Chapter 2
A New Imagination for Waste and Water in India's Peri-Urban Interface

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2.1 Introduction

Cities have always been viewed as incubators for enterprise and innovation. However, in this urbanisation era we seem to suffer from a lack of imagination on how to handle environmental problems associated with expanding cities. The simplest strategy often is to shift the problems away from the city to its periphery or the peri-urban interface (PUI; see Chap. 1). Thus the PUI ends up having a contentious relationship with the city's core. In this chapter we look at the complexity in linkages between water and waste in the PUI of two metropolitan cities, Bengaluru and Kolkata, in India. We examine the contestations between waste and water in the PUI of these expanding cities, and the challenges that even potentially positive linkages between waste and water are faced with in cities in India.

Sustainable Development Goal (SDG) 11 on sustainable cities and communities has as one of its targets the supporting of "positive economic, social and environmental links between urban, peri-urban and rural areas […]" (UNDP, 2015). However, the ecological footprint of cities, which measures how much productive land and water is required to sustain cities in terms of resources needed and for assimilating city wastes (Rees & Wackernagel, 1996) raises immediate concerns about attaining this SDG target—especially in the context of the peri-urban. Ecosystems, whether around or far from cities, are faced with incredible pressure when it comes to meeting a city's needs. While appropriations of resources from distant ecosystems, for example from rural areas, are considerable in any city across

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the globe (Folke et al., 1997), they are not immediately visible when it comes to their use by cities. They are, therefore, easily ignored in planning for sustainable cities. This, however, is not the case with ecosystems in the PUI, which are found in the immediate vicinity of cities. Yet, the PUI too falls through in planning practices for sustainable cities (Simon & Adam-Bradford, 2016).

The PUI referred to here is not just a physical space, but is characterised by the relationships and processes—ecological, economic, and social—that link it to the city and determine the nature of relationship with the city (Narain and Nischal, 2007). In physical terms, an important characteristic of the PUI is its mixed urban and rural land uses that support a wide variety of livelihoods: from fully agricultural to a mix of agriculture and small and medium enterprises (Mundoli et al., 2015). The PUI also provides resources to the city that it surrounds, enabling the city's development, but often at the cost of the environment of the PUI (Simon, 2008). For example, quarrying to supply construction material for the city impacts the local environment and the health of local residents (Mundoli et al., 2015). The PUI may provide affordable housing for a burgeoning workforce, which comes to the city in search of employment. Coming as migrants with different socio-economic backgrounds, many cannot afford to live in the expensive city core. The PUI accommodates the influx of population that needs basic services like water, sanitation, transport, and roads. To make matters worse, the PUI becomes a receiver of the wastes generated by the city (Mallik, 2009; Parkinson & Tayler, 2003). Thus the PUI is where the negative ecological footprint of the city first extends into; the PUIs of Indian cities are no exception (Narain et al., 2014; Shaw, 2005).

One of the main tensions in terms of access to and quality of water is between that of water and waste, both solid and sewage. According to Doron and Jeffrey (2018: 43), "never in history have so many people had so much to throw away and so little space to throw it as the people of India in the second decade of the twenty-first century". In urbanising India, with its aspirational population, this includes huge quantities of solid waste and sewage that needs to be disposed safely. Unfortunately, our cities have not been able to achieve even proper segregation of waste at source, or in recycling or reusing. Thus the bulk of the urban waste tends to be dumped in landfills (Ministry of Urban Development, 2016b). These landfills are often located in the PUI of cities, posing a threat to the environment and the people who live there. Waste is also dumped into water bodies in and around cities. Sewage from both households and industrial effluents ends up in water bodies too; some of it has been treated but the bulk remains untreated. These water bodies, receivers of solid waste and sewage, are at the same time accessed for household and livelihood needs by urban, peri-urban and rural communities (ESG, 2018; Narain et al., 2014; Parkinson & Tayler, 2003). The interlinkages between waste and water in Indian cities, then, are extremely complex and can have a range of impacts.

In this chapter, we look at water and waste in two sites in the peri-urban spaces of two state capitals in India: Lake Kannuru in the periphery of Bengaluru city, situated in the south-Indian state of Karnataka; and villages in *mouzas* falling in the peri-urban wetlands east of Kolkata situated in the state of West Bengal in eastern

India.[1] Water systems in both areas support the livelihoods of local communities and migrants. But while the freshwater of Lake Kannuru supported local livelihoods and subsistence, in the case of the wetlands in Kolkata sewage from the city was diverted for agriculture and aquaculture. We unravel the complexity in the waste-water relationship through these comparative cases, in which city waste is seen as a pollutant in one case and as a nutrient in the other. The chapter is an exploration into the complex linkages between waste and water that the PUI of cities face and that are a challenge to attempts to move towards a more sustainable urban future for India. We also present the potential and contestations in reimagining these linkages between waste and water in expanding cities from an open to a closed loop system (Smit & Nasr, 1992).

The chapter begins with a brief outline of the interlinked social and ecological landscape of the two cities, and includes a description of the specific study sites. In the next section we describe the methods, which is followed by the findings from the research. The findings include some of our inferences. In the last section we discuss the continuing challenges with regard to the waste and water interlinkages in the urban future projected for India.

2.2 Study Area

Bengaluru (earlier known as Bangalore) has its origins as a medieval town in the sixteenth century, though there are records of settlements in the region dating as far back as 6000 years, to the Stone Age. The city is situated on the Deccan Plateau in the southern Indian peninsula in a semi-arid region. The disadvantage of not having a perennial river to supply water was overcome by settlements in this landscape by constructing lakes to capture rainwater. The undulating topography enabled construction and diversion of rainwater into depressions, with a network of channels connecting upstream lakes to the ones downstream. Early epigraphic inscriptions also provide proof of livelihoods around agriculture and livestock rearing (Nagendra, 2016). The construction of lakes continued even after the initial boundaries of the town were drawn in 1537 CE. Towards the end of the eighteenth century, the city came under colonial rule. Since then lakes have had a mixed fortune. While the British saw the revival of lakes as important for boosting agriculture to increase their revenue, the demographic and spatial expansion of the town, as well as changing perceptions about the lakes, have had their impacts. Lakes and their wetlands began to be either seen as sites of disease, or prioritised for aesthetic purposes (Unnikrishnan et al., 2016). They were also increasingly converted to other forms of land use. The city gradually looked to more distant sources of water to meet its requirements, thus further reducing their importance. In the post-independence

[1] *Mouza* refers to an administrative unit in West Bengal containing one or more settlements or villages.

period there was a decline in the number of lakes in Bengaluru (Thippaiah, 2009). More recently, with rapid urbanisation, lakes have also become filled with sewage and industrial effluent (Nagendra, 2016). Many lakes in the city core, and increasingly also in the PUI into which they city is expanding, have been adversely impacted (Mundoli et al., 2017). The PUI has also become a dumping site for urban waste, and this too has had impacts on the environment. Once known as the "City of Lakes", Bengaluru is now called the "Garbage City" (Nagendra, 2016). The city generates huge amounts of garbage and sewage, but has failed to scientifically manage it. Waste is dumped in peri-urban villages, compromising the environment, including that of the lakes, and the health of local residents.

At present the unsegregated waste from the city is dumped in an abandoned quarry bordering Kannuru village, one of our peri-urban study sites situated northeast of Bengaluru city. It is one of the eight villages in Kannuru *Gram Panchayat.*[2] The area of Lake Kannuru, situated northwest of the village, is 25.92 ha. Kannuru has been a site of longitudinal research for us since 2013 (Mundoli et al., 2015). In this chapter we look at the changes to the lake and the environment of the village, and especially the impacts on livelihoods around the lake and the lives of local residents since the area adjacent to the lake was converted to a landfill.

Our second study site, the wetlands situated in the PUI east of Kolkata (earlier known as Calcutta), contrasts with the first one. Kolkata had its origins in a small cluster of villages situated on the eastern banks of the Hooghly River, a tributary of the Ganges. Detailing the events that led to the formation of Kolkata City since the setting up of a trading post of the East India Company in 1690 is beyond the scope of this paper. Suffice to say that, unlike Bengaluru, which is situated in a semi-arid region and grew around its human-made lakes, Kolkata originated on the banks of a perennial river, which influenced its growth. The city grew eastwards from the banks of the Hooghly by reclaiming marshy areas, which were seen as inhospitable but necessary to be reclaimed for expansion (Ghosh & Sen, 1987).

While the location of Kolkata was viewed as beneficial for trade by the British, the climate and the poor sanitation of the growing town were a cause of illness and mortality among the European and Indian population (Deb, 1905; Martin, 1839). As the population of the city grew, water-borne diseases became a particular concern. Although situated on the banks of a river and dotted with numerous tanks and wells, potable water continued to pose a problem for both the British and the Indian population. In the 1840s a project for supplying purified water through a piped system across the city from the Hooghly River was mooted. Though expensive, the British went ahead with the project, thereby adding "a new milestone in the journey of Calcutta towards urbanity (De, 2014: 291)".

But then there was the issue of sewage, including human waste, and garbage generated by the growing city. In his famous 1803 min, Lord Wellesley had indicated that it might have been an error to drain the city westwards into the Hooghly, while the incline of the city, though very slight, was more towards the southeast.

[2] A *Gram Panchayat* is the formal local self-governance system at the village level in India.

One of his recommendations was to ascertain in which direction the drains and water courses needed to be altered (Martin, 1836). In the 1850s, William Clark came up with a scheme for Kolkata's drainage with the salt lakes to the east identified as an outfall. The scheme was sanctioned and completed in 1884 (Bunting et al., 2005; Mitra, 1990). Meanwhile in 1865, one of the sites identified for disposal of the waste of the city was Dhapa, east of the city. The land, covering a square mile (the "Dhapa Square Mile") was leased to an individual who began to undertake farming on the garbage substrate in the 1880s. The tidal River Bidyadhari that lay further east of Kolkata in the 1850s, served as a source of brackish water for fish cultivation. After this river had been declared dead in 1928, sewage from the city was considered to serve as a substrate for fish cultivation (Ghosh, 1988; Ghosh & Sen, 1987). The sewage continues to flow into these wetlands, and sewage-based agriculture and aquaculture are recognised as an example of how peoples' knowledge has contributed to the productive use of urban waste for livelihood (Ghosh & Sen, 1987).

However, over the years the quantity and quality of sewage has altered, as have land use and land cover around the wetlands. Reclamation of the salt lakes has been proposed since the 1830s, but it was only in the 1960s that the reclamation of large areas actually began (Ghosh & Sen, 1987). In the 1990s, out of concern with the increasing reclamation of the wetlands and conversion to built space, a public interest litigation was filed seeking protection for the wetlands. The resulting court order demarcated the wetland for protection. This was strengthened in 2002, when 12,500 ha of the wetlands, was demarcated as the East Kolkata Wetlands (EKW), and also gained international recognition as a protected Ramsar site. The wetlands also received attention thanks to the efforts of Dhrubajyoti Ghosh, a sanitation engineer with the West Bengal government who fought to protect the wetlands and the livelihoods of people who depended on it (Calcutta High Court, 1993). The wetlands acquired a unique status because, unlike other Ramsar sites, sewage-based agriculture and aquaculture was practised on a large scale here, contributing to local livelihoods. Villages in the wetlands that fell within the boundary of Ramsar-demarcated East Kolkata Wetland were our second study site.

The *mouzas*, where the study villages are situated, lie in a landscape dominated by water. *Bheris* (fishponds) of different sizes—from small ones owned by individual fishermen to others covering hundreds of acres and run by cooperatives—spread across the wetland. Agriculture is practised as well, along with raising livestock and kitchen gardens where vegetables and spices are grown for household consumption. While both agriculture and aquaculture continue to be practised, using sewage water from the city, these livelihoods are witnessing several challenges. These will be discussed below.

2.3 Methods

In both sites we have conducted in-depth qualitative research, mainly through interviews, in the peri-urban landscape where water and waste issues intersect. In Bengaluru, we conducted 11 individual interviews around Lake Kannuru and the village in October 2019. Interviewees included local residents who engaged in farming and livestock rearing for their livelihoods, and the local resident who held the tender for fishing in the lake. In addition, we spoke to officials from the local government departments. Our focus here was to understand how the lives and livelihoods of local residents, especially the livelihoods linked to the lake, have been impacted by the landfill that had been set up near the village.

In the case of the Kolkata wetlands, we conducted interviews in seven villages in the *mouzas* of Bhagabanpur, Kharki, Deara, Hadia, and Tardah Kapashati located in the South 24 Parganas District adjacent to Kolkata District. For this research we conducted 23 interviews and interacted with 26 persons from the EKW in November and December 2018. We conducted a total of 22 individual interviews with farmers (8), fishers (8), and migrants (6). The interview durations extended between 35 and 50 min. Of the individual interviews, seven were done in Bhagabanpur, nine in Kharki, and two each in Deara, Hadia and Tardah Kapashati. The group discussion was conducted in Deara with four individuals—two fishers and two farmers—and this extended for a little over an hour.

Our focus here was to understand the challenges faced by people engaging in fishing and farming, both of which are livelihoods that are closely linked to the quality and quantity of sewage that the wetlands receive from Kolkata city. The interviews we conducted with the migrants who had settled in the wetlands more recently, were held to see what their use of and perspectives on the wetland were and to compare the migrants' views with those of long-term residents. The time span of their residence in the wetlands ranged from 7 months to 6 years. Two of the six migrants were construction labourers working in Kolkata city, two sold jaggery for a living, one had a small shop, and another was a retiree who had recently moved to the area. We have included quotations from the responses given by the interviewees as illustrative examples and to capture the perspectives of interviewees in their own words, as they are important participants in our research (Corden & Sainsbury, 2006).

2.4 Squandering Our City's Water – And Waste

2.4.1 Water Commons in Crisis: The Impact of Bengaluru's Landfill on Lake Kannuru

In our research initiated in 2013, the objective had been to understand the use, management and transformation of lake, *gunda thopes* (wooded groves), cemeteries and grazing lands around Kannuru (Mundoli et al., 2015, 2017). While tracing the

transformation of Lake Kannuru we found that urbanisation with changes in land use had reduced the inflow of water into the lake. One of the main reasons for this was the destruction of the hillock to the west of the lake due to quarrying. The water quality, however, had deteriorated only slightly compared to other lakes in peri-urban Bengaluru into which sewage and garbage had been dumped. The reduction in water quantity—due to the effects of stone quarrying, the increase in built-up area around the lake blocking inflow channels, and reported reduction in rainfall patterns in recent years (Mundoli et al., 2015)—had meant that traditional livelihoods had been impacted. Thus, paddy cultivation had been discontinued, though some millet and fodder grass cultivation still persisted in the wetlands east of the lake. The livestock herders continued to access the lake for washing and watering cattle, and for grazing and fodder grass collection, though the reduction in water quantity had impacted access to both. The tender holders for fishing found it hard to break even, as they had to deal with reduced catch and increased costs of pumping water into temporary shallow pools for raising fish. However, these traditional livelihoods linked to the lake were still found to persist (Mundoli et al., 2015).

By September 2016 the quarrying had ceased and mixed waste from the city began to be dumped in the abandoned quarry pits. These pits were not part of Kannuru *Gram Panchayat*, but of Bellehalli Ward, which falls within the *Bruhat Bengaluru Mahanagara Palike* boundary.[3] However, since the quarry, now converted into the landfill, lay on the boundary between Bellehalli and Kannuru, the adverse impacts of the landfill were soon felt by the residents of Kannuru. According to one of the interviewees, reminiscing about the past use of the lake:

> You know … the lake looked white in colour from far, that's how pure it was. When we would come to graze…when the cattle would drink water, we also put our head down and drank water like them … along with them.

This lake is in a very different state today. The water has turned black in colour and gives off a pungent smell. According to local population, the blasting for quarrying had resulted in cracks being formed in the quarry walls. As a result, leachate from the quarry pits filled with waste escaped into the lake. The farmers and herders provided perspectives on how the landfill had affected their livelihoods. One of the interviewees, a woman grazing her cattle adjacent to the lake, had migrated to Kannuru from a village in the neighbouring state of Tamil Nadu. Escaping drought, she and her husband had settled here 10 years ago to work in the quarry. Even after quarrying was stopped she, her husband and their three children continued to live in the hutment on the northern boundary of the lake, close to the landfill. She had sheep and goats of her own and, for a fee, also herded cattle of villagers around the lake. According to her, the water quality of the lake was very bad, especially during rains, when the water from the quarry overflowed into the lake. While she accesses water from a filtered source at a distance, the livestock continued to drink the filthy

[3] The *Bruhat Bengaluru Mahanagara Palike* is the administrative body responsible for providing civic amenities and infrastructure to the Greater Bengaluru Metropolitan area.

water. She was, however, concerned that if this continued the livestock too would fall sick.

The livestock numbers brought to the lake for watering and grazing had also decreased considerably. At present some herders only collected fodder for stall feeding. The other danger with grazing was the increase in the number of dogs, attracted by the garbage, that chased and bit the goats and sheep. Her own household use of the lake for washing clothes and bathing had stopped when the family had begun to fall ill and develop rashes. The other herders we interviewed shared similar concerns about the lake. The main income source of one of them is the milk from his cows. Even though he lived adjacent to the lake he said that he did not collect fodder or use lake water, as he is concerned about the impact on the health of his livestock. Instead, he collects fodder from fields located at a distance. According to him, the cattle in the village have also been producing less milk than before, though he said he could not attribute this to the landfill.

The tender holder for fishing in the lake said that the water quality had deteriorated owing to pollution from dumping, resulting in around 5000 fingerlings dying. When the water quality was better, more people came to buy fish, but nowadays he is unable to make any profit from fishing. The local population had stopped buying the fish because of the pollution, claiming that the fish did not taste as good as in the past. At the time of our study, no fishing was happening in the lake under the contract, but a few local people caught fish in the lake on Sundays.

According to the interviewees, cultivation around the lake, which had started declining in 2013, had completely stopped now. Even if there was water in the lake, the channels that carried the water to the fields downstream had fallen into disrepair and were choked with weeds. Similarly, the rituals and traditions around the lake had been forgotten. Locals who used to frequent the lake avoid it now because of the stench and mosquitos. A whole way of life has changed for the village. One of the elderly interviewees who used to spend time with other residents under the shade of the *neem* (*Azadirachta indica*) and *peepul* (*Ficus religiosa*) trees in the village square said:

> "We are supposed to inhale good air under the neem tree but we can only smell garbage. When we open our doors in the morning we smell garbage. That's how our day starts."

The officials we interviewed shared their concerns about the impacts on the village too, though they were wary of revealing too much. Confirming what one of the interviewees had said regarding milk yield, one official said that the quality of milk had definitely come down. He was also concerned about the health of local residents who retained a portion of the untreated milk for household consumption. With regard to direct impacts of the landfill on human health, there were concerns of more people falling sick as a result of groundwater contamination and working in the landfill. The migrant population that lives in Kannuru is especially vulnerable, as they work in the landfill for higher wages but fall sick from viral fever, respiratory problems and skin diseases. Questions that village level officials raised regarding the impacts of the landfill were brushed aside by higher-level district officials

saying that dumping was not happening within the Kannuru village boundary. But, as one of the interviewees asked:

> "How can they draw boundaries to water and air? Will they be in the same place?"

This quote brings out very clearly the challenges of governance, where jurisdictions between the urban ward and rural panchayat, neatly demarcated on paper, do not account for realities in the PUI.

2.4.2 Sewage as a Livelihood Source: Impacts on Wetlands East of Kolkata

The wetlands east of Kolkata not only serve as the kidneys of the city, but also support agriculture and aquaculture. The interviewees we spoke to had been doing aquaculture and agriculture in the wetlands for a decade and beyond. They had learnt the skill from their fathers and grandfathers, who worked in the *bheris* and farms. Except for one fisher who was doing the work for 10 years, fishers and farmers had been engaged in their livelihoods for 15–45 years. The interviewees all owned their own *bheris* or farms. While this meant they could enjoy the income from these activities, working on the *bheris* and farms was hard work. In the case of the *bheris*, strengthening the embankments by growing hyacinths, dredging the *bheris* to a correct depth, mixing the correct amount of sewage as food source for the fish, introducing spawn, and mixing lime and oil cake were done by the owners themselves, sometimes assisted by sons and grandsons. Catching and selling fish in the local market was another part of their work. Only one interviewee employed labour to work in his *bheri*. In the farms, too, the work for growing vegetables was done by the farmers, who took care to see that the right amount of sewage was mixed with the soil. The fishers and farmers assured us that the quality of fish and produce from the farms were absolutely safe and they were not only sold in the markets but also consumed by themselves.

But much in the landscape of the wetlands has changed and is causing concern to the farmers and fishers alike. One of the main concerns was with regard to land use changes. Several interviewees mentioned that there has been an increase in the number of people coming to live in the wetlands. To accommodate the needs of the resident and migrant population, farms and *bheris* have been converted into houses and other infrastructure. The network of roads has also expanded, which was regarded as beneficial by the interviewees for two reasons: the roads provided connectivity to the population, many of whom worked in Kolkata; and for the fishers the roads served as barriers preventing overflow from one *bheri* to another. A specific land use change, in this case the construction of roads, that we would expect to adversely impact the livelihoods was seen as beneficial by one group—the fishers. The conversions of land were the result of sales of land by fishers and farmers. Interviewees also mentioned feeling pressurised into selling their lands by the real estate lobbies.

In addition to such impacts on land use, there have also been impacts on the quantity and quality of sewage for farming and fishing. In terms of quantity, many interviewees alleged that the canals bearing sewage were filled with debris and mud that caused siltation and reduced the flow of sewage. According to the interviewees, this was a strategy to force them to give up fishing and farming, and ultimately sell their lands. The disruption in flows of sewage meant that there were less nutrients available for the farmers. This has influenced their produce, even though they may still have access to fresh water. For the fishers, who adjusted the sewage quantity to generate fish feed, less access to sewage meant that they had to buy fish feed from the market, which increased their costs and reduced their profits.

The quality of sewage was also a cause for concern. One of the main problems, according to the interviewees, was that effluents from the leather factory situated in the wetland, albeit outside the EKW boundary, were dumped into the domestic sewage. This impacted the quality of the produce, be it fish or vegetables. The fishers we interviewed also reported fish deaths in the last 4 years, especially between October and January; dead fish were in evidence during our field visits as well. They were not exactly sure what the cause of the disease was—speculating about either changes in water quality or climate change as causes. To avoid a complete loss of income, the *bheri* owners had to buy medicines from the market that they sprayed on the water. These medicines were expensive and further reduced their profit.

According to the interviewees, making ends meet in farming and fishing had always been challenging, but with the land use changes and issues of sewage supply their problems exacerbated. For all but two interviewees, who sometimes worked as wage labourers, fishing or farming was their only source of income and only skill. As one of the interviewees said:

> We, the fishermen, here depend on the *bheris* for our income to meet the daily needs of our household. From waking up in the early morning at 4 am and going to the *bheris* for fishing and then selling it in the local markets to working hard daily to maintain and protect this wetland —for us the *bheris* you see are all that we have … without the *bheris* we don't have any secure future.

Interviewees also mentioned that farming was on the decline and more farms were being converted to *bheris*. This is an interesting insight that the interviews have yielded to date, but more research needs to be done to understand the causes of these changes. But for those who continued with farming, land was of immense importance. According to a farmer:

> "Losing the land would mean losing everything. I would not be able to feed my family then."

While some interviewees expressed that the unprofitability of their livelihoods may force them to sell their lands, others were adamant that they would fight to protect the wetlands that put food on the table for their families. According to one fisherman:

> "The *bheris* are close to our hearts … we will fight hard to protect the existing *bheris* and farms … without these we don't know where to go."

To what extent the marginalised can hold out in the face of the real estate lobby, however, is not clear. The motivations to protect the wetland are owing to direct livelihood and subsistence benefits, but this too is changing, as was seen in the case of the next generation, which is moving away from farming and fishing as source of livelihood. One of the older interviewees felt that the youth were losing the connect with the wetland, and did not have the same attachment to traditional livelihoods as their parents. The youth prefer to work as construction labourers in Kolkata or at the leather factory, where the income is much higher. This is ironical, since the fishers and farmers in the interviews said that the same factory was polluting the sewage with chemicals. But the higher wages at the factory make it an attractive option. The preference among the youth for moving to other jobs was also mentioned as a cause of labour shortage for work in the farms and *bheris*. Whether to continue with traditional activities or to migrate is a dilemma faced across peri-urban settings in India—and choices made are also very site specific (Purushothaman & Patil, 2019). The question we need to explore in a productive landscape like the EKW with the potential to support livelihoods is: are the reasons for discontinuing livelihoods purely the result of unviable farming or fishing? Or is it the result of a range of factors discussed in the paper, such as pressures on and conversion of wetlands, declining access to sewage and freshwater.

Our interviews with migrants threw up some interesting perspectives. Unlike the fishers and the farmers, the migrants we interviewed were not dependent on the wetland for their livelihoods, which may have influenced their views on the wetland. They were recent residents, and their unfamiliarity with the landscape and limited dependence on the wetland for livelihood were evident in the interviews. One of them said:

> "Before coming here I never heard of the wetlands. After coming here I was surprised to see such large areas covered with water."

With regard to the changes of the landscape, the interviewees observed that they had been here for too short a time to comment on the land use change. But, with the exception of two, all had similar views on these changes. The interviewees felt that the development-related land use changes, such as roads, buildings, houses and schools, were good, as they improve the lives of those living in the wetland. However, the wetland was seen as a garbage dumping ground, and the *bheris* and farms as a health hazard. As one of the interviewees said:

> "These are nothing but mosquito breeding grounds."

Health has historically been given as a reason for filling up and reclaiming marshes and wetlands around Kolkata. The increase in migrant population with no links to livelihoods could contribute to further conversion of the wetlands, to the detriment of the farmers and fishermen and the city itself. However, a couple of interviewees, also migrants, emphasising that development was necessary, also observed that it would negatively affect the livelihoods of farmers and fishers. The retiree we interviewed was happy that, unlike the city where he had lived, the wetlands were not polluted and he could breathe fresh air. For some interviewees the use of the

wetlands was limited to washing clothes and bathing. Most of them were not concerned about the quality of fish and vegetables from the wetlands that they consumed. One of them, though, was even unaware that the fish and vegetables he consumed were grown in the wetlands.

2.5 Discussion and Conclusion

Urbanisation presents many dilemmas for attaining the sustainable development goal on sustainable cities and communities (UNDP, 2015). The rising urban population creates more demand for resources like food and water, but also increases waste generation, both sewage (human and industrial) and solid waste (wet, dry and hazardous). Urbanisation thus compromises the quantity (Mundoli et al., 2015) and quality of water sources, with untreated sewage and unsegregated garbage dumped in and around waterbodies of cities and peri-urban spaces, as shown in Kannuru. At the same time, wastewater can support livelihoods and feed the city, as agriculture and aquaculture using wastewater in the wetlands in Kolkata's PUI shows. Clearly, there is much complexity in the water-waste interlinkages in the PUI of Indian cities, and the challenge lies in ensuring that solid waste and sewage are used productively with minimal impact on ecological resources such as water.

Landfills are often found outside city boundaries (except in the case of large metros such as Mumbai and New Delhi, where city expansion has extended to encircle older landfills). In Bengaluru, landfills have moved from one site in the PUI to another. Dumping of unsegregated and untreated garbage in villages in the periphery of Bengaluru, adversely impacting the health of residents and the environment, have led to protests by local communities. The response to this by the administration has been to simply shift the landfill to another site (Environmental Support Group, 2018). The result is that today the landfill is situated adjacent to Kannuru, once again posing a hazard for the village and its residents. The rules with regard to solid waste management specify a hierarchy determining that only residual waste is to be disposed in landfills. The rest of the focus is on reduction of waste generation, reuse, recycling and converting waste to energy. The very existence of landfills like the one next to Kannuru, with tonnes of unsegregated dumped waste, is in contravention of these rules (Ministry of Urban Development, 2016a). The responsibility of the citizens with regard to protecting the environment has been laid out in the Constitution of India and has been referred to in court rulings (High Court of Karnataka, 2012). But cities in India are nowhere close to managing their waste as laid out in the legislations and rules (Ministry of Urban Development, 2016b).

Using wastewater for agriculture and aquaculture is a common practise in cities across the world (Costa-Pierce et al., 2005; Scott et al., 2004), and there are many examples in India as well. Van Rooijen et al. (2005) have explored the links between urban water supply and irrigation in the city of Hyderabad. The concerns the authors express about the impact of wastewater irrigation on health, environment and crops are mentioned as requiring additional research, but finding ways to reuse

wastewater is seen as critical for expanding cities (van Rooijen et al., 2005). Yadav et al. (2016) have explored the impact of wastewater used in agriculture in peri-urban Udaipur, where the accumulation of harmful metals in vegetables irrigated with wastewater is a concern. In Hubli-Dharwad safer and sustainable farming solutions to deal with impacts of wastewater irrigation are seen as possible by creating awareness among farmers (Bradford et al., 2003).

What is common to all these studies is that, as water supply to cities increases, wastewater irrigation is seen as inevitably replacing blue water irrigation. Similarly, aquaculture has been an important source of livelihood in urban and peri-urban cities across the world (Costa-Pierce et al., 2005). In India, various technical aspects of aquaculture in the wetlands around Kolkata have been documented, especially its role as the sewage treatment plant of Kolkata (Ghosh, 1988). The aquaculture in Kolkata's wetlands, however, is also an example of how local fishermen have used their traditional knowledge to earn a livelihood; this too has received some attention (Bunting et al., 2005; Ghosh, 2005). Aquaculture in Karnal, in the state of Haryana, was different: there a large facility for aquaculture was run by the government and later leased to a private individual. This effort is seen as an effective way of optimal resource recovery, also supplying food to the urban population (Kumar et al., 2015).

Waste in landfills that pollute water bodies in the PUI and sewage that supports livelihoods are very different framings of the impacts of the waste that our cities produce. The question, then, is how to make optimal use of the waste that cities generate. As a starting point, urban wastes, both garbage and sewage, need to be seen not just as polluters of water bodies but as a "resource for sustainable development" (Smit & Nasr, 1992: 143). This requires moving from the waste in-waste out open loop to the closed loop system, in which wastes and water can be used sustainably. This will require that we look more closely at our waste and water systems and see how we can best close the loop in each of our cities (Smit & Nasr, 1992).

In spite of the opportunities and potential of using organic solid waste as a substrate for farming, and wastewater for agriculture and aquaculture in India and across the world, the positive elements of waste receive little or no attention from policy makers or government officials. Waste generated by cities is hardly seen as a resource for meeting the increasing demand for food by a growing population in the very cities that generate it (Buechler et al., 2005; Saldias et al., 2017; Scott et al., 2004). Therefore, to begin with, there needs to be a change in perception with regard to waste and water. Solid waste needs to be reduced, recycled and reused in keeping with the regulations laid down for this.

More research in the context of waste and water specific to the PUI of cities of India is required to fill the knowledge gaps. These include how organic garbage can be used effectively as a substrate for growing food supplied to the city, while ensuring that the health of producers and consumers is not compromised. We need a better understanding of perceptions and choices of farmers with regard to using wastewater for irrigation or moving from blue water to wastewater irrigation. In the case of sewage-based agriculture and aquaculture, we need to understand how fishers and farmers who have traditionally been engaged in this livelihood, as in the case of the Kolkata wetlands, have been able to adapt to changing composition and

quantity of sewage. We also need regulatory frameworks to address issues of health and impact on environment (Buechler et al., 2005; Saldías et al., 2017).

It should also be recognised that PUIs are not just sites for disposal of a city's waste—and should not be seen and treated as such—but are themselves sites of production, supporting livelihoods and subsistence use. Instead of taking wastewater to far-off areas for irrigation, it is important to explore the possibilities of wastewater use closer to its source in the PUI and investigate what forms of decentralised management of wastewater would be optimal, as is being done in other cities in the Global South (Parkinson & Tayler, 2003). We need to explore innovative ways of nutrient recycling supported by policies that result in positive and sustainable outcomes for waste-water linkages in the PUI.

We need to challenge both the narratives about and the reality of PUIs in Indian cities. This will require finding ways to minimise the harmful impacts of the ecological footprint of cities, and also recognising that the city itself stands to gain by doing so (Rees & Wackernagel, 1996). Attaining the SDGs in the context of PUIs is definitely challenging for a variety of reasons. Sustainability in the PUI for us means ensuring environmental protection along with social justice. But instead of steps to bring these two goals together, there is a trend towards their divergence. This happens in different ways. For one, displacing the marginalised is often seen as necessary to protect the environment in the PUI (Marshall et al., 2009). This is visible in the case of lakes in Bengaluru, for example, where lake renovation by landscaping is initiated by wealthier urban residents along with the government. This results in alienating the urban poor, such as herders, who are dependent on these lakes (Nagendra, 2016). Dumping of the city waste sites in landfills, close to resources such as lakes and grazing lands that the peri-urban poor depend on, is clearly a concern when it comes to social justice. Second, in the changing PUI we can see instances of cooperation, conflict and conflict of interest co-existing, as in the case of peri-urban Gurgaon (Vij et al., 2018). A similar situation could be foreseen in the case of the wetlands of Kolkata, where linkages that exist between wastewater and livelihoods can shift positively or negatively, depending upon land use changes; only more research can reveal how such transformations will work out. For us, to move towards realizing the SDGs in the context of the PUI of cities it is imperative that we learn from situations of conflict and cooperation, building empirical information through research and working collectively to better protect the environment of the PUI and ensuring social justice for communities.

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