban agriculture has helped in diversifying the food sources, thereby reducing energy footprints. This has also led to diversification in income opportunities which helped in times of economic crisis and in alleviating poverty. Preservation of local biodiversity and recycling of urban waste are other potentials that peri-urban agriculture has offered in Gorakhpur.

Peri-urban agriculture is being practiced by small anf marginal farmers in Gorakhpur in about 200 hectares of land in different pockets. The **climate resilient agriculture,** based on the principles of integration of livestock-household-agricultural field is being promoted which is enhancing the diversity-complexity and recycling processes in the farming systems. Use of low external bio-inputs, appropriate crop varieties, space and time management, seed banking, land shaping and potable nursery systems are practices being followed by these farmers. Keeping in view the geographical conditions of the area and frequent flood events, farmers have adopted innovative and robust farming practices to sustain their livelihoods such as:

- **Integration of various farm sub-systems:** helping use of outputs of one subsystem as input for another sub-system for example the efficient use of dung from cattle shed/poultry for composting and bio-manure for agriculture field, waste from farmers house and agriculture field as feed of poultry or fish ponds etc can help in utilizing the waste/outputs efficiently, thereby reducing the requirement of inputs from beyond farm system and hence reducing input costs
- **Integration of crops and multi-tier farming:** helping in optimal utilization of resources like water, nutrients as well as saving the upper tier of crops in spite of flooding and inundation. Climbers and multi-level c rops also provides better outputs per unit area of land
- **Linking with nearby ecosystems:** like waterbodies, orchards, green spaces for inputs in farming as well as food and fodder.
- **Crop diversification, space and time management, food resilient crop varieties, Low External Input Sustainable Agriculture (LEISA)** and other such practices helped farmers in better outputs, saving from losses and lesser inputs.

Machan farming to reduce crop losses

Integration of Farm Sub-systems



4. ***Impact of Conservation of Common Property Resources:***

Excess water being accumulated in peri-urban areas was a problem. Efforts on conserving waterbodies helped farmers in getting aquatic food and at the same time helped in enhancing water holding capacity in the peri-urban as well as urban areas. With the coordinated efforts of community, almost 23,980 square ft water body has been conserved, 23,150 square ft of community land has been demarcated and conserved, and 3.5 acres of open land has been conserved through the establishment of tree plantation. In some cases, runoff and even wastewater is collected in common property resources and used for irrigating surrounding fields.

The concept of circular economy in Gorakhpur has helped double the farmers' income, reduced input costs, expansion of agricultural land under cultivation, reduced crop loss due to floods and much more. This has also helped in empowerment of women and other marginalised sections. Given how much potential peri urban regions have, their natural resources need to be conserved for a growing economy.

The Case of Gorakhpur city demonstrates that conservation and optimal use of ecosystems and its services on the one hand, helps the communities in peri-urban areas dependent on such resources and secondly, it also provides buffer spaces in the events of floods and enhances resilience of the city. Circularity amongst various sub-systems, systems and between urban and peri-urban spaces can improve the livelihood and well-being of people living in peri-urban areas and at the same time positively contribute to urban resilience through strengthening buffering capacity. Given the crucial role that the natural ecosystems play in maintaining the resilience capacity of the cities, it is imperative to to prioritise the sustainable development of peri urban araes and ecosystems through appropriate policy and governance mechanisms.

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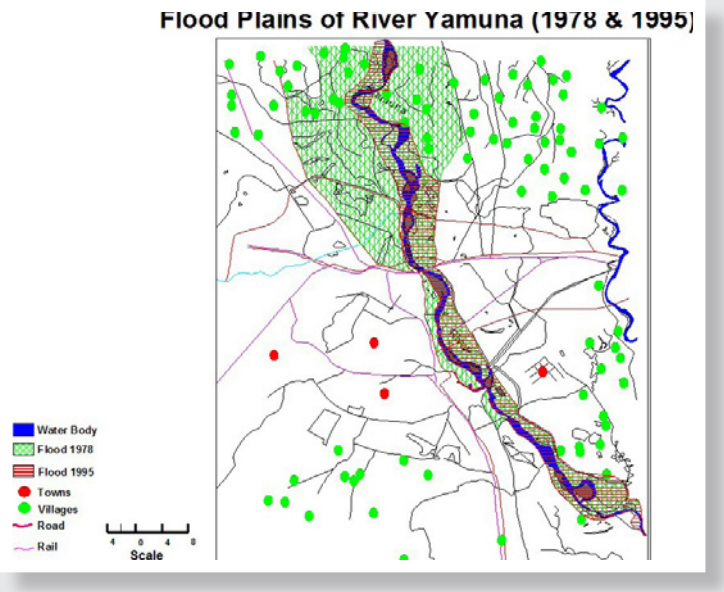
Ecosystem Services for Disaster Risk Reduction: Wetlands of Okhla Bird Sanctuary, Delhi

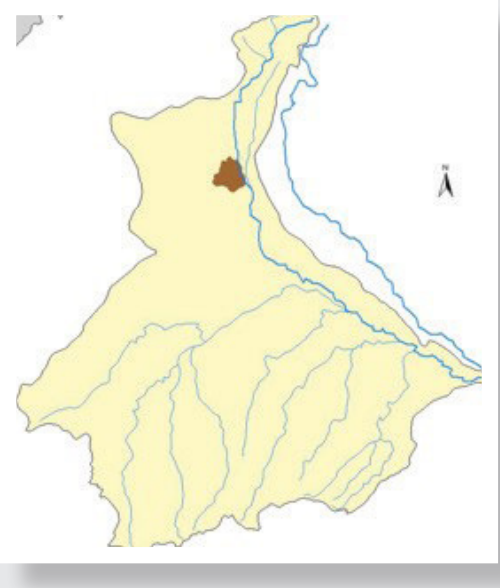
Swati Singh, Sreeja Nair, Anil Kumar Gupta

Wetland ecosystems are part of our natural wealth. According to Ramsar Convention, they provide us with services worth trillions of US dollars every year entirely free of charge making a vital contribution to human health and well being. Wetlands are one of the most productive ecosystems of the world which along with supporting unique flora and fauna provides range of ecosystem services (MA, 2005). Wetland ecosystems also contribute to reducing disaster risk by serving as natural protective barriers or buffers and thus mitigating hazard impacts (Gupta and Nair, 2012).

Well managed ecosystems can provide natural protection against common natural hazards, such as landslides, flooding, wildfires, storm surges and drought (Rieux et al., 2009). Ecosystem decline increases disaster risk both by reducing the ability of an ecosystem to act as a natural buffer, as well as by reducing people's resilience by reducing their bases for livelihoods such as food, medicine and construction materials (ProAct Network, 2008). A study was conducted to understand the role of wetland ecosystem in East Delhi to analyse the present state and the services provided by these systems. The study also analyses the role of ecosystem in reducing the risk of water and climate related disasters like flood, drought and epidemics. Besides this, the study is an attempt to analyse the importance of these services and suggest various opportunities for protecting these ecosystems and challenges in Delhiand itsvicinity.

Flood plains of river Yamuna and Yamuna river basin





(Source: Singh et al., 2013)

The Case Study Area

Delhi, the capital city of India lies between 28.380 N and 77.120 E in latitude and longitude respectively. The River Yamuna (Fig 5.6), a major tributary of Ganges, is one of the key natural infrastructures of Delhi city. The total length of the river in the city is 50 Km between its entry at Palla and exit at Jaitpur. Its floodplains extends to an area of 94.84 km2 comprising forests, agriculture land, settlements and lakes/ponds and can hold lot of water-about 2 billion cubic meters. The maximum width of the active floodplain is observed near Okhla where a large quantumofwaterisbroughtthroughHinduncut. Despitehighurbanstress,thefloraldiversity of the floodplains include 74 species of macrophytes and 90 species of phytoplankton, whereas the faunal diversity constitutes 62 species of zooplankton, 55 species of benthos, 36 fish species and 131 bird species (Source: Wetland International-SouthAsia).

Delhi region has suffered major floods during 1924, 1947, 1967, 1971,1975,1976,1978, 1988, 1993, 1995, 1998 and 2010. The 1978 was the worst ever flood in Delhi when water Level reached at 207.49 m (danger level is 204.83 m) with discharge 2.53 lakh cusec at old Railway bridge (7.0 lakh cusec discharge was released from Tajewala) when130 villages and 25 urban colonies in Delhi were submerged in water. As per the map of flood prone areas prepared by central water commission, Delhi has been classified into thirteen zones based on the flooding risk in relation to incremental rise in the water level of the of the Yamuna. Beside this, the Delhi flood control order (2011) also divides the NCTD into four flood sectors, namely Shahdra, Wazirabad-Babrapur, Alipur and Nangloi-Najafgarg sectors. A detailed analysis of the eight flood affected villages during 2010 September, from the North Delhi, it is evident that the area witnessed tremendous land use land cover changes over past two decades. During the September 2010, rainfall in Delhi was 359.7 mm which 180% more than the normal rainfall. Urban floods are becoming a perennial feature of the city due to inadequate drainage, uncontrolled development and land use changes particularly in the Yamuna Flood Plain.

Methodology

Transect walk was carried out across the corridor of river Yamuna in Delhi to identify and explain the relationships among floodplain, natural vegetation, cultivation, human activities & settlement pattern and understand the various ecosystem services provided by the wetland. Transect walk helped us to understand natural resources, present land use pattern, vegetation, changes in the physical features and cropping systems, and so on in villages Public resources, land use, social differentiation and mobility in urban communities (de Zeeuw, 2004). A survey was also conducted to have view of communities living on the fringes of wetland on disasters faced by them and ecosystem services provided by the wetland. Experts view (academicians, ecologist, practioners, and bureaucrats) on the integration of ecosystem services and DRR were also taken. Scoring was done (on the basis of number of hazards addressed by one ecosystem service) for analysing the ecosystem services and DRR aspects addressed and based on the scores importance were attached as high (4-5), medium (3) and low (<3). In this study five is the highest score.

Discussions: Ecosystem services of wetland of East Delhi

The availability of water near Okhla throughout the year helps to maintain minimum water level required for functioning of the floodplain. The surplus water during monsoon percolates down and helps to control floods and maintain moisture regimes during lean period. Bio accumulation of key nutrients in floodplain helps to reduce pollution stress thereby leading to development of rich biodiversity habitat. Okhla Bird Sanctuary (notified in 1990 by UP Govt.) situated in Gautam Budha Nagar is rich in avifaunal diversity and presently inhabits more than 145 bird species include 22 species of resident water birds, 44 species of resident terrestrial birds, 43 species of migratory water birds and 26 species of terrestrial migratory birds. The sanctuary covers rich aquatic, semi-aquatic and terrestrial habitat where more than 25 species of aquatic plants, 110 species of terrestrial plants including herbs, shrubs, climbers, grasses and trees have been recorded (Source: Divisional Forest Officer, Gautam Budha Nagar, UP, 2012).

Communities residing in the floodplain derive their basic needs like water for drinking, irrigation and domestic purposes from the floodplains of Yamuna. For drinking purpose hand pump is available and water depth is found to be 10-15ft. For irrigation bore wells are used. The source of livelihood of the communities is agriculture and labour. The floodplain is very fertile and supports lots of vegetables, horticulture and floriculture. Vegetables grown are lobia, cauliflower, cabbage, bottleguard, lady's finger, onion, potato, spinach, corn and bitter guard. It was surprising to the researchers to find out that cultivators used urea, DIP and other chemical fertilizers in their field. Community didn't complain about diseases caused by water however dengue outbreak has been reported after monsoon and flood in the entire city.

The key services from the wetland ecosystems in East Delhi

Ecosystem services provided by wetland of Delhi

Ecosystem Services		Comments
Regulating		
E1	Storing excess water during heavy rainfall	Safe passage of excess waters in the city
E2	Ground water recharge	Source of surface and ground water which is much needed to meet the city's growing needs of water for domestic, industrial and agricultural uses.
E3	Disease regulation	Helps in control of water borne diseases
E4	Carbon Sequestration	Act as an essential carbon storage and thus help in climate change mitigation
E5	Shelter belt	Provides a potential shelter belt against advancing land degradation
E6	Thermal regulation	Regulates thermal currents in the city where summer temperatures are today becoming unbearable with every passing year in the context of climate change and global warming.
Provisioning		
E7	Livelihood Support	Production and sell of vegetables and fruits like water chestnut, lotus root, green vegetables are key means of sustenance particularly for slum dwellers
E8	Fisheries	Hardy and tolerant fish species found in the river stretch except in upstream of Wazirabad barrage where still major and minor carps are found The fish species found are rohu, katla, mrigal, channa, singada etc.
E9	Water for drinking, domestic purpose and irrigation	Source of drinking water to major part of the city. Also provide water for irrigating crops
Supporting		
E10	Support heavy nutrient load	Vegetation such as water hyacinth and different grass species like Typha, Phragmites carca, Lamphrophyla etc. are found that take up nutrients received from the nearby drainage and thus help in controlling water pollution
E11	Sediment retention and accumulation of organic matter	Organic fertilizers are made from the water hyacinth after processing. Also bio fuels by briquetting have been made.
Cultural		
E12	Recreational	Okhla Bird Sanctuary in Gautam Buddha Nagar provides a source of recreational activities. More than 145 species are reported from Okhla out of this about 50% are migratory birds, 36% are resident birds and rest are vagrant sightings. A variety of both native and exotic species of plants are found in the sanctuary
E13	Educational	Source of formal and informal education and training, Many school children visit the bird sanctuary along with researchers and scholars.
E14	Aesthetic	Wetland provide scenic beauty

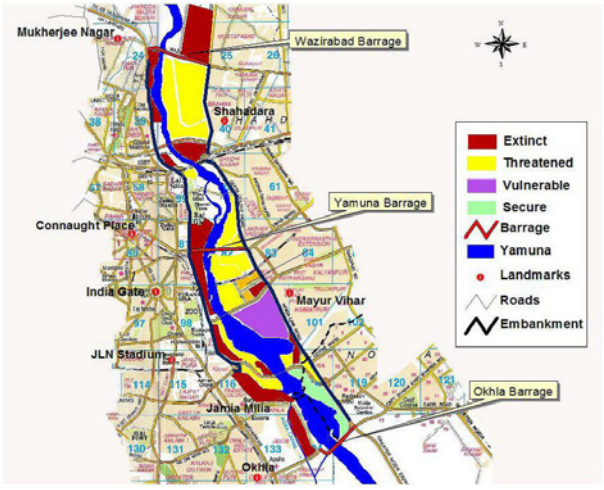
(Source: Singh et al., 2013)

Exposure and Risks

The Flood plains of river Yamuna in Delhi are critically threatened due to biotic, abiotic and huge urbanisation pressures. Biotic stress includes uncontrolled siltation and weed infestation, uncontrolled discharge of waste water, industrial effluents etc. Abiotic stress includes encroachment resulting in shrinkage of area, anthropogenic pressures leading in habitat destruction and loss of biodiversity etc. Rapidly increasing urbanisation with limited integration of values and functions of floodplains in developmental planning has led to their fragmentation. Flows in the river are drastically reduced due to upstream abstractions for irrigation, industrial and domestic water supply. Conversion of floodplain areas for developmental activities like NOIDA toll bridge, Akshardham Temple, Millennium depot, Delhi Secretariat, Commonwealth games infrastructure etc. are making the region more vulnerable. From risk perspective, degradation of floodplains is increasing flooding risks to the city along with stresses related to food and water scarcity.

In 2010 the city witnessed one of the worst floods because of heavy rainfall coupled with development within the natural course of the river. Yamuna water entered Delhi after being released from Tajewala and Hathnikund barrages up North, the water had lesser area to accommodate itself on the floodplain since a chunk of the floodplain–the size of the Commonwealth Games Village–was no longer available to the river that it was for centuries. As evident from the above figure 5.7 the entire river bed in the west between the ring road and stream has been lost due to various construction and developmental activities. A tour through the Yamuna flood plain gives the glimpse of encroached wetland. Indraprastha thermal power plant was established on the bank of the river to discharge waste generated directly into the flowing water. Samadhis of our several leaders and politicians had been built in the floodplain between Nigambhod Ghat and Rajghat. Millennium Bus Depot (Asia's biggest depot) which was constructed during Common Wealth games, remain flooded for almost three months because of no drainage system in 2010 and ironically it happened just before a month for games to commence. Ponds, near Barakullah drain have disappeared due to bridges and flyovers and have now been converted into parks full of water hyacinths showing eutrophied condition. The important lung space of the city has been lost converting it into heat island.

Vulnerability map showing present State of river bed in Delhi



(Source: Yamuna Jiye Abhiyaan, 2007)

Many marginalised communities depend upon the ecological services provided by the wetland to meet their day to day requirements(Table5.2).Migratory birds that come to Okhla Sanctuary used to rest at Gautam Buddha Park which has now been converted into concrete political park. Ecologist and Conservationist Mr. T K Roy say that Gautam Buddha Park has negatively affected the species diversity and also the duration of stay of migratory species has lessened. The reason is non availability of tree species for nesting and food. The species that have not been sighted in the sanctuary from last 5-6 years are paradise flycatcher, Egyptian vulture and great spottedeagle.

Unplanned urbanisation has drastically altered the drainage characteristics of natural catchments by increasing the volume and rate of surface runoff. Drainage systems are unable to cope up with the increased volume of water and are often encountered with the blockage due to indiscriminate disposal of solid wastes. Twenty prominent sewage and drainage system that carries the untreated loads of in and around Delhi is increasing the vulnerability of the sanctuary. Total quantity of sewage generated in Delhi is around 2,871 MLD whereas the capacity of sewage treatment plan is 1,478 MLD only. The figure clearly indicates that 1,393 mld of untreated sewage is directly discharge into the river (Source: Wetland International-South Asia). The table 5.3 provides how the floodplain has been addressing various hazards and helped in disaster risk reduction.

Disaster Risk Reduction function of Yamuna floodplain

Addressing Hazard		
H1	Flood	Addressing flood hazard by means of spread and passage of flood waters during the monsoon every year and exceptional floods once every decade or more (1978, 1988, 1995, 2010).
H2	Epidemics	Addressing epidemics like dengue and malaria
H3	Drought	Addressing meteorological drought in the capital by supplying water for irrigation during lean period
Reducing Vulnerability		
V1	Physical vulnerability	Reducing physical vulnerability by providing buffer to build in infrastructure like irrigation system, municipal water supply, sanitation and drainage by checking land degradation both to the people as well as of the ecosystem
V2	Economic vulnerability	Reducing economic vulnerability by providing stable source of income from fruits, vegetables and fisheries
V3	Livelihood vulnerability	Reducing vulnerability of local people who are dependent on wetland for their livelihood like vegetables and fruits along with addressing issue of food security. Also reducing vulnerability of the people who are dependent on fisheries for their livelihood support
V4	Environment Vulnerability	Reducing environmental vulnerability by checking water scarcity, providing suitable environment for fish breeding, taking nutrient loads from the drainage system etc. around the city.
Increasing Capacity		
C1	Governance	Strengthens knowledge and policy environment which in turn helps strengthening governance and hence increasing the capacity to address disaster in a holistic way. It helps traditional DM professionals and engineers recognise DRR benefits of ecosystems
C2	Society and economy	Communities are engaged in diverse and environmentally sustainable livelihoods resistant to hazards.
C3	Land use management and structural design	Effective land use and structural design that complement environmental, economic, and community goals and reduce risks from hazards.
C4	Risk Knowledge	Leadership and community members are aware of hazards and risk information is utilized when making decisions.
C5	Warning and evacuation	Community is capable of receiving notifications and alerts of flood, warning at-risk populations and individuals acting on the alert.
C6	Emergency Response	Mechanisms and networks are established and maintained to respond quickly to flood and drought disasters and address emergency needs at the community level
C7	Disaster Recovery	Plans are in place prior to hazard events that accelerate disaster recovery. Engage communities in the recovery process and minimize impacts

(Source: Singh et al., 2013)

Opportunities and challenges of Integrating Ecosystem Approach in Disaster Risk Reduction

Ecosystem approach to DRR is widely advocated as second paradigm shift in disaster management, as it directly links with the livelihood of the people and sustainability of their resources (Gupta, 2012). This calls for emphasis on natural resource management,ecosystem services, land-use and adaptation to climate change within the strategies of disaster prevention, preparedness and post-disaster relief and recovery process (National Policy on Disaster Management, 2009, section 5.1.6). Most of the floodplains have been encroached for various developmental projects, however, there are opportunities available for developing ecosystem approaches for reducing disaster risks due to climate change in Delhi and nearby areas. In the table below an effort has been made to integrate ecosystem services in DRR framework.

The table above clearly shows that each of the ecosystem services addresses one or more aspects of DRR. Out of 14 ecosystem services provided by the wetland of East Delhi four are highly important (E1R, E7P, E9P and E11S), one holds medium importance (E8P) and rest are of low importance. The scoring and importance attached does not discourage the other ecosystem services provided by the wetland rather it gives the priority for such services that can be integrated in the DRR framework.

Conclusion

Wetlands on the corridor of Yamuna have become one of the most threatened ecosystems and are rapidly diminishing due to anthropogenic activities. Pressure for conversion of wetlands for developmental purposes is very high especially in case of urban riparian wetlands. These wetland ecosystems provide many tangible and intangible benefits on a sustainable basis not only to the urban society but also to the associated dependent ecosystems. According to Dr. David Pithart, we can consider river floodplain as a tool for mitigation of flood waves or extreme low discharges, only if a floodplain management and structure respect this natural function. Recognizing the importance of wetland ecosystems, the National Environment Policy (NEP), 2006, contains an unambiguous assertion ofthe need for a holistic view of wetlands, which looks at each identified wetland in terms of its causal linkages with other natural entities, human needs, and its own attributes. The ecosystem approach to disaster risk reduction advocates for sustainableecosystems management as strategy to reduce exposure and vulnerability, through hazard mitigation or regulation as well as enhancement of livelihood capacities and resilience.

Note: Reference for more detailed understanding of the case study is following:

Singh, S., Nair, S.S., & Gupta, A.K. (2013). Ecosystem Services for Disaster Risk Reduction: A Case Study of Wetland in East Delhi Region, India. Global Jour. on Human Social Science, Geog., Geo- Sciences, Env. and Disaster Mgt, 13 (4), 37-47.

Integrating Ecosystem services and Disaster Risk reduction of the wetland of East Delhi

Ecosystem Services		DRR aspects addressed	Scoring	Importance
E1R	Storing excess water during heavy rainfall	H1, V1, C3,C5	4	High
E2R	Ground water recharge	V4	1	Low
E3R	Disease regulation	H2	1	Low
E4R	Carbon Sequestration	V4	1	Low
E5R	Shelter belt	V1	1	Low
E6R	Thermal regulation	V4	1	Low
E7P	Livelihood Support	V2, V3, V4, C1, C2	5	High
E8P	Fisheries	V2, V3, V4	3	Medium
E9P	Water for drinking, domestic purpose and irrigation	H3,V1, V4, C3	4	High
E10S	Support heavy nutrient load	V4	1	Low
E11S	Sediment retention and accumulation of organic matter	V1, V4, C1, C3	4	High
E12C	Recreational	C1	1	Low
E13C	Educational	C4	1	Low
E14C	Aesthetic	V4	1	Low

(Source: Singh et al., 2013)
Note: R, P S and C stands for regulating, provisioning, supporting and cultural services of eco system respectively.

Peri-urban Ecosystems impacting Urban Resilience

A case study of Secondary Cities in Eastern India

Nivedita Mani, Shiraz A Wajih

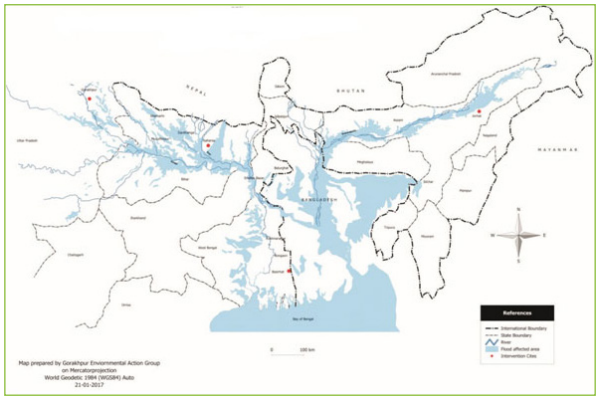
This case study seeks to examine the links between ecosystem services, urbanisation and resilience to climate change, using the cases of few cities in the Ganga-Brahmaputra Plains of eastern India. This includes understanding the notion of an ecosystem and how urban transformations, unless carefully 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 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.

Even as cities' burst at their seams, they continue to turn a blind eye as their natural blue and green infrastructure, in and around them, slowly and steadily morphs into a deeper, darker shade of grey. And when disaster strikes, as it often does in today's changing climate, these same cities are left battered and disoriented. The impact of climate change poses newer challenges for the cities because of their demographic, geo-climatic and socio-economic settings.

The cities along the Ganga-Brahmaputra basin are no different. With climate variability here ranging from high precipitation to rain shadow areas, snowfall to strong winds, the region is highly vulnerable. With climate change adding even more unpredictability to an already volatile scenario, the basin and its people face a greater risk than before. When we talk of urban climate resilience, we can no longer discuss urban areas in isolation. The places around it, especially the peri-urban spaces play an essential role in urban well-being. It is possible for cities to grow and still be resilient. The steady march of urban concrete into river basins, open areas and agricultural land needs to hit a pause button. After all, it is these 'transition' zones that help make a city smart, sustainable and resilient. The challenge, though, lies in turning these common resources into viable opportunities. And, more often than not, it is the men and women living in these risk prone areas, who turn their modest ideas into innovations that help show the way forward to a resilient urban space.

Case Study Cities (Four cities of eastern India in the Ganga-Brahmaputra Plains

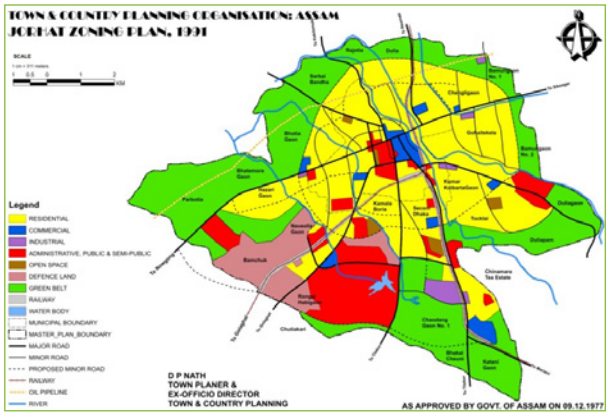


Under the Asian Cities Climate Change Resilience Network (ACCCRN) initiative of the Rockefeller Foundation, Gorakhpur Environmental Action Group (GEAG) worked in the peri urban areas of Gorakhpur (UP), Jorhat (Assam), Bashirhat (West Bengal) and Saharsa (Bihar) to scale up its experiences on conserving peri-urban areas and ecosystems for urban resilience.

Peri-urban Ecosystems in Jorhat, Assam

Jorhat is a secondary city located in the north-eastern part of Assam. The city is located on the Bohgodi and Tarajan rivers which are tributaries of river Brahmaputra. Jorhat is one of the fastest-growing cities in Assam. The peri urban areas of Jorhat are particularly prone to recurring floods and water logging for two to three months every year, because of which small and marginal farmers suffer from crop losses. Climate change is likely to increase the intensity of similar rainfall events by 5-10 % in the future. Climate projections have indicated that the intensity of extreme rainfall in Jorhat is likely to increase in the coming years, which will cause significant flooding in the city and peri urban areas. Flooding occurs in most of the village which are in low-lying areas.

Jorhat city and its periphery showing green areas



Between 1962 and 2005, major land use changes have taken place both in residential and commercial areas in Jorhat Municipal Area. The vacant land which was demarcated as “no-construction zone” decreased from 87.35 hectares to 39.88 hectares. In case of roads and railways, the land area has increased from 55.95 hectares in 1962 to 81.78 hectares in 2005. The area under parks and playgrounds has decreased from 15.39 hectares to 14.09 hectares.

Similarly, the vacant land demarcated for open and green areas and water bodies have also decreased. All these land use changes are mainly due to urbanisation and new settlements. It is observed that covered areas have increased at a faster rate, which ultimately reduced the capacity of surface flow. As a result, surface water accumulates more and rushes to depressed areas resulting in waterlogging in the city.

The current situation of peri-urban ecosystems in Jorhat is alarming. Before 10-15 years, 60-70% of the households in villages had their own waterbodies like ponds but they are only left with presently 30-32% water bodies. The main causes for decreasing of water bodies are the contamination of ponds, high land value, climate change (less rain fall), and urbanization pressure. Further, the bamboo plantation area in the peri-urban areas has also reduced by 30-35%. The forest cover has also reduced because of constructions taking place which has also impacted the natural habitat for animals.

Peri-urban agriculture in Jorhat is also facing threats of land use change and distressed selling of land because of low income from agriculture. The ecosystems are also shrinking which used to provide much of the inputs at no cost for agriculture. GEAG worked with the peri-urban farmers in Jorhat and supported them in learning new techniques of low external input and climate resilient agriculture at small scale for small land holding small and marginal farmers, integrated farming systems with combinations of crop-horticulture, horticulture-fisheries, animals-fishery-crop, growing high value crops like vegetables, flowers, citrus fruit cultivation, increasing crop diversity, and so on.

Flower Power: A woman farmer shows the way

Barnalli Datta, a forty-three old woman, living in Dhenuchosa village in the peri urban areas of Jorhat, adopted climate resilient farming systems in her crop fields. On her land, water logging was a major nuisance and the soil remained wet throughout the year. The land was fertile no doubt, but water surplus; 1.5 acres was not always available for cultivation, many times nothing could be irrigated here due to water logging and the rest arable for just about six months in a year. The only way to keep plants from being smothered by water was to raise the level of the land. Gaining insights on resilient farming techniques, Barnalli went on to construct rows of high beds, nearly three feet in height. A deeper trench, more than four feet deep, was then built around the entire field, sloping towards an existing natural channel in the area.

Barnalli further learnt that flowers had a ready market, and the idea of fragrance and colour in her fields swayed her decision to go for 'flower power'. She began to experiment with different flowers that were planted on the ridges. The furrows are taken up by rice, vegetables or marigold planting. Today, her field is one blooming garden all year round. And the money is good. Flowers are in demand throughout the year, and she manages to earn a handsome profit from her venture. She is astute enough to understand the pulse of the market and ensures that there is atleast a gap of 10-15 days between flower plantations. This prevents too many blooms reaching the market at one go, which would result in lower prices for her. Another interesting innovation is the placement of plastic sheets on the raised beds. These have holes punched in them for the plant to grow, while the rest of the soil is left covered. With this, the need for weeding reduces, as does the labour cost.

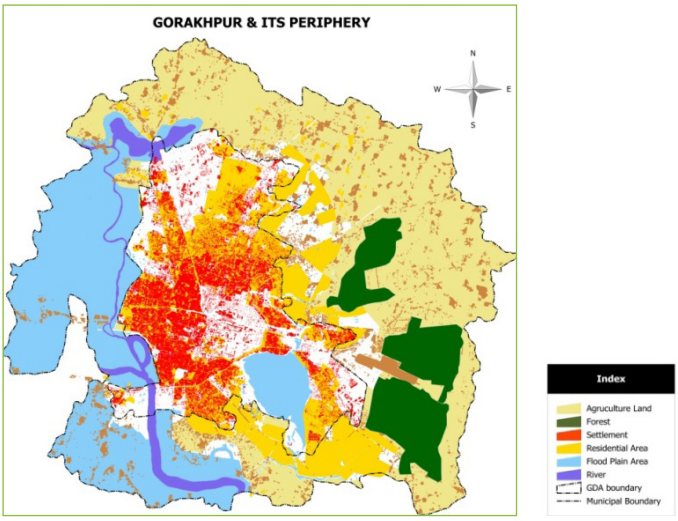
The trench that borders her land is an added asset. It acts a water storage unit, from where water is pumped for irrigating the fields. During heavy rains, the surplus is allowed to runoff into the natural channel that it meets. And in the normal course of events, this water channel doubles as a fishery. A quick and easy source of income and nutrition for the family, local varieties of fish thrive here. Barnalli makes a neat profit of approx. Rs 20,000 to Rs 30,000 by selling off her fish produce. Today Barnalli has completely moved away from the mono cropping method to a diversified farming system which is not only fetching her good prices but is also resilient to climate shocks.

Peri-urban Ecosystems in Gorakhpur, Uttar Pradesh

Gorakhpur, a secondary city, located in eastern Uttar Pradesh at the confluence of rivers Rapti and Rohin, has grown rapidly into an economic and institutional hub in the region. The peri-urban areas of Gorakhpur are particularly prone to recurring floods and waterlogging for 2 to 3 months every year due to which small and marginal farmers suffer from crop losses.

In the peri-urban areas of Gorakhpur, 8089 hectares of land is prone to flood. This is in the western part of the city and gets inundated every year. In spite of flood plains and being a no construction zone, the rapid encroachment is being manifested in many parts. As per the satellite images of two-time period (2002

Gorakhpur city and its surroundings



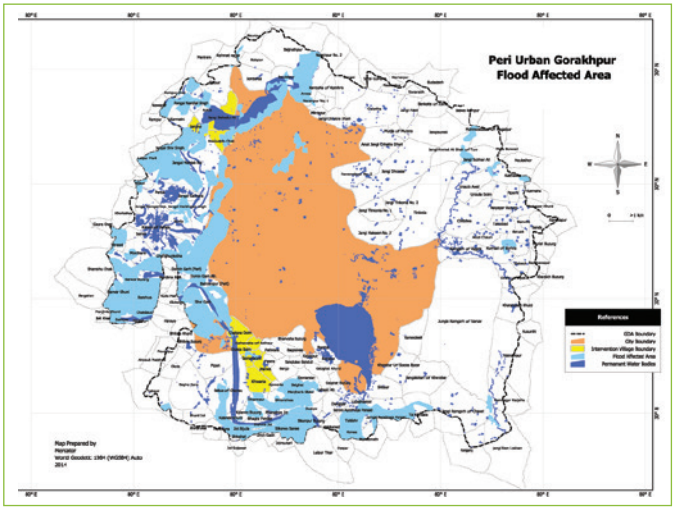
and 2015), 267.42 hectares (33%) of land has been converted into built-up area. The north, north-east, east and south-eastern part of the city periphery are free from water logging and flood. This segment accounts 11558.17 hectares which is marked as agriculture land/ green land. The city is growing in this direction. Due to rapid urbanization, the land mafias (builders) are more active in this zone and converting the open spaces/ agriculture lands into residential area.

About 54% of the peri-urban area represented in the Gorakhpur city Master Plan-2021 for agricultural use, has a population of 0.1 million of which a significant proportion belongs to small and marginal farmers' category. These farmers are hit by several problems of flood and waterlogging, sewage dumping, increasing cost in agriculture, changing land use patterns and governance issues which make them socially and economically vulnerable.

The peri-urban 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 sources of energy and electricity.

GEAG undertook the initiative which sought to mitigate flood risks through maintenance of open spaces by strengthening peri-urban agriculture based livelihoods around the city of Gorakhpur. While the initiative aimed at enhancing incomes and increasing food security for low-income residents, it also targeted to influence

Peri-urban Gorakhpur - flood affected areas



citywide land use planning decisions towards the goal of developing greater flood resilience. Today, peri-urban agriculture in Gorakhpur city of India represents a practical mechanism for diversifying urban livelihoods, particularly those of poor and marginalised communities, ensuring the availability of local food supplies, particularly vegetables and fruits and maintaining open areas that can serve as flood buffers. The land use pattern and ecosystem services in these areas are maintained to promote climate resilient peri-urban agriculture with innovative methods. This has resulted in securing livelihoods of small and marginal farmers, enhancing agricultural productivity and ensuring urban food security.

Peri-urban Ecosystems in Bashirhat, West Bengal

The peri-urban areas of North 24 Parganas is experiencing rapid urbanization due to the neighbouring Bangladesh border. With the spread of

Sprouting the seeds of change

Ram Nagina, a marginal farmer with three acres of land in Nuruddin Chak village in the peri-urban areas of Gorakhpur city laboriously collects every single seed from his vegetable patch. Saving seeds is a ritual as old as farming itself, and has always been an integral part of a farmer's yearly calendar. But that has been the case primarily for cereals, grains and pulses, not so much for seasonal vegetables. Ram Nagina is trying to tip the balance just for that, so he grows vegetables for seeds.

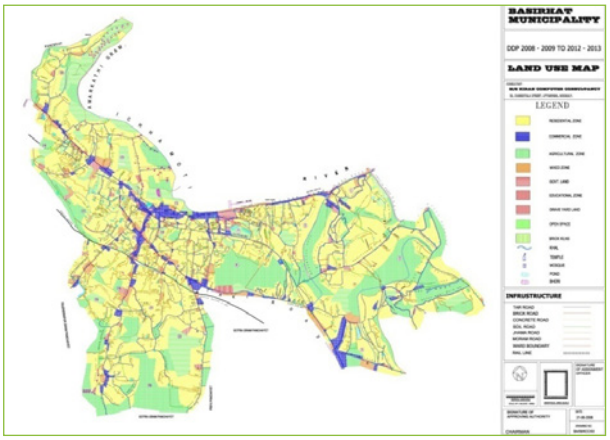
Conservation of seeds helps him create the finest seed possible for where he lives, seeds that perform best in the local agro-ecosystem and environment, thus conserving greater diversity. In today's times when climate change is a reality that is slowly seeping into our everyday life and environment, seed diversity can make farmers more resilient. Home grown vegetable seeds allow a farmer, especially the small and marginal ones, greater flexibility, reduce his risk to outside influences and help him.

urban sprawl, a drastic change in land use land cover and socio-economic environment has been taking place. Huge migration and rapid urbanization has resulted in the loss of critical ecosystem services. The city is also witnessing a clear impact of climate change in the form of erratic rainfall, high temperatures and humidity, impacting lives and livelihoods of people.

Some of the key changes witnessed in the peri-urban ecosystems of Bashirhat are that, that rapid land use change is taking place and in the last 10 years, 5-8% of agriculture land has been converted to residential buildings. There is a huge shrinkage in water bodies due to rampant encroachment and about 30% ponds are contaminated due to hybrid fish rearing. Drinking water is a major issue impacting health of the urban poor people.

The current problem in Basirhat peri-urban area is the reduction in the area for agricultural activities and continuous waterlogging, impacting the flood resilience of the city. One of the main reasons behind these two problems is that people have shifted from traditional fishing practices to rearing hybrid fish in the last decade or so. Earlier, the fish which was in demand locally was bred but now people have started rearing catfish as that is more commercially viable. Catfish is usually reared in dirty water which contaminates the environment and the groundwater.

Bashirhat Municipality demarcating green areas



Peri-urban Ecosystems in Saharsa, Bihar

Saharsa is a city and a municipality in the Saharsa district in the state of Bihar in the north of the country, east of the Kosi River. Saharsa and its surrounding areas are a flat alluvial plain forming part of the Kosi river basin. This makes the land very fertile. However, frequent changes during the Kosi, one of the largest tributaries of the Ganges, have led to soil erosion. Saharsa is hit by floods almost annually, causing a significant loss of life and property. In Saharsa district, the main problems of

Less water flows, more food grows

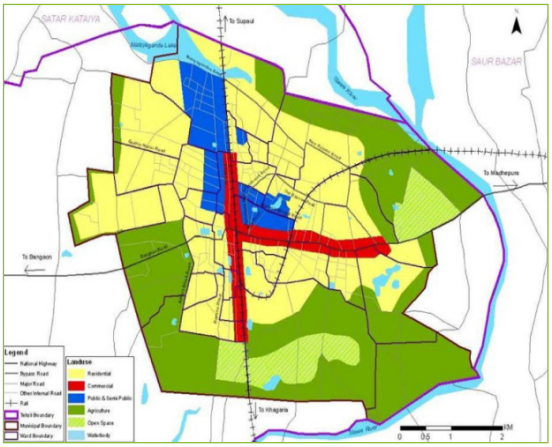
The peri-urban areas of Basirhat city in West Bengal, on the banks of Ichamati river, a tributary of river Ganges, are water affluent. Not so Sangrampur village, barely 2 kilometres away from the city, where Amal Kumar Basu is a marginal farmer. Neither floods nor water logging affect Basu's land; on the contrary he suffers from a lack of this precious manna. The soil in his fields is sandy, unable to retain rainwater during the monsoons. Growing vegetables proved to be an uphill task on his one-acre land, even as rains and erratic temperatures played havoc with his existing irrigation system. Basu switched to furrow farming, shaping mud bunds nearly six inches high on every field. All vegetables - cauliflower, cabbage, radish, chilli, cucumber, carrot, onion, potato and even red amarnath leaves were then planted on these mounds. Mixed farming of exciting combinations, inter cropping of plants that complement each other, swaying banana trees with orange tinged turmeric plants or white flowering cauliflowers with big, fat pumpkins, today keep his field flushed with greens.

These vegetable crops are watered through the empty channels along these bunds which reduce the water need by nearly 45 percent, a huge relief for Basu in his water scarce land. His yearlong continuous supply of col crops to the market, where cabbages and cauliflowers are in high demand has earned him the title of 'Cabbage man' amongst other local farmers, who are unable to grow the same in the hot summer season.

the people are poverty, unemployment, and literacy. The Kosi floods of 2008 have been a landmark event in the history of disasters in Bihar.

The land use pattern in the peri-urban area of Saharsa is mostly agriculture which is degrading at a very fast pace. As per the land use data of Saharsa, approx. 47.19% of the area is declared as open space which comprises of 37.58% agricultural land, 2.26% water bodies and 7.35% open space. In Saharsa, a lot of the poor population reside on the fringes of the city, between the embankment and the river Kosi. Most of the construction is taking place in the open lands of peri urban areas for safe houses which can protect people from floods. On one hand, where this is a requirement of people, on the other, the encroachment on open lands and natural ecosystems is furthermore increasing the flood vulnerability of the city. Another critical factor degrading the ecosystems in the peri urban areas of Saharsa are the brick kilns. There are about 125 brick kilns in the peri urban area which are degrading the top soil, causing erosion, and encroaching over the open spaces.

Saharsa Land Use



The magic of 3 M's: Machli, Murgi, Makhana

The agricultural fields of Umesh Yadav, a resident of village Sukhasan, two and a half kilometres from the city of Saharsa in Bihar used to be waterlogged for 8-9 months in a year. Adopting the new resilient farming techniques, Umesh Yadav learnt the art of making money in the water stagnant fertile land. He adopted integrated farming system wherein sixty percent of the land was kept for makahana (foxnut) cultivation and the rest for rearing fish. Local varieties of fish such as Grass Carp, Common Carp and Rohu were introduced in the water. Further, cement pillars were erected inside the waterbody towards the edge, nearly ten feet tall. Locally available bamboo was chopped, stripped and rounded off to build a 200 sqft structure over the concrete foundation. Old, plastic coated flex banners of varied political lineage and grandiose advertisements were collected and fitted over the roof frame for safety and shelter. Jalkhumbi (water hyacinth) was skimmed from the water and put on top of the roof to regulate temperature in the heat. And in this homemade poultry farm, 200 chicks were housed for the purpose of meat.

This combination of machli (fishes), murgi (poultry) and makhana (foxnut) proved to be a success. The faeces of the chicken dropped unhindered through the bamboo slots into the water below. Nutrients in this chicken manure gave an enormous boost to the growth of plankton in the ponds, main food of the fish, which grew much bigger in size than usual. Under the shade of the bamboo structure, at the edge of this manmade pond, vegetable creepers were planted.

Today, Umesh's sons help him on the land, and the lure of migration grows farther and farther from their heart. Chick Umesh seems to have has learnt the art of making earth and water work for him, and the magic of making money from water too.

Climate resilient agriculture being promoted in the peri urban areas ensure farmers with better livelihoods and aids in enhancing the resilience of the city by conserving open and green spaces.

As more and more cities and their peripheral areas face an increased frequency of climatic risks, their impact on life increases dramatically. People and places, are both left vulnerable, unable to rise effectively to these challenges. As we well know, cities do not operate in isolation, but within a 'sphere of dependence' on surrounding areas and their ecosystems. With the onset of climate change and a growing unpredictability in weather conditions, this dependency on the so called 'fringe' areas has only increased. Thus, protecting ecosystems and their services in peri-urban areas becomes essential for the wellbeing of the urban people and for enhancing a city's resilience.

Gorakhpur Environmental Action Group (GEAG)

Gorakhpur Environmental Action Group (GEAG) is a voluntary organization working in the field of environment and sustainable development since 1975. Ever since its inception, GEAG has been actively engaged in implementing several development projects addressing livelihood issues of small and marginal farmers, particularly women, based on ecological principles and gender-sensitive participatory approach. Besides, GEAG has accomplished several appraisals, studies, researches at the micro and macro levels as well as successfully conducted several capacity building programmes for various stakeholders including women farmers, civil societies groups and government officials etc.

GEAG has established its identity in North India as a leading resource institution on sustainable agriculture, participatory approaches, methodologies and gender. Acknowledging its achievements, GEAG was awarded the Lighthouse Activity Award by UNFCCC in 2013. GEAG also holds the Observer status to Green Climate Fund.

National Institute of Disaster Management

The National Institute of Disaster Management constituted under the Disaster Management Act 2005, has been entrusted with the nodal national responsibility for human resource development, capacity building, research, documentation and policy advocacy in the field of disaster management. The Institute provides training in face-to-face, on-line and self-learning mode as well as satellites based training. NIDM provides technical support to the state governments through the Disaster Management Centres (DMCs) in the Administrative Training Institutes (ATIs) of the States and Union Territories. Presently NIDM is supporting thirty such centres. Upgraded from National Centre for Disaster Management of the Indian Institute of Public Administration on 16th October 2003, NIDM is steadily marching forward to fulfil its mission to make disaster resilient India by developing and promoting a culture of prevention and preparedness at all levels.

Climate Development Knowledge Network

The Climate and Development Knowledge Network works to enhance the quality of life for the poorest and most vulnerable to climate change. We support decision-makers in designing and delivering climate compatible development. We do this by combining knowledge, research and technical advisory in support of locally owned and managed policy processes. We work in partnership with decision-makers in the public, private and non-governmental sectors nationally, regionally and globally.

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