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Research

Shifts in ecosystem services in deprived urban areas: understanding people's responses and consequences for well-being

Marthe L. Derkzen[1], Harini Nagendra[2], Astrid J. A. Van Teeffelen[1], Anusha Purushotham[3] and Peter H. Verburg[1]

ABSTRACT. Urban commons are under pressure. City development has led to the encroachment and ecological degradation of urban open space. Although there is growing insight that urban ecosystems need to be protected, there is hardly any attention for the consequences (of both pressures and protection efforts) for vulnerable human population groups. We aim to understand how urban development affects the well-being of the urban poor, through shifts in ecosystem services (ES) and people's responses to these shifts. We performed household interviews and group mapping sessions in seven urban lake communities in Bangalore, India. Changes at Bangalore's lakes can be summarized by three trends: privatization followed by conversion, pollution followed by degradation, and restoration followed by gentrification. Over time, this resulted in a shift in the types of ES supplied and demanded, the nature of use, and de facto governance: from provisioning, communal and public; to cultural, individual, and private. Lake dwellers responded by finding (other) sources of income, accepting lower quality or less accessible ES, and/or completely stopping the use of certain ES. The consequences of ecosystem change for people's well-being differ depending on a household's ability to adapt and on individual circumstances, land tenure and financial capital in particular. To guarantee a future for Bangalore's lakes, restoration seems the only viable option. Although beautiful lake parks may be a solution for the well-off and not-too-poor, leaving the very poor without options to adapt to the new circumstances puts them at risk of becoming even more marginalized. We show that ecosystem degradation and restoration alike can impact the well-being of the urban poor. People's experiences allowed us to couple ecosystem change to well-being through ES and adaptation strategies. Hence, we revealed multiple cause-effect relations. Understanding these relations contributes to sustainable urban development for people from all layers of society.

Key Words: *ecosystem restoration; environmental justice; gentrification; green infrastructure; participatory mapping; trade-offs; urban commons*

INTRODUCTION

Ecosystems and ecosystem services (ES) have been put forward as critical constituents of human well-being (MA 2005). Because the majority of the global population lives in cities (UN 2014), it is in this urban context that ES are particularly important (Elmqvist et al. 2015). Around the globe, people depend on urban ecosystems for cooling, air quality regulation, cultural identity, recreation and tourism, physical and mental health (Wu 2014). Urban nature is also increasingly recognized as an asset for climate change mitigation and adaptation (Demuzere et al. 2014). In developing countries, part of the urban population relies on ecosystems for a much wider range of services: food collection and production, biomass fuels, laundry, sanitary needs, etc. The livelihoods of the urban poor are traditionally more closely interconnected with natural public spaces, or the urban commons, than the middle- and upper classes of urban society (Duraiappah 2004, TEEB 2010).

For the urban poor provisioning ES are the foundation of numerous livelihood strategies and serve an important role as safety net in time of stress, while cultural ES support social functions and biodiversity conservation (CEPSA 2008, Shackleton et al. 2015). For example, Ghanaian livestock herders use urban river banks as feeding grounds for their sheep and goats (Eduful and Shively 2015), and newly arrived urbanites in sub-Saharan Africa were found to bring along natural resource based practices from their rural origins, leading to a distinctive urban-rural mix (Ward and Shackleton 2016). Although dependency on provisioning ES may be largely indirect in the urban core, e.g., through the demand for biomass fuels, ES dependency is more direct in the rural-urban fringe. The wetlands of Accra, Ghana and Cebu City, Philippines, for example, are used by the urban poor for farming, fishing, and the collection of medicinal plants and raw materials (CBD 2012, Ancog and Ruzol 2015). Practicing agriculture for commerce and food security is also gaining ground in and around Kampala, Uganda but the same region exemplifies how urbanization processes lead to the conversion of forests and wetlands (NEMA 2006).

Because the poor are more dependent on ecosystems for their livelihoods, decreases in ecosystem cover, quality, and accessibility could have disproportionally large effects on the poor compared with the affluent. Given the high pressure on urban ecosystems, possibilities to access, use, and govern these natural resources can be expected to be reduced. Urbanization leads to changes in land use, value, ownership, regulations, and quality, changes that leave their mark on the urban commons (Shrestha et al. 2012, Colding and Barthel 2013). Open spaces feel the pressure of city expansion from the center to the hinterland that gradually becomes incorporated within city limits as the periphery (Grimm et al. 2008). This process, and the concurrent change in property rights, has led to the loss and degradation of common lands all over the world (Ostrom 2001, Narain and Vij 2016). This includes urban water bodies, as exemplified by the case of Kumasi, Ghana where encroachment, waste disposal, and poor sanitation have led to severe water pollution (Eduful and Shively 2015). As

[1]Environmental Geography Group, Department of Earth Sciences, Vrije Universiteit Amsterdam, [2]School of Development, Azim Premji University, [3]Karuna Trust

a result, the water can no longer be used for household chores. Urbanization may also lead to a change in accessibility of ecosystems. Urban expansion near India's capital city Delhi increased the demand for land to the extent that local communities saw their access to land and water shrink and needed to completely alter their livelihoods (Vij and Narain 2016). Likewise, privatization and encroachment by authorities and real estate parties may lead to access restrictions and ecosystem destruction (MA 2005, Heynen et al. 2006).

Urban commons offer an opportunity to increase both the resilience of the city and the resilience of the most marginalized people. Whereas the first, resilience of the city, is gaining ground among urban planners, citizen groups, and scientists (e.g., Colding and Barthel 2013), the latter, resilience of marginalized people, appears to receive little attention. With the argument that ecosystem conservation could go hand in hand with poverty alleviation (Daw et al. 2011), a better understanding is needed of the relation between changes in urban ecosystems (degradation and restoration) and the effects on ES and well-being of the people relying on these. Although this relation gains importance with the unceasing growth of urban populations worldwide, and especially rural-urban migration in developing countries, its understanding appears limited (CEPSA 2008, Colding et al. 2013).

We aim to understand how urban development affects the well-being of the urban poor, through shifts in ES and people's responses to these shifts. Using data from seven urban lake communities in Bangalore, India, we demonstrate how changes in urban ecosystems influence the role of the urban commons and thus the well-being of the urban poor. Through interviews and group mapping, we assess changes over time in ecosystem presence and ES use. We show in what way residents adapted to these changes and how the changes and adaptations thereto have affected their well-being.

METHODS

Study area

Bangalore

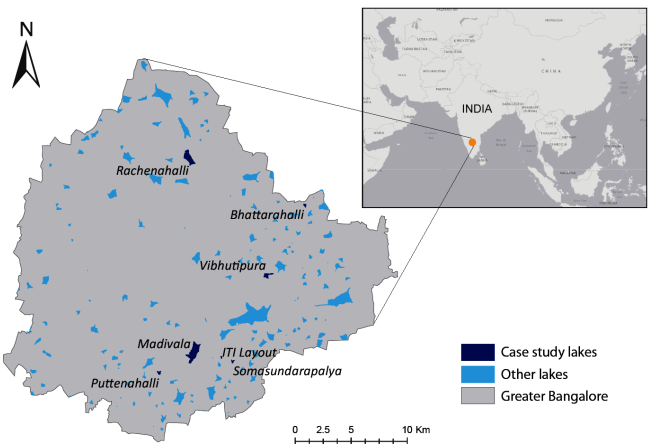
Bangalore is India's third most populous city and home to nearly 10 million people. With a large migrant influx, Bangalore grows fast and will continue to grow: India's urban population is projected to increase by 404 million between 2014 and 2050 (UN 2014). In the previous century, Bangalore was lovingly referred to as the Garden City, dotted with numerous lakes and green spaces. The cool climate, regular rains, and fertile soil were summed up as a Pensioners' Paradise until rapid urbanization, triggered by the IT boom, caused many of these natural refuges to disappear. Those that remain today face a range of challenges: residential and commercial construction, pollution, encroachment, privatization, and so on. We look into the case of Bangalore's lakes and explore how residents of low-income settlements abutting these lakes cope with ecosystem change.

Bangalore's lakes are actually man-made reservoirs that were created centuries ago to supply water to the river-less city. The settlements located at the banks of these lakes are primarily low income, the reason being that low-lying areas are usually the least preferred for habitation because of flooding/marshy nature of the land. Hence, the poorest sections of society (either rural migrant or from the city) are left with no other option than to occupy such unclaimed, undesirable lands, which often belong to the government. Some of these settlements are former villages, others are spontaneous settlements of two to four decades old and few are relatively new. The older settlements, mostly, are converted into slums (both recognized and unrecognized) with brick/cement houses. The newer settlements are mostly small unrecognized migrant settlements with tarp tents or sheds without any access to electricity or water supply.

Case study selection

Potentially suitable case study areas were identified by asking experts about their knowledge of low-income settlements existing next to lakes and by scanning Google Maps satellite images of residential structures in lake surroundings. In May and June 2015, 14 lakes were visited to explore the area, observe activities, and interview residents to get an impression of ongoing developments, local problems, and the historical context. The selection process entailed over 70 interviews and conversations with individual residents, groups of people, elders, or long-time residents, and a few children. Seven lakes (Fig. 1) were considered suitable for further data collection because they (i) were abutted by a low-income settlement; (ii) consisted of at least 100 dwellings; (iii) were not temporary, i.e., not just for the time construction works were being executed; and (iv) were accessible for residents who used the lake for ES provision, if not currently than at least 20-30 years ago.

Fig. 1. Map of Bangalore, India, its lakes, and the selected case study locations.



Data collection

In each of the seven case study areas we held household interviews (30-33 per lake, see form in Appendix 1) and a group mapping session (one per lake, see form in Appendix 2) to collect information on the state and function of the local ecosystem for the local people, both currently and in the past, focusing on ES use and ecosystem disservices (ecosystem-related nuisances or losses, see Lyytimäki and Sipilä 2009). Five to eight visits per lake were needed to collect the survey and mapping data. Figure 2 gives an impression of a lake landscape and the data collection process.

Fig. 2. Impression of a household interview (a), group mapping session (b), and lake area (c).

Central to the interviews was the past and current use of ecosystems, their ES, and disservices. To encourage a uniform understanding of these concepts we developed locally appropriate choice cards with symbols depicting different ecosystems, ES, and disservices (see Appendix 3). The cards also served to engage participants with the study and ease communication with people from different backgrounds, age, and idioms. To identify a relevant set of ecosystems, ES, and disservices to include on the choice cards, we gathered information about local ecosystems and their uses in four ways: (i) publications about vegetation in Bangalore's slums (Gopal et al. 2015) and their uses and functions (Gopal and Nagendra 2014); (ii) repeated discussions with six local experts; (iii) observations during 11 visits to 8 lake settlements; and (iv) interviews and conversations at the same locations. This information was used to select 9 ecosystem types, 16 ES, and 6 disservices. The choice cards were tested and redesigned until 90% of the cards were understood at first sight by both children and adults in three pilot sessions. During the survey we also provided a verbal explanation of the choice cards.

Group mapping sessions

At each location we organized a group mapping session to understand how local ecosystems have changed over time and how this affected people's livelihoods and well-being. A session lasted two hours on average and typically had three to six participants: long-term residents with knowledge of past land use, infrastructure, and community organization. Participants were sampled based on conversations and leads we got during the household survey, followed by a snowball approach. Simple topographic maps showing the lake outline and surrounding streets were prepared using My Maps service from Google Maps and printed A1 size. A session always included a few minutes of orientation to allow participants to become acquainted with the map and determine their current location and major landmarks. Then, a facilitator asked participants to indicate, locate, and pencil draw land uses, roads, and settlements surrounding the lake 20-30 years ago. We used choice cards and figurines (symbolizing sacred trees and livestock) that participants could place on the map to make the process more interactive. It usually took several rounds of placing, drawing, and erasing before consensus was reached about exact locations and sizes. For each formerly present ecosystem the participants discussed its use, accessibility, and management. This was followed by a discussion of important (drivers of) changes in ecosystems, livelihoods, and community life and values. Finally, participants described their expectations and hopes for their future environment. Each session was ended by drawing the final map using colored markers.

Household survey

The household survey comprised 71 questions with 74 subquestions about current and past ES use and was conducted between July and October 2015. Households were sampled on a door-to-door basis, making sure that each part of a settlement was covered, including migrant, village, and spontaneous settlements. Interviews were completed face-to-face and lasted from 10 minutes up to 4 hours (44 minutes on average). The sample (214 interviews in total) consisted of 67% females, average age was 42 (± 16.3), 49% lived at the location for 10 years or more, 28% arrived within the past 10 years, and 23% was born there. Of all respondents, 73% had a rural background, including those living in settlements that used to be rural but by now have become part of Bangalore city.

During the survey we enquired about the use of 16 ES, assisted by the choice cards. Interviewees also ranked the top three ES currently most important for their household's general well-being. For each of these ES we listed why it was used, with which frequency, and where it was sourced from. This exercise was repeated for ES used in the past, with those interviewees who had been living at the location for at least 10 years (n = 166). If differences appeared between current and past use, we asked when the change took place, what the reason was, and which alternative the ES was substituted for. We also asked interviewees about preferred ecosystem types and perceived ecosystem disservices.

Analysis

For a proper understanding of the context, we first assessed changes over time in land use, ecosystem coverage, and quality using primarily group mapping results. Next we analyzed overall and lake-specific patterns of change in ES use and ES importance based on survey data. Then we outlined the consequences of these shifts for people's livelihoods, the ways in which people adapted, and how this affected their well-being, based on survey data.

RESULTS

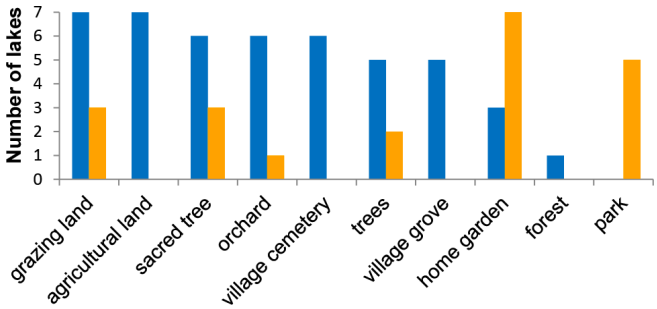
Changes in land use, ecosystem quality, and community structure

The surroundings of the studied lakes have changed substantially in the past decades: agriculture, orchards, and village groves made way for industry and residential and commercial layouts. Group mapping revealed that before the 1980s, lakes were surrounded by downstream rice paddies and upstream *ragi* (finger millet) fields,

interspersed with orchards and pastures. Settlements were not located at the lakeshore directly because the area was used for food production, livestock raising, and material collection. Lake water was used for rice irrigation, drinking water (people used to dig a hole next to the lake to access groundwater), laundry, and bathing. Several lakes functioned as seasonal brick factories cum fish ponds; after the rainy season workers dammed a shallow area that, after the fish was caught and the water had seeped away, provided the raw material to produce bricks from lake sediment. The high dependence on natural resources meant that villagers managed the ecosystems in a cooperative manner to ensure a sustainable use of the resources. At some lakes, fields were irrigated by taking turns and farmers worked on each other's land to divide labor and equipment. At other locations a few land owners, often coming from the same family, managed the land that was farmed by laborers on a sharing basis, e.g., 50% of the harvest goes to the owner and 50% to the laborer. In the village grove, people were allowed to collect fruits or fallen branches for fuelwood and it was a place for cows and goats to graze. A big tree branch could be cut for a wedding or other ceremony but only with permission from the village leaders.

The described landscape started to transform in the 1980s when the authorities decided that Bangalore's periphery needed to be "developed." Industrial, commercial, and residential layouts wiped away the agricultural fields and started contaminating the lake. With the loss of fields and clean water, the shared responsibility for a healthy ecosystem also vanished. There are few or no common endeavors to combat street and lake pollution, in contrast to the past when residents would take up action to, e.g., improve the roads together. What remains in terms of urban nature are the lakes, or actually, small and polluted versions of them. Also, two new types of ecosystems have appeared: home gardens and parks (Fig. 3). Parks have been created and are maintained by the municipality, business parks, citizen trusts, or a combination of these.

Fig. 3. Land use in the seven lake areas for both past conditions (around 1980, blue bars) and current conditions (2015, yellow bars).



Patterns of change in ecosystem services use

Each lake has undergone major changes in the past 20-30 years that led to a severe decrease in the number of families using ES and a smaller bundle of ES provided per lake. Earlier, 14 out of 16 ES were used by at least one-third of all households in our survey, while today this is only three out of 16. Water-based ES such as drinking water provision, laundry, and swimming/bathing have disappeared almost completely because of pollution, while food production in arable fields stopped and fodder collection plummeted when farmlands were sold for city development. Currently, gardening is the most popular use of urban nature, followed by fuelwood and then other cultural ES such as sacred uses, scenic beauty, and recreation. Over time, the data show a decreasing trend for provisioning ES and an increasing trend for cultural ES, especially because the practice of gardening increased strongly (Fig. 4).

Fig. 4. Ecosystem services use of the lake area per type for both past conditions (around 1980, blue bars) and current conditions (2015, yellow bars).

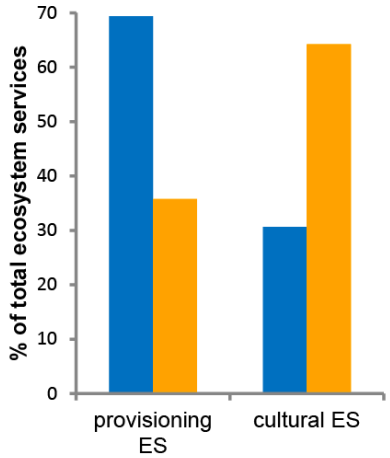


Figure 5 shows a general trend of reduced ES use but also reveals different patterns of change among the seven lake communities. Respondents in Bhattarahalli and Rachenahalli communities were most reliant on ES in the past, e.g., for the collection of fuelwood, wild foods, and other natural material, followed by ITI Layout where residents mostly used the lake surroundings for provisioning ES like laundry and cattle herding. Although these three communities have experienced large changes in ES use over time, respondents living at Rachenahalli Lake still use more ES than at other lakes. Of all lakes, ITI Layout has seen the sharpest decrease in ES use with all except gardening being used by less than 20% of respondents. In contrast, Puttenahalli Lake was relatively little used earlier but has come to be used more compared with the other lakes, mainly for cultural ES. This is exemplified by the ES scenic beauty, which decreased at all locations except for Puttenahalli and Vibhutipura lakes. These two lakes have recently undergone clean-up and restoration activities that apparently succeeded in improving the lakes' visual attractiveness.

Fuelwood, livestock herding, and laundry were considered the most important ES in the past (Fig. 6). Fuelwood was collected around the lake, agricultural fields, and groves, and used daily for cooking and heating bathing water. Over time it became harder to find wood and the local government provided kerosene stoves to low-income households, which were later replaced by gas. In the same fields, people would take their cows, goats, and sheep for grazing and the animals provided them with a livelihood in return: a milk or meat business, for ploughing, and manure

Fig. 5. Changes in the use of ecosystem services for all lakes together (top left panel) and for each individual lake for both past conditions (around 1980, dashed line) and current conditions (2015, solid line). Axis indicates the share of households using the services from 0% (center) to 100% (outer ring).

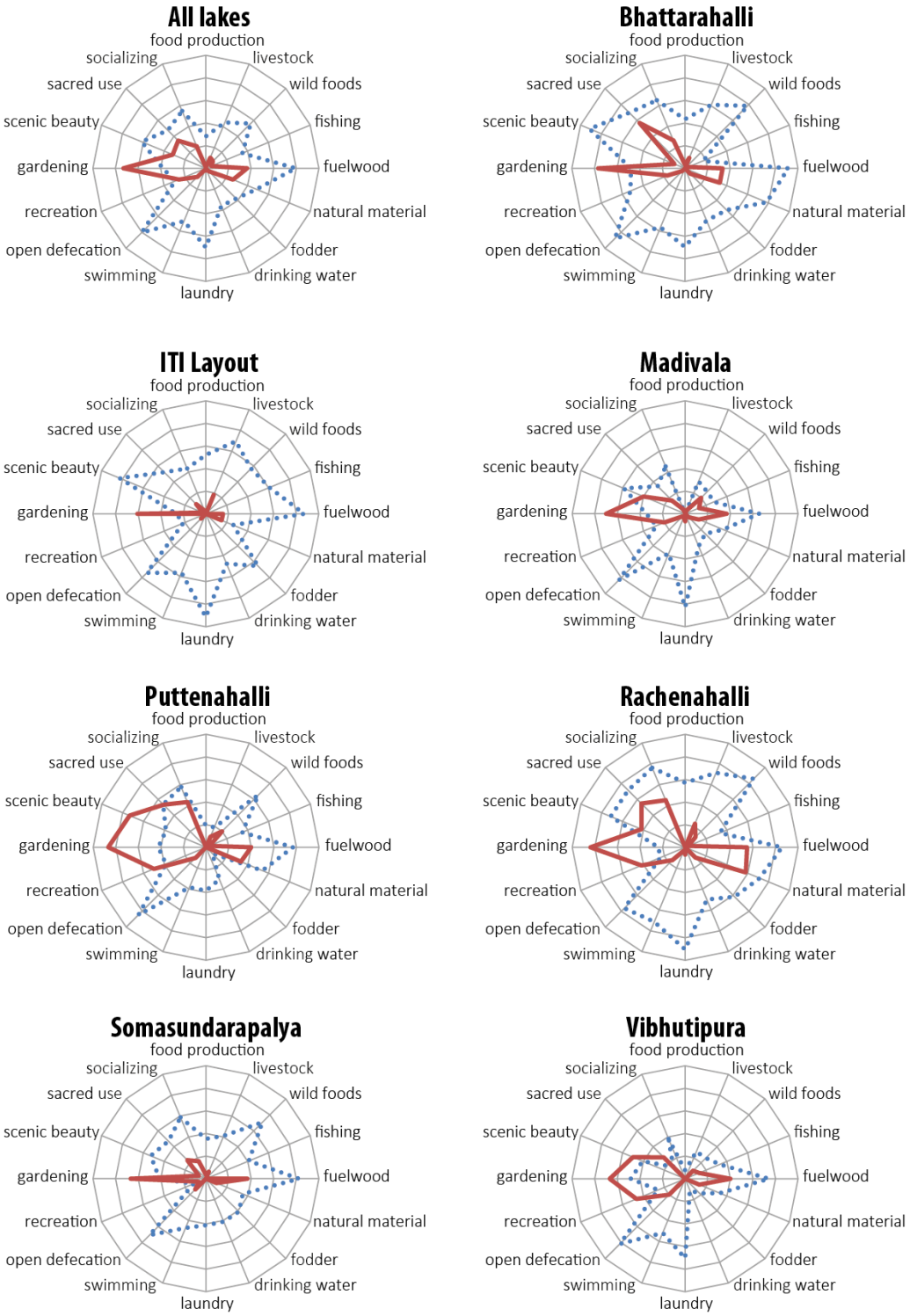
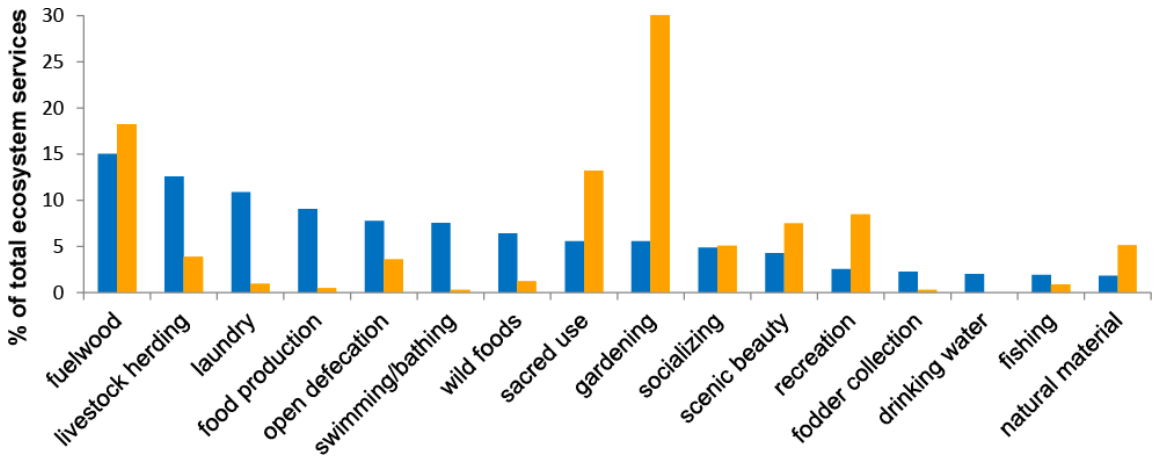


Fig. 6. Relative importance of ecosystem services for both past conditions (around 1980, blue bars) and current conditions (2015, yellow bars).



provision. When the fields transformed into residential layouts families had to start working in wage labor, often as unskilled laborers, or became dependent on their children's revenue. Also the women doing laundry at the lakeshore have become a rare sight since lake water got polluted and access to the water became difficult because of fencing and elevated lake bunds. Instead, people use water from bore wells or tanks that are supplied two to three times a week.

Most ES that were considered important in the past are no longer considered important today. An exception is fuelwood, which is still used to heat bathing water in the morning, although today the wood or coconut chips are often bought and if collected, mostly from cut roadside trees or construction sites. In the analysis we included households collecting fuelwood from various sources and excluded those buying fuelwood. Ecosystems are also used for sacred and religious purposes: trees, ant hills, and occasionally the lake itself. Lake festivals and rituals were more abundant in the past, when they were performed to, e.g., safeguard or bless a good harvest. But the most important ES at present is definitely gardening, ranging from a few flower pots to much used kitchen gardens, which people do for ornamental, consumption, religious, medicinal, and cosmetic reasons. The most common plants are the medicinal aloe vera, used for skin care and home remedies, and the sacred *tulsi* or Holy Basil (*Ocimum tenuiflorum*) to which Hindus pray and which is also an herbal medicine. Other favorites are flowers, chilly, tomatoes, and eggplant.

Changes in the use of lake ES in Bangalore are driven by a combination of factors: land use change, pollution, access restrictions, and changing needs and norms. The transformation from agricultural land and open fields to industrial, commercial, and residential layouts has led to a reduced availability of natural resources and has especially influenced land-based ES such as food production, livestock herding, and the collection of natural material. When the new occupants started dumping waste and sanitary water into the lake this also led to a reduction in ecosystem quality and a resulting decline in the use of water-based ES. ES use became further constrained by new rules and regulations resulting from changes in land ownership: people were no longer allowed to collect fallen branches in the government forest or pluck fruits from the orchards. In some cases the lake has become inaccessible because a physical barrier has been built to prevent people from entering and using the lake. Finally, ES use declined because of changes in people's needs and norms such as the fading traditions of using fuelwood for cooking and sacred lake festivals, but also the arrival of technological alternatives (gas stove, toilet, washing machine). At the same time, changing needs and norms have also led to an increase in ES use such as the new interest people have in gardening and recreation.

Consequences of change: how have people adapted?

The altered ecosystem forced those living next to the lake to adapt to the new circumstances. A majority switched from farming and livestock raising to casual or other types of paid labor. Some travelled to other locations to find resources such as fodder and fuelwood while those with the financial means paid for goods and services and went elsewhere in search of aesthetic enjoyment. For other ES, their use stopped. However, the way in which people adapted to their changing environment differs for the various types of lake residents.

Among our interviewees we noticed that those living in reasonably secure circumstances, with regard to housing and employment, show a growing interest in the recreational and aesthetic enjoyment of the lake. They no longer rely on the lake for provisioning ES because they are able to pay for goods and services, and their norms and needs change according to an urban lifestyle. What may remain of their ancestors' background is the use of fuelwood to heat morning bathing water and growing a few sacred, medicinal, and ornamental plants in pots. This adaptation pattern is visible among the better-off (often those receiving revenue from renting out apartments built with money from farmland sales) in the former villages around Bhattarahalli and Rachenahalli lakes, and also in the oldest spontaneous settlements of Madivala and Vibhutipura lakes.

Interestingly, some families that have become very rich from land sales still have tight connections with nature and agriculture. These families often own fields and orchards outside of the city

from which they bring home some produce. Also their gardens are full of native plants whose medicinal properties they can lengthily describe. They maintain the open wells built by their grandfathers and use traditional tools such as grinding stones while the newest motorcycle is parked outside. Such families are found around the lakes of Bhattarahalli, ITI Layout, Rachenahalli, and Somasundarapalya.

Another group of respondents typically adapted to the decreased possibility to use natural resources by finding alternative income; the women working as domestic help and the men doing manual labor. Some may have sold their farmland but did not invest in building rental apartments. Some continue raising livestock but now need to buy fodder or find it elsewhere. Their houses are equipped with basic sanitary facilities or they use shared toilets. They use fuelwood to heat bathing water and often have gardens with useful plants for consumption, medicinal, and sacred use. Even if families enjoy reasonably steady employment and financial capital, they may still be lacking housing security because their houses are built on government land: they have permission to live here, but as soon as the government needs the land for a different use the families may receive an eviction order. These patterns are visible among residents of the spontaneous settlements at Bhattarahalli and Puttenahalli lakes and residents living in rental housing at ITI Layout, Madivala, and Somasundarapalya lakes.

A final group consists of those without secure land tenure and financial capital, largely rural migrants who left their native place because there were not enough rains to nourish their fields. They come to the city and end up working in construction, men and women alike. Their settlements can be recognized by the shacks of ply- and waste wood or stones, covered by blue tarpaulin sheets and lacking any sanitary facilities. They have no water connection and cook on open-air fuelwood stoves. Some stay for a few months, others over 10 years. Because of the insecure housing situation and the heavy work load, families do not grow any plants. They generally do not have a historical connection to the place, but do rely on the lake in times of need. Vegetated surroundings are used for open defecation and in the absence of water they wash their dishes and laundry with lake water. Just like fishing and the collection of wild foods and natural material, these uses are becoming increasingly difficult because lakes are increasingly difficult to access. Fencing, rules, and restrictions but also pollution and the privatization of open fields reduce the possibilities to access natural resources for the most vulnerable groups. These groups lack the financial means for proper and safe alternatives, and suffer from insufficient institutional support. As a result, those already vulnerable become even more marginalized. This type of resident can be found at Puttenahalli, Rachenahalli, Somasundarapalya, and Vibhutipura lakes.

The links between drivers of change, ES use, and resulting adaptation strategies are depicted in Figure 7. The diagram also shows a number of consequences for human well-being that are faced by lake residents, such as an increased reliance on paid labor and financial capital and a decreased possibility to express cultural and spiritual values related to the lake ecosystem. Whether these consequences are negative or positive depends for a large part on an individual's socioeconomic position and security.

Preferences for ecosystem types and future pathways

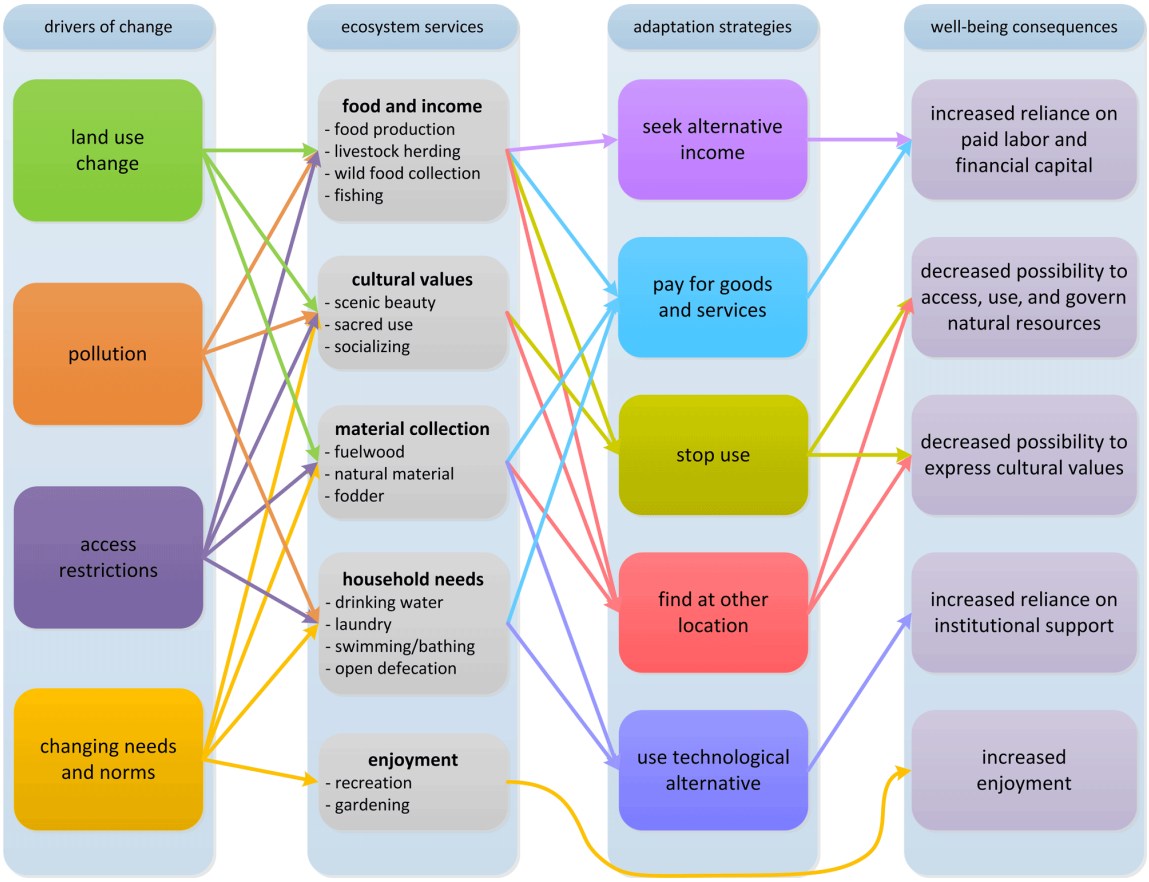
In such a context of change, the question is what will happen in the near future. When we asked respondents which ecosystem types they would prefer to have around, agricultural land was chosen by one out of five. Despite that people realized it is not possible to farm around the lake nowadays because of land availability and ownership, they still longed to be surrounded by agricultural fields. To many, agriculture is "everything in life" and its popularity has much to owe to nostalgia. The same nostalgic reasons appeared for grazing land (7%) and forest (7%), although forest was also treasured for its shade, cool climate, peacefulness, animals, and fuelwood and fodder provision. Among these three ecosystem types, some remnants of grazing land are left in only three of the studied lake areas.

From the currently existing ecosystem types, fruit trees were most preferred (15%). Fruit trees were favored for eating or selling the fruits, to use in cooking, for weddings and religious functions, and making broomsticks. However, most existing fruit trees are privately owned, either grown by individuals or in groves. Other trees such as the sacred banyan tree (10%) were appreciated for their provision of shade and wind, as a place to meet, talk, and play, for spiritual purposes, and for their wood. Large trees are generally found at the village *ashwat katte* (platform with sacred trees) where spiritual use is common, but the social use may be dominated by men. Home gardens (14%) were chosen for growing ornamental plants, fruits, and vegetables, for health reasons, and because gardens are considered to improve the microclimate. Although gardening is already the most common ecosystem practice, not everyone has, or in case of rental housing is allowed to use, the space to grow plants or place pots. In addition, for garden plants there is the risk of them being eaten by cows. Finally, 13% of all preferences were attributed to the lake, though in a clean and nonpolluted state so that the lake area can be used for its scenic beauty and for domestic chores, bathing, fishing, and for other animals to thrive. Respondents also made a connection between the dirty water and the presence of mosquitos and diseases and therefore expect health benefits from a clean lake.

Conversion, degradation, or restoration

Several respondents (14%) and group mapping participants mentioned that parks were the only realistic option for developing new greenery in a city like Bangalore. Without an incentive for restoration, the lakes seem destined to endure severe degradation and/or complete encroachment by landless families and real estate developers. Especially in the last case, encroachment may lead to the disappearance of urban lakes and surrounding open space, as has happened repeatedly in Bangalore (D'Souza and Nagendra 2011). But Bangalore has recently witnessed several citizen initiatives to save or restore lakes, coming from middle and high-end income groups with lobbying power (Enqvist et al. 2014). Lake restoration efforts seek support from the relevant local authorities and go hand in hand with park development, alongside with elevated lake bunds being turned into walking and jogging tracks. Two lakes in our sample, Puttenahalli Lake and Vibhutipura Lake have undergone restoration activities such as cleaning the lake, creating a walking path, and planting flowers and ornamental trees. A fence should help maintain the rejuvenated lakes and indeed it stopped people (and livestock) from entering the lakes while recreational uses increased. The parks and walking paths are much used, also at Rachenahalli Lake

Fig. 7. Diagram showing the links between drivers of change, ecosystem services, household adaptation strategies, and well-being consequences.



where the village grove was turned into a park by a private owner, who is the owner of the neighboring tech park, i.e., office park. Lake restoration regularly coincides with the construction of lake view apartments and other luxury housing projects targeted at the new urban elite and upper-middle class for whom the lakes are places for recreation and aesthetic enjoyment.

DISCUSSION

We aimed to understand how urban development affects urban ecosystems and the well-being of the urban poor, through shifts in ES and people's responses to these shifts. By enquiring about both past and current availability and use of ES, we were able to illustrate spatial and temporal patterns for several lakes. Our method of combining household interviews with group mapping sessions provided an adequate sample to distinguish patterns of ES use while also collecting rich data on the historical context, land sales, changes in ecosystem management, and consequences for community structure. This combination allowed us to reveal the links between drivers of change, changes in ES use, people's adaptation strategies, and well-being consequences. It also provided us with insights into people's expectations and preferences for the future of Bangalore's lakes, a future which seems to revolve around conversion, degradation, and restoration.

The context of Bangalore's lakes reveals a trend from the use of provisioning ES in the past to the use of cultural ES to date, and from communal to individual management of local ecosystems. A clear pattern is the shift toward using public space for recreational purposes while some provisioning ES are provided on a small scale in the private realm through the practice of gardening. Lake dwellers responded to the increasingly urbanizing environment by finding (other) sources of income through a paid job, often as unskilled laborer, accepting lower quality or less accessible ES, and/or completely stopping the use of certain ES. The consequences of these changes for people's well-being differ depending on their financial and land tenure security: those with a relatively steady income are able to pay for goods and services and therefore are not much affected, while those without a steady income need to rely on other safety nets and are thus more affected by changes in ES provision. Last, those without secure land tenure lack the option of growing a kitchen garden and live in constant fear of eviction that makes it hard to invest in the future.

Changes in and around Bangalore's lakes can be summarized by three trends: privatization followed by conversion, pollution followed by degradation, and restoration followed by gentrification. These trends are by no means unique to Bangalore, but not everywhere have they had similar consequences. The trend

of privatizing public space and greenery, for example, has also been prominent in urban policies in the UK and U.S. since the 1970s (Warner 2012), and two decades later in the postsocialist cities of Eastern Europe (Hirt 2012). Privatization and collective action can on the one hand lead to nature conservation, regeneration, and stronger community ties (Foster 2012). On the other hand privatization may exclude people from entering and using the space, which thereby loses its meaning as a commons (Le Goix and Webster 2006), and is what we observed in Bangalore. Likewise, the trend of ecosystem degradation by pollution is not unique to Bangalore and water bodies in other contexts of rapid urbanization have witnessed the same (Hettiarachchi et al. 2014, Eduful and Shively 2015). We observed the lakes being fed by insufficiently treated sewage water from surrounding apartments and institutes while slum rubbish reaches the lake via open storm water drains. For the families that continue living near a degraded lake ecosystem and for those who are new to the city and come to live at one of the few remaining open spaces, the lakes seem to have little to offer. Living near a lake may be more of a burden than a benefit, being deprived of proper garbage, sewage, and sanitary systems and suffering from the health risks of being exposed to polluted water; residents related the perceived increase in mosquitoes and disease to an increase in pollution.

The third trend, and the only one seemingly able to provide a viable future for the city's lakes, that drives changes around Bangalore's lakes is restoration. Restoration of the urban commons has been set in motion through global treaties, e.g., Ramsar for wetland protection, as well as collective citizen action. Although such initiatives have succeeded in raising public awareness and support, improving ecological conditions, and creating tourism and recreational benefits, such initiatives do not necessarily benefit all citizens alike (Enqvist et al. 2014, Cobbinah et al. 2015, Dennis and James 2016). Even though restoration may counter the negative effects of environmental degradation, it comes with access restrictions that have the same effect that pollution has: the use of livelihood-supporting ES is inhibited. This process makes room for recreational and aesthetic uses of the urban commons and benefits those looking for a recreational use of the city's lakes: the urban elite and growing middle-class. Residents in our sample who have been able to adjust to the urban lifestyle are happy with the creation of lake parks because they found new value in these places: a nice view, walking paths, and a place for their children to play. At the same time, other residents do not feel welcome or are too unfamiliar with this new use of urban nature. As with the case of South Africa (McConnachie and Shackleton 2010), the urban poor cannot afford to visit more natural places in or outside the city (botanical garden, rural areas), meaning that changes in the ecosystem leave them deprived of both cultural and provisioning ES. In this way, a focus on ecology, i.e., lake restoration, leads to exclusion of certain groups.

Another consequence of lake restoration is gentrification, the process in which upgrading of deprived neighborhoods results in an influx of wealthier residents that displaces poorer residents (Wolch et al. 2014). The role of urban ecosystems as a real estate asset and the related process of gentrification is taking place worldwide, from Seoul (Lim et al. 2013) to Maputo (Barros et al. 2014) and from London (Lees and Ferreri 2016) to Manila (Ortega 2016). These contexts all tell about increased inequalities between the urban poor and the urban elite, about access, quality of urban services, and displacement. The urban poor may be dislocated as a result of brownfield restoration as happened with New York's High Line Project (Steiner 2014). Similar processes are happening at Bangalore's lakes where spontaneous settlements are being demolished as soon as the area undergoes rejuvenation work. In Bangalore, gentrification mostly seems to result from neighborhood improvement for the already well-off; restoration efforts are largely initiated by and serve the goals of elite groups, i.e., those with higher education, income, and political influence. Indeed, lower socioeconomic status was found to negatively influence community participation rates in Dhaka, Bangladesh (Swapan 2014). But there are exceptions, such as in Cape Town, South Africa where formerly marginalized citizens initiated a restoration project on the derelict land they came to live on, triggering multiple other socioecological projects in the area (Colding et al. 2013). Still, this case concerned residents with property rights, while the most vulnerable groups, who are also the most ES reliant, generally do not have the legal rights to the land on which they live on, something that seems a significant impeding factor in prompting action for ecosystem restoration (Shackleton et al. 2015).

Our aim with this study was to understand how low-income settlements depend(ed) on lake ES and how urbanization affected their livelihoods and well-being. We used a combination of household interviews and group mapping sessions, focusing on slum residents. This combination allowed us to reveal the links between drivers of change, changes in ES use, people's adaptation strategies, and well-being consequences. However, our approach also has certain limitations. First, our focus on slum residents means that views and preferred lake uses of nonslum residents were not taken into account. Incorporating their perceptions would have given a more complete picture of especially the current situation and future prospects of lake use. Second, we mapped land use and changes therein through group mapping sessions. These maps could not be compared and verified with historical maps of past land use because these are, to our knowledge, not available while historic remote sensing data do not provide sufficient detail to depict the actual use of the ecosystems around the lakes. The participatory mapping foremost served to guide the discussion and understand local dynamics of ecosystem change, more than being geographically accurate. Third, our household sample has an overrepresentation of women, which may skew the types of ES assessed. For example, we gained more insight into the use of certain ES such as the collection and medicinal use of wild plants, but as a consequence we collected fewer details about ES use such as fishing and swimming, which are often men-led. We compensated for this imbalance in the ES types considered by separately interviewing key persons encountered at the lake, not as part of the survey, who engaged in fishing, bathing, and herding cattle.

Our results show that lake residents are divided between those who long for the old days of farming and living in close connection with the surrounding ecosystems, and those who have accepted the changing tide and managed to adapt to a new lifestyle. Considering Bangalore's growth rate, the old days are unlikely to return. But a realization that the city's open spaces and especially its unique network of lakes need immediate attention is sprouting. Supported by the local government as well as civil society, lake

restoration efforts are ongoing and the first success stories made it to national and international news. At the same time, horror stories of urban lakes frothing with chemicals make sure that everyone knows there is still a long way to go. What is missing in these debates is a consideration of the people living right at and depending on the lakes. This study provides new insights into their livelihood decisions and expectations. Although beautiful lake parks may be a solution for the well-off and not-too-poor, leaving the very poor without options to adapt to the new circumstances puts them at risk of becoming even more vulnerable and marginalized. There is a dire need for their voices to be included in ecosystem restoration projects. But the needs of the urban poor often do not seep through into policymakers' plans because their voices remain unheard; that is why stakeholder participation is essential (Eduful and Shively 2015). A restoration project that includes everyone's voices and stakes will possibly be the most successful in ecological terms as well, because a secure livelihood can encourage environmental stewardship (Cobbinah et al. 2015). The challenge is to find common ground among the heterogeneous and often individualistic spirit of urban communities (Zhu and Simarmata 2015). Bangalore has taken the first steps of political will and public awareness. A next step would be to create a safe platform to facilitate discussions with people from all layers of society.

CONCLUSION

This study supports the notion that ecosystems and ES are critical constituents of human well-being, particularly for the urban poor. We show, however, that shifts in the availability, quality, and access to local ES affect well-being in different ways and can have positive as well as negative consequences. Having access to a large bundle of ES does not automatically translate to higher well-being, and ecosystem degradation does not necessarily bring about losses in terms of well-being. Rather, the consequences of ecosystem change depend much more on a household's ability to adapt and on individual circumstances, secure land tenure and financial capital in particular. Other important nuances that may be overlooked are the issues of access and trade-offs among ES such as provisioning versus cultural services. In the current context of Bangalore's lakes, ES provision may be helpful in addressing poverty but does not automatically contribute to poverty alleviation.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/9168

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Appendix 1. Household survey form

Location *Date*

Interviewers *Time*

Name(s)	Gender	Age	From rural / urban	Language Religion	Living here since	Moved here because

Occupation	Household composition	House	Describe house
Woman: Man: Son/daughter:	Grandparents: Adults: Children:	rented / owned	

Ecosystem services

Ecosystem service	**Used at present**	Rank	**Used in past**	Years	Rank	**Comments**
Drinking water						
Laundry						
Fishing						
Livestock herding						
Fodder collection						
Food production						
Wild food collection						
Gardening						
Fuelwood						
Natural material						
Open defecation						
Sacred use						
Socializing						
Swimming/bathing						
Recreation						
Scenic beauty						

*3 most important ecosystem services at **present***

Rank	Frequency	Source	Reason	Consequence of restricted access & alternative
1				
2				
3				

*3 most important ecosystem services in the **past***

Rank	Frequency	Source	Reason	When change	Why change	Alternative
1						
2						
3						

*3 **preferred** ecosystem types*

Rank	Ecosystem type	Why preferred	If present, why not/little used
1			
2			
3			

Ecosystem disservices

	Snakes	Mosquitos, disease	Pollution	Flooding (rain/lake)	Drowning	Anti-social (alcohol)
Present						
Rank						
Past						
Years						
Rank						

*3 most hazardous ecosystem disservices at **present***

Rank	Location	Coping mechanism
1		
2		
3		

*3 most hazardous ecosystem disservices in the **past***

Rank	Location	Coping mechanism
1		
2		
3		

Appendix 2. Group mapping form

Location *Date*

Interviewers *Time*

Name	**Gender**	**Age**	**Living here since (year)**	**Current occupation**	**Past occupations**
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Ecosystem	Present during	Description: Type of uses, purpose	Users	Accessibility	Management	How cope with change? Impact on livelihood?
Lake						
Forest						
Village/ sacred grove						
Grazing land						
Agriculture						
Village cemetery						

Ecosystem	Present during	Description: Type of uses, purpose	Users	Accessibility	Management	How cope with change? Impact on livelihood?
Tree plantations						
Sacred trees						
Trees						
Park						
Home garden						

Past

Most important ecosystem	Reason	Changed into…	Why?
1			
2			
3			

Present

Most important ecosystem	Reason
1	
2	
3	

How did these changes impact the community? Life, values, traditions, etc.

Future

How would you like your surroundings (lake & vegetation) to look like in ten years? Which ecosystems would you like to be present?

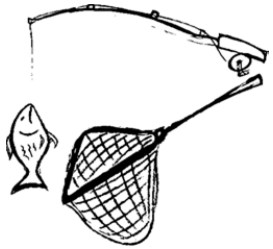
Appendix 3. Choice cards

Ecosystem services

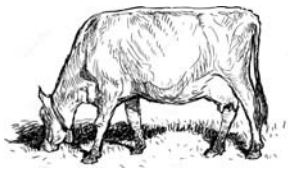
Drinking water

Laundry

Fishing



Livestock herding



Fodder collection

Food production

Wild food collection

Gardening

Fuelwood

Natural material (I)

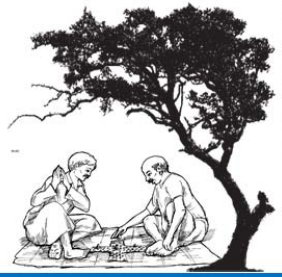
Natural material (II)

Open defecation

Sacred use

Socializing (I)

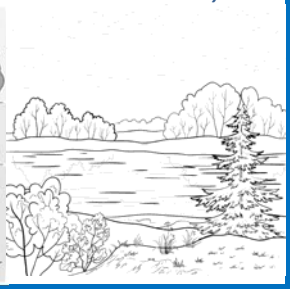
Socializing (II)



Swimming/bathing

Recreation

Scenic beauty



Ecosystem disservices

Snakes

Mosquitos, disease

Pollution

Flooding

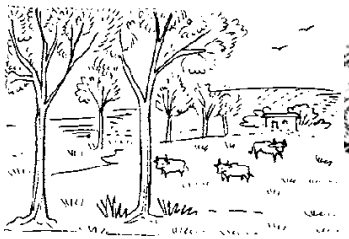
Drowning

Anti-social

Ecosystems

Lake

Grazing land



Agricultural land

Sacred tree

Orchard (I)

Orchard (II)

Home garden

Forest

Park