Youth and Young Water Professionals

Global Water Partnership South Asia

# RESOURCE BOOK

## Water Academy for Youth South Asia 2022


**Editors**

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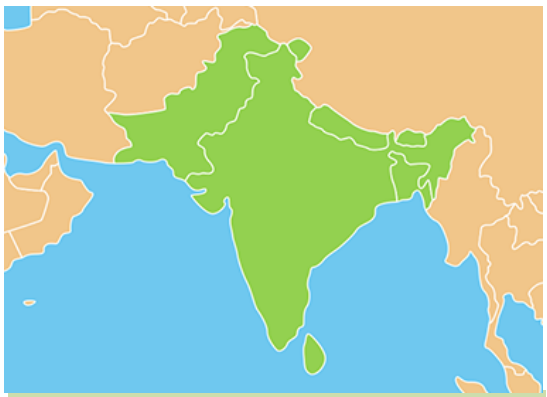
# About this Publication

Water Academy for Youth (WAY) is Global Water Partnership's (GWP's) flagship Youth Programmes launched by aiming to promote leadership, mentorship, fellowships/internships, networking, and intergenerational dialogues among regional youth. The South Asia edition of the programme was coordinated by GWP South Asia (GWP SAS) held in an online format for a duration of 9 weeks between 26th September and 30th November 2022. The programme was facilitated in close collaboration with Waterlution, Water Science Policy, and GWP Southeast Asia.

Young professionals and experts were also connected to decision makers, practitioners, and senior water leaders for mentorship, inter-generational dialogues, to network and act on SDG implementation focused on riverscapes and riverine ecosystems in South Asia. At the end of the programme, participants joined 'Youth and Young Water Professionals Platform (YYPP),' a body that functions as a pool of knowledgeable youth working to support improved water management in South Asia.

This resource book is a public recognition of the commitment of the cohort of WAY programme members from across South Asia, highlights youth contributions towards water action, and supports the dissemination of findings. Furthermore, it validates the value of creating youth opportunities to empower them as agents of change while sharing knowledge and experiences related to water in their respective countries.



## GWP South Asia

GWP SAS Regional Water Partnership (RWP) is based in Sri Lanka having its vision "a water secure South Asia". GWP SAS is one out of 13 RWPs of the GWP, an intergovernmental organisation with a network of more than 3,000 partners across the world. There are six Country Water Partnerships based in Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka that support GWP SAS to deliver its mission. Youth is an across-anchor area of the GWP Strategy and GWP SAS recognises and encourages meaningful youth engagement in programmes.

# Youth and Young Water Professionals Platform (YYPP)

YYPP is a youth network organisation founded in 2021 with the support of GWP SAS. Since its foundation, YYPP has been actively engaging with a range of partners to highlight youth expertise while contributing to ongoing water conversations and action.

YYPP supports the next generation of water experts through its peer-to-peer support network that engages in dialogues and partnerships. The YYPP approach aligns with the GWP youth strategy of ensuring initiatives: “By the youth, for the youth, with the youth.”

# Acknowledgements

GWP South Asia and YYPP would like to thank Waterlution for bringing their extensive experience to plan, facilitate, and deliver the design thinking, systems thinking, and problem identification sessions, Water Science Policy for hosting an engaging dialogue on storytelling, and GWP Southeast Asia for their support in hosting joint sessions for inter-regional networking. Furthermore, we would like to thank all the mentors and guest speakers for dedicating their time and efforts to support the Water Academy for Youth in South Asia.

# Message from the Regional Chair

Cross generational inclusion is one of the key factors to build a fair and just society that values diversity. Nearly a quarter of the population in Asia - Pacific is currently below the age of 25; youthfulness is a powerful force that could be invested for sustainable development in the region. Looking at the engagement and participation of youth in water management, studies have indicated that water supply and sanitation services are at risk because they fail to attract and leverage the potential of youth. Similarly, studies have identified several barriers to effectively engage youth in mainstream water management processes.

Youth are risk takers and possess energy to generate creative solutions for continuing problems across water and water-related sectors. The current leaders have the responsibility to swift and take meaningful action to empower the youth and young professionals to reach their potential, by integrating them in mainstream decision-making processes. Integrating youth and young professionals in decision making processes can improve their confidence. They will gain practical knowledge beyond academic curriculums which better prepares them as future leaders. Furthermore, inclusive planning processes that include youth are often more transformational, innovative, and resilient while they allow youth development of stronger bonds with communities.

It also includes giving youth due credit for their contribution, while providing them with leadership opportunities. The South Asia Water Academy for Youth (WAY) programme as the primary step in this process as the Youth and Young Professionals Platform (YYPP) now takes on the role to document and highlight youth contributions and capacity through this resource book. As water related challenges grow more critical and the needs of our communities become more pressing, we cannot afford to lose on the talent, energy and enthusiasm represented by youth in South Asia for promoting sustainable water action.

Sardar Tariq
Interim Regional Council Chair
Global Water Partnership South Asia

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# Assessment of Water Quality, Fish Species Availability, and Ecological Health Risks of River Buriganga: A Mixed-Methods Analysis

Authors: Tabassum Mehnaz

Keywords: *Bangladesh, Water Quality, Ecosystem*

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## Abstract

The river Buriganga had been playing a crucial role in the formation, operation, and sustenance of the major activities of Dhaka, the capital city of Bangladesh, from time immemorial. Since the Mughal period, Buriganga has been economically significant for the city's rapid growth and development. However, even though Dhaka has developed at an incredible pace, Buriganga has been utterly ignored. Today, it ranks as one of the most polluted rivers in the world and is considered as "biologically dead." The development of tannery industries surrounding Buriganga is the prime cause of its pollution. It is a matter of great concern that the citizens do not realize how much their health and living are dependent on the life of Buriganga. This study was aimed to assess the status of water quality and the availability of fish species in the river Buriganga. Furthermore, it investigated the causes of biodiversity loss and its negative impacts on fish diversity. It also detected the potential ecological health risks on the local inhabitants and city dwellers posed by this ecological change in the river. The research included both primary and secondary data sets. After a thorough literature review, the hypothesis was that the current condition of the river makes it inhabitable for any fish species. The study followed a qual+quant method where qualitative research was dominant and included a review of published papers, reports, and grey literature, along with 10 key informant interviews (KIIs). For quantitative research, ten (10) water quality parameters such as BOD, COD, DO, TDS, Turbidity, temperature, pH, salinity, conductivity, and phosphate level were tested. Two water samples (each with a set of three replicates) were taken to test the parameters. The results obtained from this study indicated that all the parameters other than pH and conductivity failed to meet the standard level required for any aquatic lifeform to survive in this river. Therefore, the hypothesis has been supported by the study findings. The current

research has opened doors for future research concerning the likelihood of Buriganga's restoration and effective policy implementation framework.

## Introduction

### Buriganga as a Dead River; Why and How!

Buriganga had been playing a crucial role in the formation, operation, and sustenance of the major activities of Dhaka city from time immemorial. During 1610, Buriganga was a prime location for trade and commerce by the Mughals, which consequently made Dhaka the capital of the country (Kibria, M. G., Kadir, M. N., Alam, S., 2015). Since then, Buriganga has been economically significant for the city's rapid growth and development. According to (Majumdar, R.C., 1971), a branch of the river Ganges flowed into the Bay of Bengal through the Dhaleswari river that over time changed its course and emerged as a separate river called "Buriganga". Today, Buriganga is one of the most polluted rivers in the world (Reza & Yousuf, 2016). According to the classification of the Department of Environment (DoE), Buriganga is considered as "biologically dead," a river that can no longer sustain any aquatic lifeform due to the poor status of its physical health owing to the degraded water quality parameters. In Bangladesh, there are two other dead rivers along with Buriganga; Turag and Balu rivers (3 Rivers Now Biologically Dead: DoE | The Daily Star, n.d.).

### Fish as an Indicative Species in the current context

Fish are widely recognized and considered as an indicator of the chemical and physical habitat degradation of a waterbody, barriers in migration of aquatic species, and balance of the entire ecosystem productivity. Any change in the chemical status of the river such as increase or decrease of dissolved oxygen, temperature, turbidity affects the growth and survival patterns of fish. Whether a certain waterbody, be it a river or pond, is in a healthy state can be understood from the fish assemblage present in that. They have long been serving as a reliable indicator of water quality and ecological integrity of the aquatic ecosystem (Indicators: Fish Assemblage | 9 US EPA, n.d.). In an aquatic food pyramid, fish are found to exist in the trophic levels starting from 2nd tier to the top (4th) tier as shown in Figure 1.

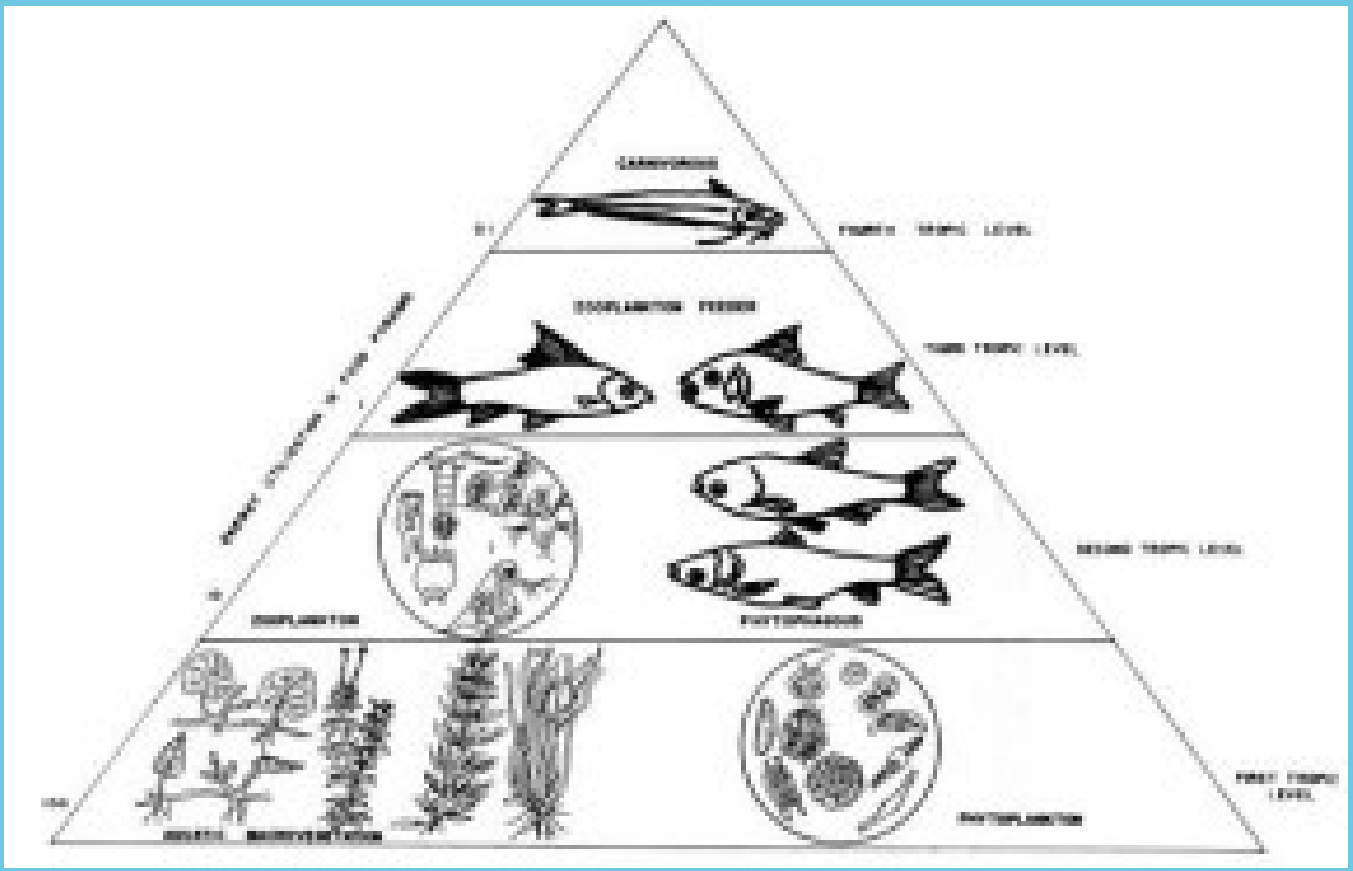

Figure 1. Aquatic Food Pyramid. by https://www.fao.org/3/T0555E/T0555E02.htm

According to (Marcogliese & Cone, 1997), fish indicate the dynamic of an aquatic ecosystem, determines its trophic structure, balances between environmental stress and biodiversity. The study (Marcogliese & Cone, 1997) conducted in 28 different sites in Nova Scotia, a province in Canada, supported the hypothesis of fish being a good indicator of the sustenance of aquatic lifeforms and properly estimated the parasite distribution and species richness existing in the rivers in those regions. Another study by (Lasne et al., 2007) utilized the idea of considering fish zonation as an indicative biomarker to evaluate the ecological status of Loire Basin, a river in France. The results obtained from their assessment revealed that the fish zonation patterns suggested shifts in the lotic (running) to lentic (stagnant) state of the river. The principal reason behind this was presumably the disturbances created due to human activities and improper river management plans. Thus, the studies confirm the reliability in considering fish as a bioindicator of a river's physical state.

## Role of Buriganga in the Urban Landscape

Being a riverine country, Bangladesh is an abode of around 700 small and large rivers, which encompass an area of about 24,140 km. For ages, the people of this country had been relying on these rivers that form one of the biggest networks in the world and provide abundant resources. The livelihood, accommodation, and transportation of around 140 million people living in and around Dhaka are directly dependent on important rivers like Buriganga (Buriganga Chokes on Pollutants, n.d.). This suggests of the significant contribution played by rivers in our lives. Regarding this, (Mowla, Q. A. et al., 2015) specifically highlighted the importance of Buriganga, which includes but is not limited to communication infrastructure, trading, domestic use, drainage, waterway, fish species diversity, environmental impact, and ecosystem.

## Ecological Health Risks and their Potential Hazards

Throughout the years, Dhaka had been developing at an incredible pace; however, Buriganga was utterly ignored. In the past, there used to be several channels around Buriganga, which facilitated the city's sewerage system through proper drainage and waste disposal. At present, majority of these channels do not exist anymore due to unplanned urbanization done without environmental concerns (Mowla, Q. A., Mozumder M. A. K., 2015). It is a matter of great concern that the citizens don't realize how much their health and living is dependent on the life of Buriganga. Despite playing a critical role in the urban landscape of Dhaka city, Buriganga continually ranked as one of the worst polluted rivers of all times (Azad, M., 2009). Among the major causes of its deterioration, waste disposal, improper management, and riverside encroachment top the list (Mowla, Q. A., Mozumder M. A. K., 2015). This results in people, especially the ones living in the neighbouring areas of the river, to be exposed to the potential health hazards created due to the pollution from toxic industrial emissions. In a study by (Nargis et al., 2019), the authors collected sediments from different sites at Buriganga and tested a total of 48 elements by utilizing the analytical technique called Inductively Coupled Plasma Mass Spectrometry (ICP-MS). They considered different sites to ensure spatial variation and did a comparative analysis of the ecological hazards posed by those 48 elements between two seasons: monsoon and winter. The results found the presence of a high amount of Chromium (Cr) in both Monsoon and Winter due to the indiscriminate discharge of industrial effluents for a considerable period of time. Besides, the concentration of other heavy metals such as

Cadmium (Cd), Lead (Pb), Nickel (Ni), etc. were found in higher amounts during winter. According to (Yan et al., 2016) these heavy metals are the potential risk factors and index of ecological risk owing to their high carcinogenic attributes. Similar research was conducted by (Kawser Ahmed et al., 2016), where they tested 14 heavy metals and metalloids collected directly from fish that were found in Buriganga back then. The consistent increase of these heavy metals and consequently, the degradation of the river's water quality has had detrimental impact on the health and wellness of both humans and aquatic life. These heavy metals, unlike the regular organic pollutants, are persistent in nature with the potential of entering the food chain of aquatic lifeforms. They play a devastating role in the disruption of fish and other aquatic organisms' growth rate and development, reduce their survival chances, and increase the hardness of water. These affected fish, when consumed, can damage the kidney, bones, liver, and have renal failures in human bodies owing to their hazardous and toxic properties. While being present in water, they can further lead to bioaccumulation in it and eventually affect a large part of the aquatic and terrestrial food webs (Töre et al., 2021). Figure-2 depicts the exposure pathways of heavy metals in the human body through fish and aquatic food chains.

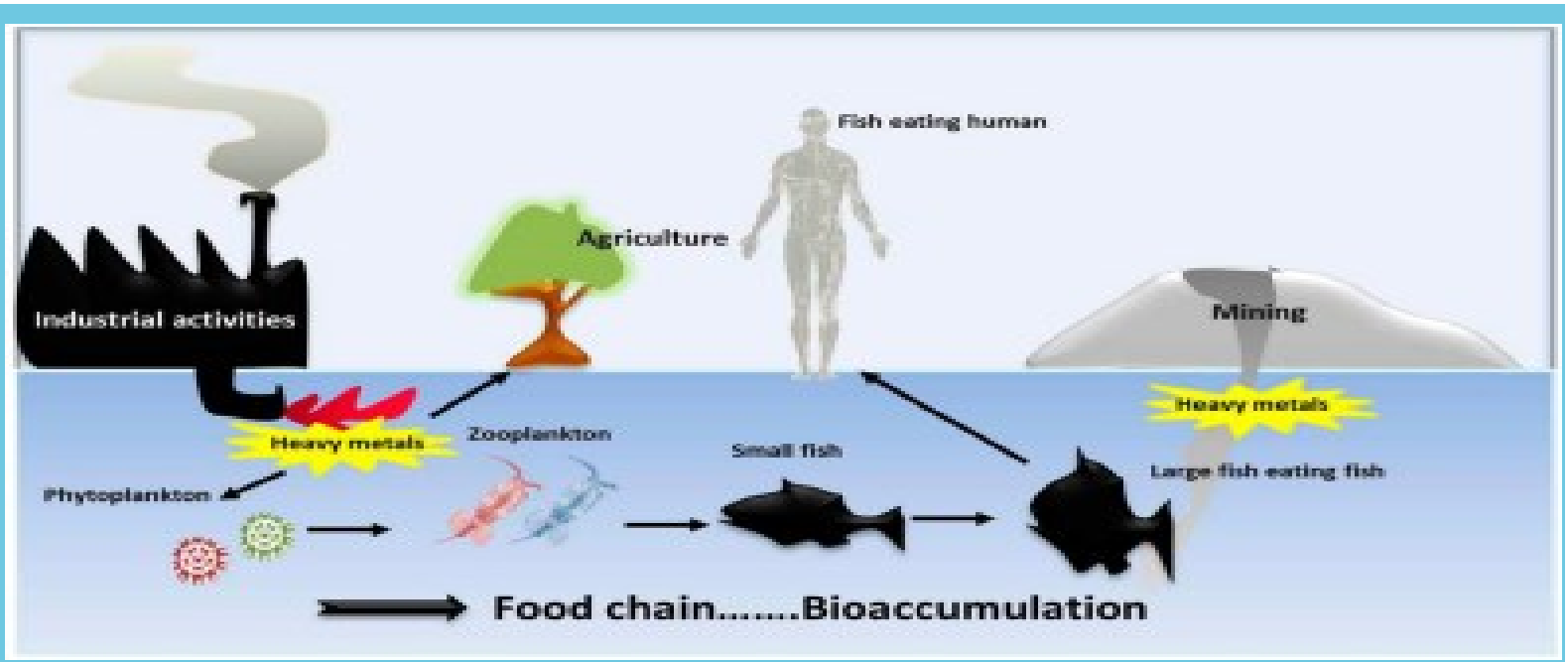


Figure 2. Heavy metal bioaccumulation in fishes and its diverse impact on the food chain and the aquatic ecosystem. Mehana et al., 2020.

## Study Gaps and Novelty of the Research

Over time, research has been conducted to analyse the reasons behind water quality deterioration and unmanaged waste disposal system in Buriganga. However, most of

those were carried out 5-6 years ago when the river was still in a dying state. Now that the river is at its worst levels, being labelled as a "Dead River", little to no attention is paid to its current state, which is a major study gap in this field. One of the main differences between the previous studies and this research is that the focus of majority of those studies was solely on the analysis of water quality; however, this study focused on the existing species richness (considering fish as an indicative species) and ecological health hazards to human life based on the "present condition" of the river. A combination of both qualitative and quantitative methods is used based on primary and secondary datasets. This created provisions for public health safety of the city people by realizing the risk factors and causes of biodiversity loss. Moreover, it also facilitated better comprehension of the scope of restoring the ecological balance and preservation of natural resources of the river. For a developing country with an annual GDP growth rate of only 3.5%, this research was economically viable and practically feasible (GDP Growth (Annual %) - Bangladesh | Data, n.d.).

## Research Design and Methodology

### Study Area

Buriganga, one of the most significant rivers in Bangladesh is situated at the southwestern periphery of the country's capital, Dhaka. The average depth of the river is 7.6 meters with a recorded highest depth of 18 meters, depending on the varying water levels in different seasons. The average length of the river is 18 kilometres. For water sampling, the target study areas were restricted to 50 meters upstream and downstream at both Babu Bazar ghat and Badamtali ghat. These areas were opted based on critical observation for best possible measurement of the water quality parameters. The figure-5 and figure-6 correspond to the satellite images (shown above) and were taken during the water sampling process.

### Study Design

The design of this project will be mixed method with quantitative and primary data being dominant (qual+quant). Both primary and secondary data collection methods consisting of qualitative and quantitative data sets were used to understand concepts, opinions, and experiences of the study participants and for gathering in-depth insights into the experience of living around Buriganga. Secondary and grey literature was also reviewed to gain better understanding and insights into the theoretical and age-old aspects of the research carried out in Buriganga.

## Study Subject Sampling

The sampling method used to select the participants for KII was purposive random sampling. It is a non-probability sampling where study participants are chosen based on certain criteria or judgment determined by a researcher (Palinkas et al., 2015). The set criterion was to choose participants who would be living around Buriganga for at least 5-6 years in order to obtain valid information based on their general observation. This type of sampling is readily used in qualitative research that helps a researcher to identify cases or study subjects that are likely to provide valuable information.

## Study Participants

The study participants are chosen based on random sampling technique with the set criterion of age, profession, experience of using water, and stay duration around Buriganga. The selected group's age range was roughly between 28 to 60, belonging to occupations of boatpeople, fishers, service providers to government officials; selected students were also interviewed. Other than the government official, everyone else belonged to local residences surrounding the Buriganga. Most of the boatpeople were reportedly homeless and were compelled to live along riverbanks. Except for two boatpeople, all the other participants preferred staying anonymous, which is why their identities and job designations are not mentioned.

## Key Informant Interviews (KII)

A total of thirteen key informants ranging from fishers (3), boatpeople (7), residents to community people (2) and a government official from the public health engineering department of Bangladesh were interviewed throughout the course of this study. While most of them preferred staying anonymous, a 59-year-old boatman named Mintu Shah and a 56-year-old fisher named Tota Miah, both of whom have been living around Buriganga for more than a decade provided some useful information related to the fish availability in Buriganga. According to them, currently, there are no fish in Buriganga as the water is inhabitable in nature. However, they added that during monsoon, two species of fish called "catfish" (Bengali: shing maach) and "bronze featherback" (Bengali: foli maach) are heavily seen in Buriganga. This piece of

information added a new insight into this research. They also added that although available, these fish are extremely poisonous owing to the toxic state of the river and hence, completely inedible. In order to investigate why only these two kinds of fish are found in Buriganga despite the river's inhabitability for aquatic species, the water quality analysis was performed. The test results are presented and discussed in detail in the following section.

### Focus Group Discussion (FGD)

Although initially, it was intended to conduct only one-on-one in-depth interviews with the key informants, their responsiveness and positive attitude initiated a focus group discussion (FGD). A group of around 7-8 key informants (most of whom were boatpeople and fishers) was formed. Upon receiving their verbal consent and explaining to them the purpose of the study, a set of questions were asked including how long they have been living around Buriganga, whether they use the river water, what kind of health implications they experience, whether there are any fish species available at present. Lastly, their recommendations about improving the overall situation of the river were procured to ensure their involvement in any future policy implementation, especially from a bottom-up approach. The responses received helped to gain insights into the attitudes, opinions, beliefs, perceptions or ideas of the community people. These responses were instantly stored in Microsoft Excel 2010 for further statistical analysis.

## Water Sampling

Two sets of water samples (each with 3 replicates) were obtained; one in the middle of March and the other in the 3rd week of April of 2022 from two point-sources in Buriganga i.e. Babubazar Ghat & Badamtoli Ghat. The first replicate was collected from the centre of the river, beneath Babubazar bridge, while the second one was collected from 50 meters upstream and the third from 50 meters downstream of the central point. Similarly, the other three replicates were collected from Badamtoli Ghat, one from the centre of the river and the other two from 50 meters upstream and downstream respectively. The samples were collected following the standard water sampling techniques set by the Environmental Protection Agency (EPA) (US-EPA, n.d.). The collected water samples were tested in two laboratories:

1. AUW lab and

2. Dhaka Public Health Engineering (DPHE) lab

The average values were obtained from the samples of each sampling point. The samples were tested for a varied range of parameters such as temperature, pH, conductivity, salinity, nutrients ($PO_4^{3-}$), DO, BOD, COD, Turbidity and TDS.

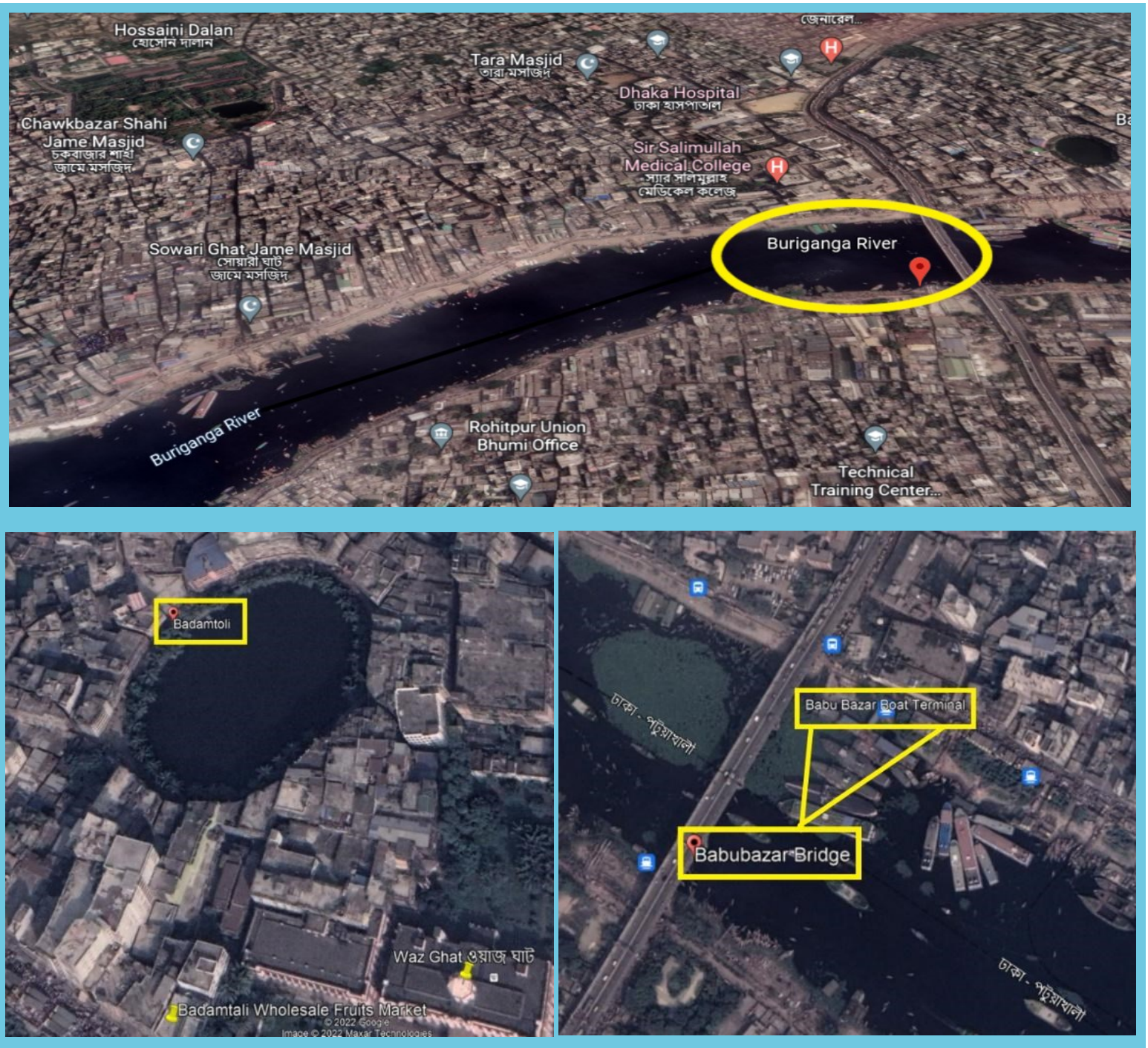


Figure 3. Locations of Water Sampling.
Google Earth.

## Data Analysis

A questionnaire was formulated on google form with close-ended questions to avoid respondents' biases. Statistical data collected during the KIIs was then stored in Microsoft Excel 2010 sheets, analysed and presented graphically. The Google form application helped in organizing the data and drawing conclusions from collected responses.

## Study Instruments

The water samples collected from the study sites were tested for 10 parameters in two Laboratories, i.e. AUW lab and DPHE lab. The instruments used for each of the parameters are mentioned in Table 1.

Table 1. Test conducted at AUW lab

| AUW LAB (1st Sampling) | |
|---|---|
| Parameters | Instruments |
| Temperature | Thermometer, beaker |
| pH | pH meter and pH indicator paper |
| Salinity | Burette, pipette, graduated cylinder, beaker, AgNO3 solution, K2CrO4 (indicator) for titration |
| Conductivity | Conductivity meter, beaker |
| Phosphate | Phosphate testing kit (Name: HI 3833) consisted of 20 mL beaker, color comparator cube, phosphate reagents |

Table 2. Tests conducted at DPHE Lab

| DPHE LAB (2nd Sampling) | |
|---|---|
| **Parameters** | **Instruments** |
| DO | Multimeter |
| BOD5 | 5 days incubation |
| COD | COD standard solution |
| TDS | Multimeter |
| Turbidity | Turbidity meter |

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# Results

## Laboratory test results

Table 3. Experimental values of Buriganga's water quality parameters; reference values taken from (Department of Public Health Engineering (DPHE), n.d.)

| Parameters | Units | Experimental value* | Standard Value | Analysis Method | Notes |
|---|---|---|---|---|---|
| **pH** | - | 7.3 | 6.5-8.5 | pH meter | Acceptable |
| **Temperature** | °C | 31 | 20-30 | Thermometer | Slightly higher |
| **Conductivity** | µs/cm | 1.406 | - | Conductivity meter | - |
| **Phosphate** | mg/L | 4 | 0.1 | Phosphate detection kit (HI 3833) | Exceptionally high |
| **Salinity** | g/Kg | 0.72% | 0% | Titrimetric Analysis | Slightly higher |
| **Parameters** | Units | Experimental value (Average of Sample 4,5,6) | Standard Value | Analysis Method | Notes |
| **DO** | mg/L | 4.30 | 6 | Multimeter | Low |
| **BOD5** | mg/L | 2 | 0.2 | 5 days incubation | Very high |
| **COD** | mg/L | 8 | 4.0 | CRM | High |
| **Turbidity** | NTU | 5.0 | 10 | Turbidity meter | Low |
| **TDS** | mg/L | 110 | 1000 | Multimeter | Very low |

*Average of Sample 1,2,3

## Achieving Realistic and Expected Outcomes

Table 3 shows the results of lab experiments of the water quality parameters. The data reveals that almost all the parameters (other than pH and conductivity) failed to meet the standard or required levels as determined by the Department of Public Health Engineering (DPHE), a government agency in charge of building community capacity to implement water and sanitation facilities, based in Dhaka, Bangladesh.

This explains why aquatic species (in this case considering fish as an indicative species) cannot survive in Buriganga. As evident from results, the majority of the water quality parameters (DO, BOD, COD, TDS, Turbidity, salinity, phosphate, etc.) failed to meet its designated values set by the DPHE. This data supports the hypothesis of this research and confirms that the condition of Buriganga is indeed at its worst now and is continually deteriorating. The data is also found to be consistent with the responses of the key informants and the information obtained from the literature review. The KII responses indicate that most people (around 50%) residing around Buriganga who were directly in contact with the river water had been inflicted by certain dermatitis and water-borne diseases, which underscores the deplorable condition of the river, as delineated by (Reza & Yousuf, 2016). Besides, the explanation regarding the sudden disappearance of sucker fish could be due to the fact that the water is so heavily polluted that even these dangerous ever-thriving fish could not survive here. However, to speculate why and how catfish and foli fish manage to survive even in this condition during monsoon, their survival rates were checked and compared with other fish. Catfish have a relatively higher survival rate (85%) than other fish such as carp (rui, mrigal, catla) and snakehead fish (shol, taki, gozar) (Striped Catfish (Pangasianodon Hypophthalmus, Sauvage, 1878) Aquaculture in Bangladesh: An Overview | Request PDF, n.d.). Again, foli fish (bronze featherback) showed to have a survival rate of 93.33% (Samad et al., 2017). Besides, both fish species are found to survive in dissolved oxygen levels below 1 mg/L. Consequently, only these two fish species are found in the river during monsoon as opposed to other fish. However, this has provided a new direction for further research on speculation of the possibility of increasing the growth and survival rates of the other fish species.

## Responses from KII and FGD

The responses from the KIIs added some insightful dimensions to this study. All the respondents except for one were local people who had been living around Buriganga for more than 5 years as evident in Figure 13.

Figure 4a depicts that from the thirteen respondents, six of them replied in the affirmative when asked whether they use the river water directly. All of them were either boatpeople or fishers who live on the river as they did not have other places to live in. The remaining six respondents (residents) stated that they did not really use

the water directly. This manifests a correlation between the water usage and socio-economic status of the respondents.

Figure 4b shows the percentage of people who use the water specifically for washing their hands and faces. Whereas figure 16 further stresses the situation of people living around Buriganga who are seen bathing, washing hands and face, and even carrying river water in water jars for drinking purposes. This emphasizes the gravity of the problem that is entrenched within the attitude and behavioural practice of these people. These photos were taken during the preliminary site visits earlier in 2022.

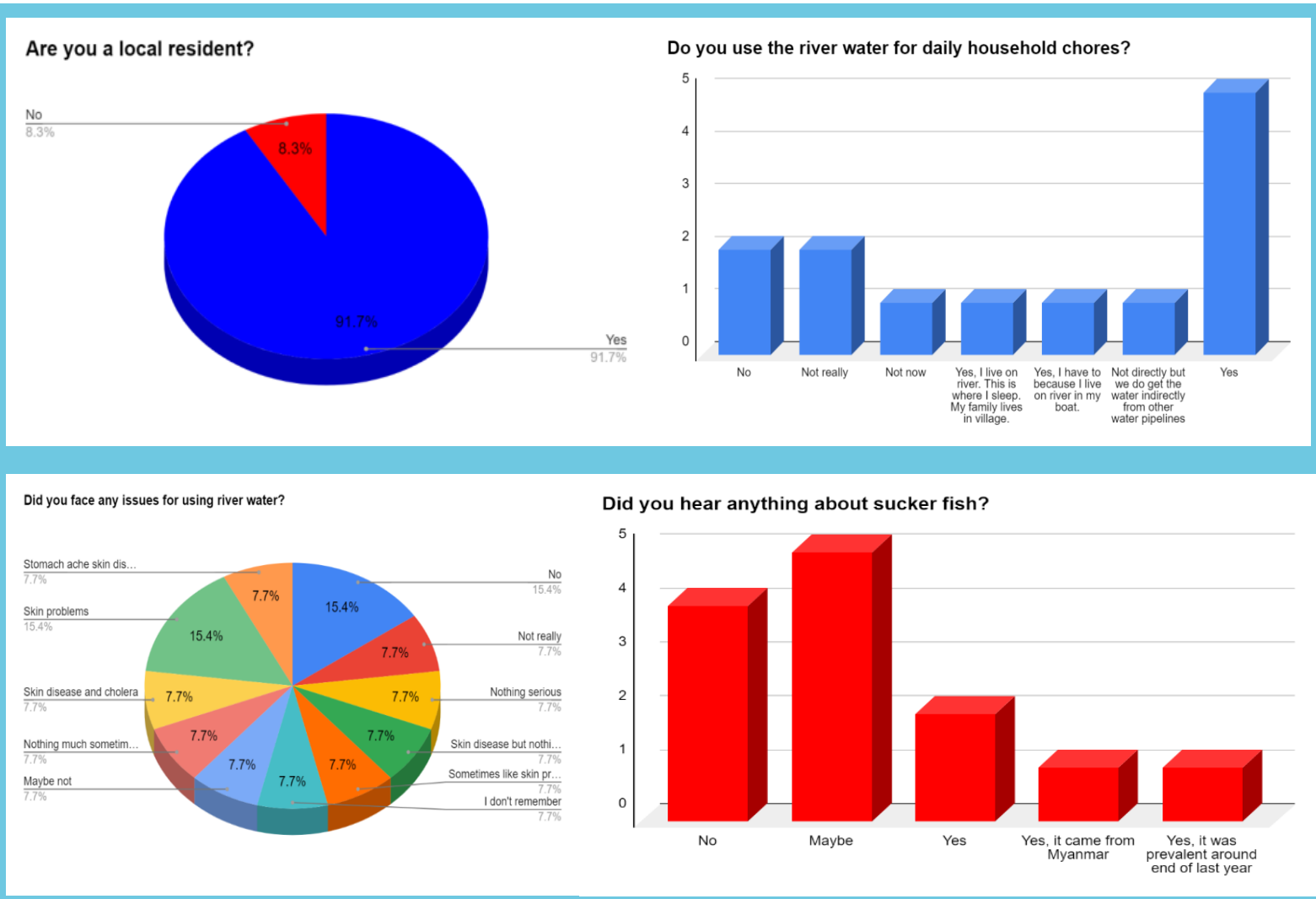


Figure 4a. 4b. Representative diagrams of conducted surveys.

## Discussion

This research is significant to provide grounds for further multi-directional expansions from it in the future. The study has successfully tested ten (10) water quality parameters through laboratory analysis and conducted a comparative analysis between the state-of-the-art water quality with that of the previous years. The lower value of dissolved oxygen and consequently higher BOD and COD indicate the incapability of the river to sustain any form of living organisms. The only two parameters that are pH and conductivity are found within the permissible limits. The neutral pH in water could be due to the neutralization reaction between heavy acidic and basic chemicals present in the river. However, both pH and conductivity are not as major of deciding factors as the others. The salinity and temperature were a little higher than usual. TDS was very low, whereas turbidity was relatively lesser low than the reference value. This could be because the water sampling was not done from around the industrial areas. It is safe to assume that the water from point sources around industries and factories will have exceptionally higher TDS and turbidity values. The responses from KII also added an interesting and insightful aspect to the research. At present, there is reportedly no fish to be found in Buriganga river, which is a strong indicator of the poor water quality. Besides, the sudden disappearance of suckermouth fish also added a mysterious note that requires further investigation.

## Conclusion

It is concluded that river Buriganga's polluted water caters to issues related to the ecological health risks and fish species loss and associated human health risks due to dependency on the river. It is a matter of great concern that despite the river being so important and the biodiversity degradation issues being so relevant, little to no attention had been given to the current state of Buriganga neither from the field nor at the policy level. The current research has highlighted this gap and attempted to identify the root causes of pollution in the river Buriganga. This has not only advanced the existing knowledge in this field but also provided a number of direct benefits to the people living in the city and eventually to the whole country. Besides, the quality analysis of Buriganga's water has added a new insight into the survival rates of some of the fish species through a comparative analysis between two fish species (catfish and bronze featherback) that are seen to appear only during monsoon and fish which used to be abundant 4-5 years ago but are no longer available. This analysis has opened the scope for further research as to

whether it is at all possible to revert the condition of both the river as well its existing aquatic species that are on the verge of extinction.

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Featured Image: Mohammad Shahadat Hossain

# Floating Agriculture: A Nature-Based Climate Solution for Vulnerable Communities

Authors: Mohammad Shahadat Hossain

Keywords: *Bangladesh, Nature Based Solutions, Agriculture*

https://doi.org/

Experts estimate that more than 1 billion people are going to be affected due to the adverse effects of climate change by 2050 while the demand for food production may increase to 70% in 2050 (FAO, 2009). Due to the extreme events of climate change, our food production is hampered each year. Crops are damaged due to devastating floods and each year farmers lose their cultivable land due to rising sea level. In deltas, these two problems will become the biggest challenges for food production in the coming days. Each year farmers face floods and their agricultural production declines both in developed and underdeveloped countries around the world. They often lose their crops before harvesting and lead a marginalized life.

At parallel, our freshwater sources are in danger because of human activities in addition to certain natural causes. As the whole ecosystem is disrupted by irresponsible human acts. Additionally, different kinds of aquatic species and plants are growing so fast and gradually destroying our freshwater bodies. Certain types of aquatic plants are often seen as a problem in many communities around the world, especially depending on the wetlands, lakes, and rivers, water hyacinth being one of them. It is the fastest-growing aquatic plant and can be found in the tropical regions of the world. It can double its population in favourable environments. It can clog/cover the surface of freshwater bodies thus destroying the entire aquatic ecosystem. It has been identified as an invasive aquatic plant in the United States since 1984, in Africa since the early 1900s, in Asia since 1902, and in Europe since the 1930s (Dersseh and Melesse, 2019). However, the water hyacinth problem is often neglected in developing and underdeveloped countries in tropical regions and the situation is going out of control day by day. Especially since it can double its population within 15 days in favourable weather and it is costly to remove from water bodies within a reasonably short period of time. The freshwater bodies in Bangladesh, Sri Lanka, Thailand, Indonesia, Vietnam, Kenya, Tanzania, Ethiopia, and many other countries are facing the same problem.

However, local farmers are using this invasive aquatic plant, water hyacinth, as a key resource to fight against the adverse effects of climate change.

Bangladesh, a small country in South Asia, is one of the most climatically vulnerable countries in the world and is highly dependent on agriculture. Due to the rising sea-level and heavy rainfall, many parts of Bangladesh remain underwater for up to eight months in a year. As the water hyacinth is abundant here, farmers have invented a floating cultivation method using this aquatic plant for their survival.

In 2021, a field visit was conducted to a remote small village called Gagan in the Pirojpur district of southern Bangladesh. The village is surrounded by the rivers and canals. Local communities are closely connected to these water bodies. Survival gets tough during the monsoon months and people often live with flood water inside their homes occasionally. Women and children are forced to live in inhuman conditions during that period. Sometimes they even have to build new houses or leave their villages looking for a better life.

Figure 1. The water and land edge with infrastructures of everyday life. M Shahadat.

However, the villagers have started adapting to these perpetual flooding using locally available techniques for their survival. As the land can be cultivated only for three to four months in a year, farmers have begun using century-old floating cultivation methods invented by their ancestors, for the time when land remains underwater. They use water hyacinth and other locally available aquatic plants to make the floating bed on stagnant water and grow different types of seasonal vegetables. This method is called “Dhap method” by the locals.

The floating bed made using water hyacinth works like a green fertilizer itself, so the seedlings grow faster, and farmers get higher prices from these organic vegetables. This floating agriculture method provides food security for all, as well as employment for many people in this climate vulnerable region. The villagers use this method for six to eight months and each water hyacinth bed is used multiple times. During the dry season, the old beds are used as a green fertilizer by the local farmers.
I was hosted by a family of farmers in that village. Mr. Hossian was the head of the family and had been using the floating agriculture method for over fifteen years.

He cultivated paddy during the dry season and grew vegetables on the floating bed for the rest of the year. This has made him financially more stable and now he can afford his children's education. His son Jisan often helps him make beds as he prepares himself for the future. Mr. Hossain also mentioned, "Floating agriculture is becoming more and more popular these days. Some people, who had once migrated to the cities in search of jobs have now returned to the village and are making a living owing to floating farms."

Figure 2. Women making small seed pots. M Shahadat.

His wife and daughters also help him in different stages of the "Dhap" method. Generally, men work in the field and women work at home. Women make small seed pots using "Sonali Lata", another kind of aquatic plant.

After seed germination, farmers transplant the pod onto the floating bed, and it becomes ready for sale within fifteen days. Farmers also cultivate seasonal vegetables, herbs, and spices. The floating farm produces chillies, garlic, turmeric, strawberry, vegetable, rice, and wheat seedlings.

Farmers from the low-lying areas are becoming more dependent on floating cultivation. The Bangladesh government is also taking initiatives to support new

practitioners. Many experts believe that the floating agriculture method using locally available resources can be a role model for many other climate vulnerable countries around the world.

The United Nations' Food and Agricultural Organisation (FAO) recognized floating farming as a Globally Important Agricultural Heritage System (GIAHS) in 2015 (FAO and GIAHS, 2015).

Though the water hyacinth is an invasive aquatic plant, it can be a life saver for many communities around the world. Especially in the delta regions around the world, floating agriculture using water hyacinth can help millions to ensure food security. It also can be used to make high value biodegradable products that will help the poor and climatically vulnerable communities to improve their lives. Instead of investing huge amounts of money to remove the water hyacinth, local communities can be trained to diversify the uses of these aquatic natural resources.

Figure 3. Farmer working on the floating strip. M Shahadat.

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Featured Image: Sabarmati Riverfront. SRFDCL.

# Riverfronts without Rivers: A case of two dying rivers in thriving India

Authors: Bhavya Jain

Keywords: *India, Basin Management, Urban Planning*

https://doi.org/

What comes to your mind if I ask, 'What does a river do'? In a social media survey with this question, the most common response was that it 'flows'. Your creative mind might think that it gives life, or it meanders and traverses, or it breeds fish, etc.; but you would never think that it is stagnant. It is the flow of water through landscapes, however inconsistent it may be, that makes it a river. In India, the mass-implemented riverfront projects are contending this intuitional understanding of a river. Probing further into the pros and cons of such a project, I wonder can it still be called a riverfront, if the process of building one causes a river to be dead?

Under the Smart City Mission, India has seen an expansive boom of urban infrastructure. This boom is accompanied with drastic alteration of ecological systems, riverine and aquatic ecosystems being no exception. Open spaces and riverfront developments have been proposed in 60 tier 2 and tier 3 cities in India (Smart Cities Mission, n.d.). On analysing the official proposals of many of these projects, one

realises that their focus is on economic boost, creation of recreational activities, and tourism influx, while ecological rationality takes a backseat. Many of them have already started showing signs of visible damage to the environment, while many have been halted due to immediate instances of disaster-induction. This demands an urgent remodelling of the way we engage with our rivers as we build next to them. It is important to identify the inadequacies in the current strategies of building water infrastructures like riverfronts.

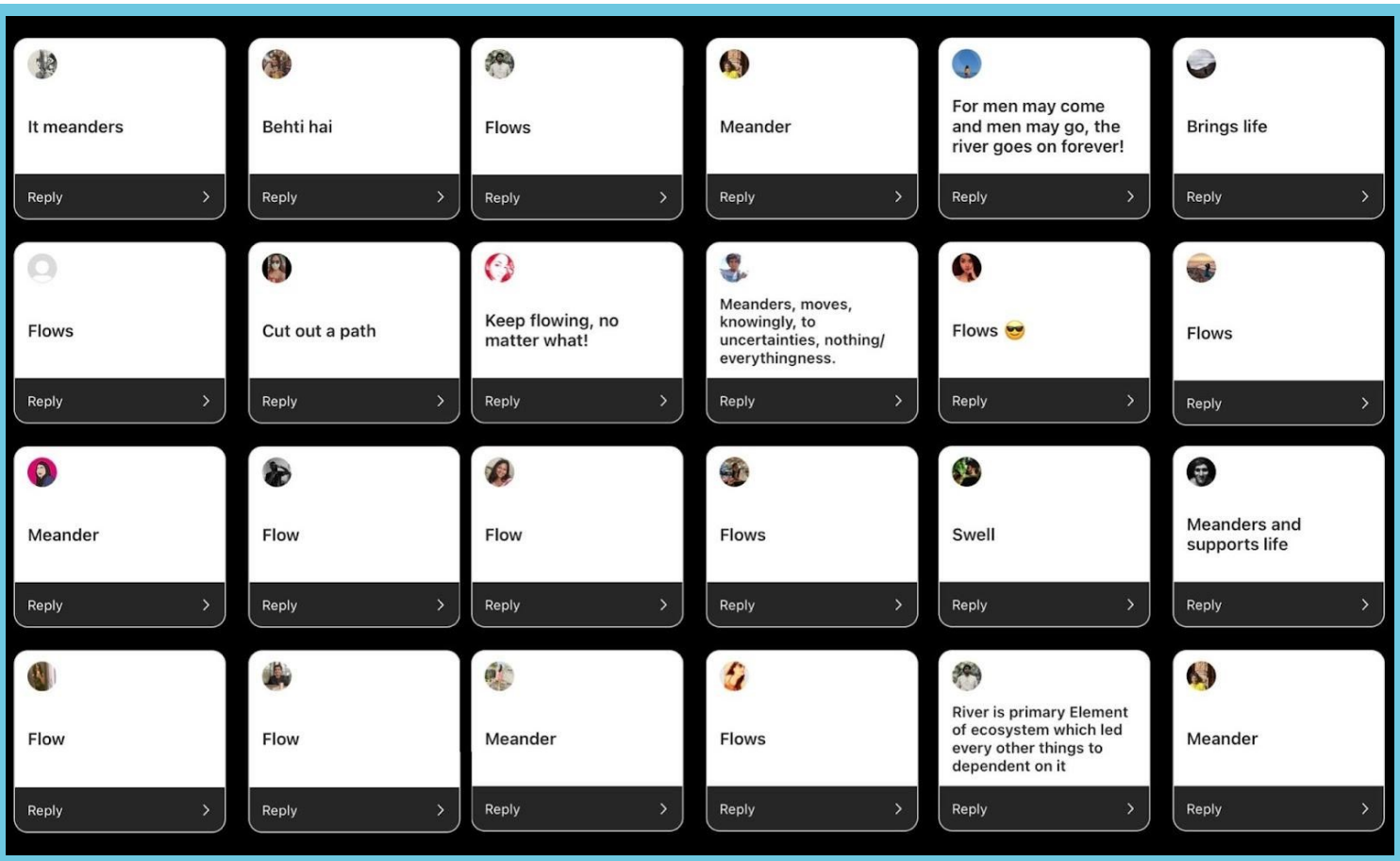


Figure 1. Responses collected from an Instagram survey asking, "What does a river do?" B Jain.

To further elaborate the design, social, and environmental strategies that are used to build riverfronts, and their lack thereof, two examples are discussed here. The first is one of the earliest riverfronts implemented in the country, which became a model project for many to follow. The second is being built on the same model. The first one is Sabarmati Riverfront in Ahmedabad, in Central-western India, while the second is Tawi Artificial Lake Project in the Himalayan foothill town, Jammu.

## Sabarmati Riverfront

A video about the Sabarmati Riverfront on the website of Ahmedabad Municipal Corporation advertises the project as an instrument that transformed an unusable and polluted river into a cleaner-looking channel (SRFDCL, 2020). It boasts of the clearly defined banks built on reclaimed river-bed next to non-porous concrete walls. The various amenities, apparently, make the riverfront a successful urban innovation, bringing the city to the edge of the water channel to view it from afar. The video, however, forgets to address that while glorifying the banks with a water-view, the project accelerated the dying of the river, let alone attempting to restore it. In this project, the design led to the construction of a concrete barrage, creation of an artificial lake, and channelising the river in concrete embankments. Walkways, parks, and leisure stations were then created next to the embankments. This has come at the cost of not only escalating the drought-like condition of the river, but also increasing pressure on the strained river Narmada, from which the riverfront lake gets its water.

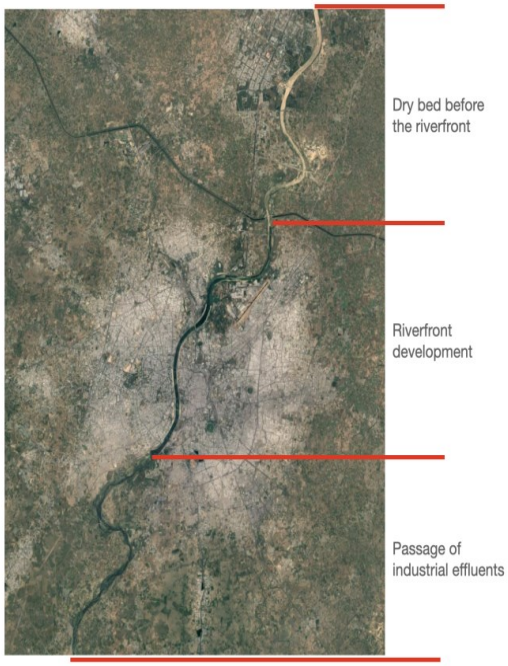


Figure 2. Influence of the riverfront on the stretches of Sabarmati before and after the riverfront. Google Earth.

The wide river basin has been reduced from a range of 300 to 425m to merely 275m, thus reducing the river to a canal. The channel enclosed by the riverfront is filled with stagnant, polluted, and borrowed water while the once perennial preceding stretch is dry. The succeeding stretch only carries industrial effluents and sewage from industries into the Arabian Sea. The project has resulted in considerably reducing the underground water table owing to the heavy use of reinforced cement concrete to contain the water (Khanna, 2019). The stagnation of the water also leads to an increase in the pollution levels and breeds disease-causing mosquito larvae. An investigation by the Paryavaran Suraksha Samiti (Environment Protection Board) and Gujarat Pollution Control Board in March 2019, indicated critical levels of pollution, way beyond the permissible limits, the stagnancy of water being the chief cause

(Paryavaran Suraksha Samiti, 2019). This water causes grave damage to the agricultural lands and villages beyond the riverfront.

It has also been suggested that the water sourced from Narmada to artificially fill Sabarmati could be used to quench the thirst of the drought-affected regions of Kutchch, Saurashtra and North Gujarat, where groundnut and cotton farmers constantly face hardships due to rainfall shortage (Mohan, 2017). Yet, Ahmedabad's riverfront is celebrated as a success story. It is the role model of the many thickset riverfronts being built/ proposed in India, where aspirations of growth, economic development, and infrastructural expansions are altering the landscape of the entire country.

## Tawi Riverfront

One of the more recent riverfront projects being implemented in India is situated in the foothill town of Jammu in northern India, on the banks of river Tawi. Local media has been lauding the project for its aim of enhancing the 'aesthetic value' of the river, while increasing infrastructural amenities for recreation. To do the same, the river is being gated and converted into an artificial lake (Dubey, 2022). The project seeks direct advisory from the Sabarmati Riverfront Development Board and is being executed along the same lines.

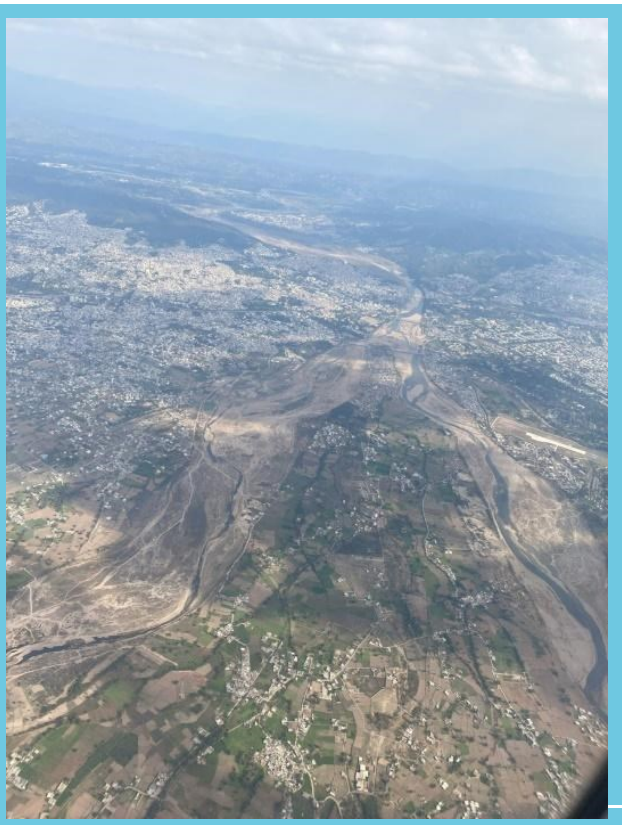

Figure 3. Aerial photograph of river Tawi flowing through Jammu city. B Jain.

Unlike Sabarmati, which had become almost a dry bed before the construction of the riverfront, Tawi flash floods almost every monsoon, swelling its wide basin in entirety. The extent of these floods in the past has been havoc-wreaking with collapse of concrete bridges, submerging settlement and loss of life. In 2014 alone, 2500 roads, 163 small bridges were damaged in Jammu province due to the swelling of rivers and rivulets during monsoon (Hakhoo, 2015). The increasing temperature in the Himalayas is only causing an increase in the frequency and intensity

of such floods, not to mention occasional cloud bursts in the region. The channelising of Tawi into an artificial lake includes reclamation of floodplains, reducing the width of the river and therefore its capacity to deal with floods. Additionally, the concretization of the banks would affect the natural groundwater recharge processes. Thus, stagnating the water would lead to a loss of the endangered biodiversity of the river (Hussain & Naik, 2023).

## Towards a change in the culture of development

Riverfronts drastically alter the land and water edge that houses majority of the ecological activity of a river. Therefore, the design of such an infrastructure carries the responsibility of maintaining the health of the river as well as the land next to it. Landscape architect Kate Orff presents in her manifesto and book, 'Towards an Urban Ecology', "we must begin to view environmental, urban, and social issues as interconnected domains and advocate their synthesis in practice to create a truly urban ecology" (Orff, 2017). Infrastructure development where the ecological health of landscapes and waterscapes are at forefront exemplifies such a possibility. One such example is the original scheme to develop Sabarmati and regions around it as an eco-valley, as conceptually proposed by Bernard Kohn. According to the architect, the scheme intended to create a symbiotic paradigm of give and take alongside the entire stretch of Sabarmati from Gulf of Cambay to the Arabian sea.

The reinforcement of such informed schemes and the rejection of insensitive schemes requires public voice and action as well. In Vadodara, a city close to Ahmedabad, citizens joined hands to raise their voices against infrastructural projects that are expected to cause ecological transformations and biodiversity loss in the ecosystem of river Vishwamitri. From pleas to national governmental institutions to awareness drives for the public, activism in Vadodara has prevented river Vishwamitri from meeting the same fate as river Sabarmati.

## Conclusion

Rivers have always been at the heart of civilization and a manifestation of culture. In the Indian subcontinent, rivers have often been personified and given religious importance. Mahatma Gandhi's ashram was built on the banks of Sabarmati River; making the river symbolically associated with the freedom struggle for an independent India. In Jammu, river Tawi is believed to be the holy daughter of the Sun God (Suryaputri), which provides water and safety to the entire town. The way rivers are

treated and engaged with, demonstrates the cultural and political inclination of a society at a given point in time. Reflecting on the culture, history, and politics of climate change in India, from the perspective of literature, Amitav Ghosh writes,

> *"... in a substantially altered world, when sea level rise has 'swallowed' the sundarbans and made cities like Kolkata, New York, and Bangkok uninhabitable, when readers and museumgoers turn to the art and literature of our time, will they not look, first and most urgently, for traces and portents of the altered world of their inheritance? And when they fail to find them... Quite possibly then, this era, which so congratulates itself on its self-awareness, will come to be known as the time of the great derangement" (Ghosh, 2015, pp. 14-15).*

The same can be said for the ignorance of our development strategies towards ecology, environment, and climate change. In both the cases discussed, the state ended up spending a lot of money to build next to rivers, reducing them to mere aesthetic spectacles. The schemes have practically given no consideration to the restoration of riverine ecology, judicial use of water at macro-level, protection of the flora and fauna of the river systems, response to the contingencies of climate-change induced disasters, and the list goes on. The scales that we use for measuring development are often limited to economic growth and monetary gains. The socio-ecological price being paid, takes a secondary seat in the process. Development itself, however, cannot be pitched as an antagonist in the environmental debate. Instead, there needs to be strife towards gathering scientific and social knowledge to devise and implement an eco-sensitive approach; a paradigm which questions our existing prejudices and redefines development and activities associated with it.

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Featured Image: The three golden Buddha Statues. L Joshi.

# The paradox of too much and too little water: A tale of Kathmandu valley

Authors: Lasata Joshi, Utsab Phuyal, and Ranju Ghimire

Keywords: *Nepal, Water Quantity, Urban Planning*

https://doi.org/

## Abstract

Rekha, a resident in a squatter settlement in Thapathali, which is located on the banks of river Bagmati, recalls her experience of the monsoon of September 2021, “I had to wake up numerous times during last year’s monsoon to check for the water level in the river. The water level had risen significantly. I was stricken with fear regarding many what ifs; what if the water entered my house, where would I go? I have nowhere to go. What would I do to protect my assets? What I have at the moment is all I have. What if it is swept away with the flood?”

Kathmandu Valley is the largest urban agglomeration in Nepal and one of the fastest-growing metropolises in South Asia. It accounts for nearly one-tenth of the country’s population, with a growth rate of 4.63% (Shrestha, 2019). The population of the valley has been exponentially growing since the 1960s. The growth was further accelerated with an influx of people from various parts of the country to secure education and employment for a better livelihood, while some had migrated to the valley to seek a safe haven from political conflicts and familial crises. Like Rekha, there are thousands of people and counting, who reside on the banks of the Bagmati river and its tributaries.

Bagmati river is the artery of civilization in Kathmandu Valley. The river originates from the top of the hills on the
northeast of the valley and is fed by its numerous tributaries originating from various surrounding hills as shown in Figure 1. These tributaries converge directly towards the central long diameter of the floor of the valley, causing flooding during the monsoon season annually.

## Water woes

Torrential rainfall during monsoon and post-monsoon season (DHM, 2011), for those living near rivers in Kathmandu valley, translates to sleepless nights, anxious observations, waiting, and praying for the swollen monsoon rivers to not spill outside of the banks and enter their abode.

However, migration to the valley has exposed newer risks and vulnerabilities to some, especially those who had to live in squatter settlements. Most squatter settlements are located on the banks of the Bagmati river and its tributaries. For instance, settlers of the squatters near Manohara River, a tributary of Bagmati, is one of the largest informal settlements on the riverbank in the valley.

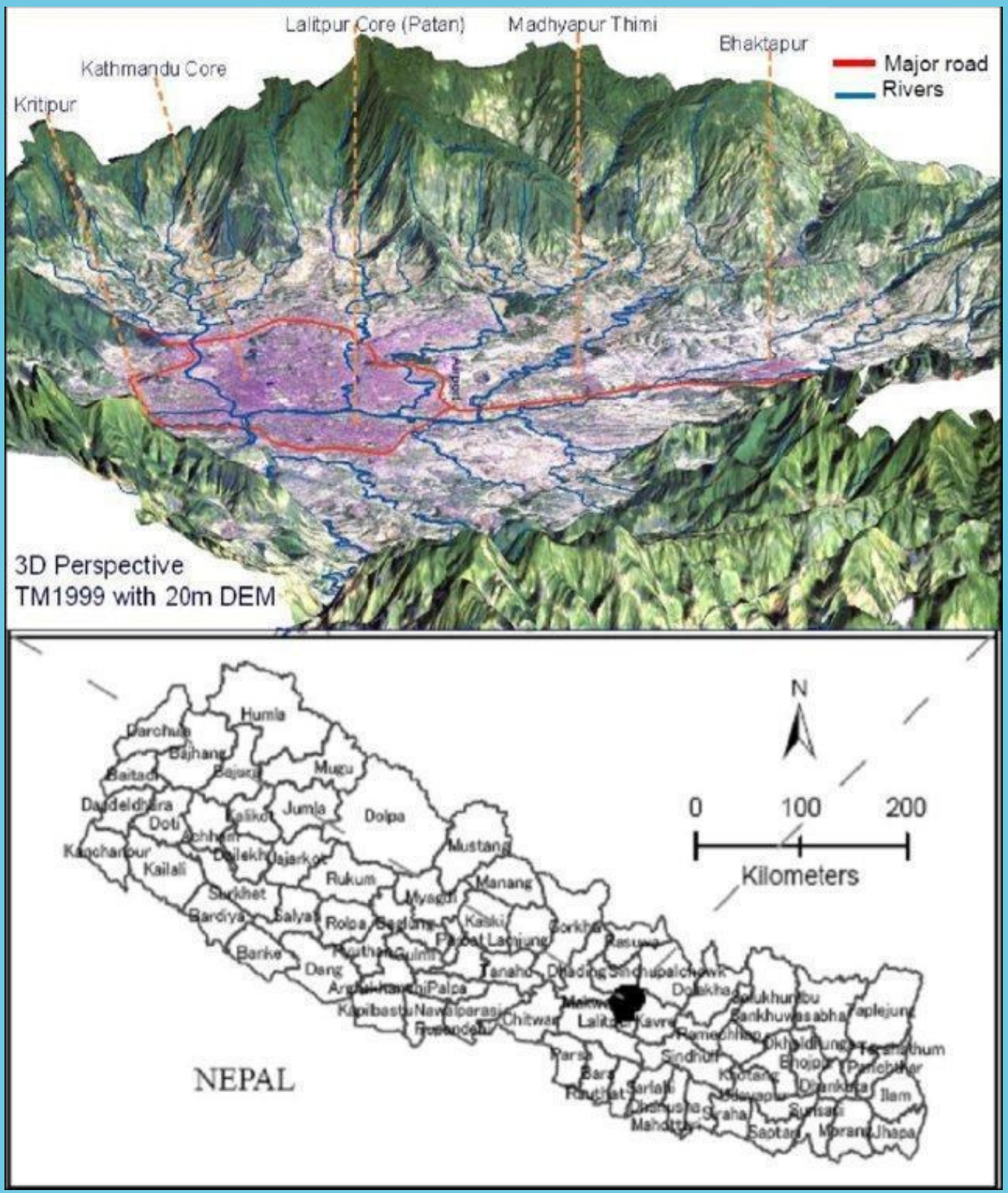


Figure 1. xxx by xxx, x. and xxx, x. (xxx)

The people residing in those settlements arrived in the valley in 2002 during the Civil War for a secure living (Subedi & Dixit, 2021). Unfortunately, the river inundates the surrounding settlements seasonally and exposes the settlers to additional stress like risks of contamination of drinking water, spread of water-borne diseases, hindrance to accessible water sanitation and hygiene (WASH) services, loss of property during the monsoon, and lack of access to drinking water during the dry season. Despite the known risks, they have no alternatives for relocating elsewhere due to lack of affordability of secured housing. Noteworthily, floods do not only appear from rivers. Residents also share episodes of pluvial flooding in locations where there are no rivers in the periphery. The pavements, streets, and open spaces become waterlogged with stormwater and sewage backflow. A painting shop owner in Patan, a city in Kathmandu valley, shared, "when it rains heavily, the streets disappear as they become waterlogged. In a matter of seconds, we all become knee-deep in the water...the traffic in the area becomes bad." Furthermore, there are numerous incidences of fluvial and pluvial flooding in the valley reported and covered by various news and media outlets annually. What is most alarming about it is the frequency and scale of the havoc wreaked by floods in recent years.

Contrary to too much water brought by a seasonal cloudburst and flooding events, the valley faces yet another water crisis, that is of scarcity. The water demand has outstripped the supply in the valley since the 1980s. Currently, Kathmandu Upatyaka Khanepani Limited (KUKL), a public utility responsible to supply potable water in the valley, estimates an average of 415 million liters a day (MLD) as a water demand for a population of 3 million, but currently, it has the capacity to supply about 150 MLD in the rainy season and 90 MLD in dry season (KUKL, 2018).

In order to cover the deficient water, people cannot depend on river water as it is too polluted and unfit for consumption. For years, the valley had been dependent on aquifers. Before the haphazard concretization of the valley floor, the soil had an immense capacity to soak and retain the rainwater. But now more water flows away in the form of floods during monsoon and less water makes its way to the aquifers. With almost every other community syphoning water out of the ground wells, the aquifers are depleting fast. Ergo, it is normal to see a number of water tanks from various private service providers and long queues of people with communal water sources like *hiti pranali* (indigenous system for water supply and management) to meet their demands as shown in Figure 2.

Figure 2. Private water service providers.

With the water woes, the residents of the valley have the sword of Damocles hanging over their heads. Amidst the continuous growth of population in the valley, more people will be affected by flooding and water scarcity. Experts say that the fundamental cause for both water woes is rapid and haphazard urbanisation and poor governance, which is exacerbated by climate change.

Backtracking the urbanisation of the valley, Tom Robertson (2021) in his article "Kathmandu's 'flash floods' are 4 decades in the making" writes that the floods are not a new phenomenon in the valley but became destructive after the valley's water landscape drastically transformed since the 1980s. A report by the Government of Nepal and USAID (1986) noted that it was "only recently" (in the 1980s) that Kathmandu "...began to occupy lower-lying flood plains" for residency. The floodplains were initially reserved for agriculture, as seen in the aerial image of Kathmandu as shown in Figure 3.

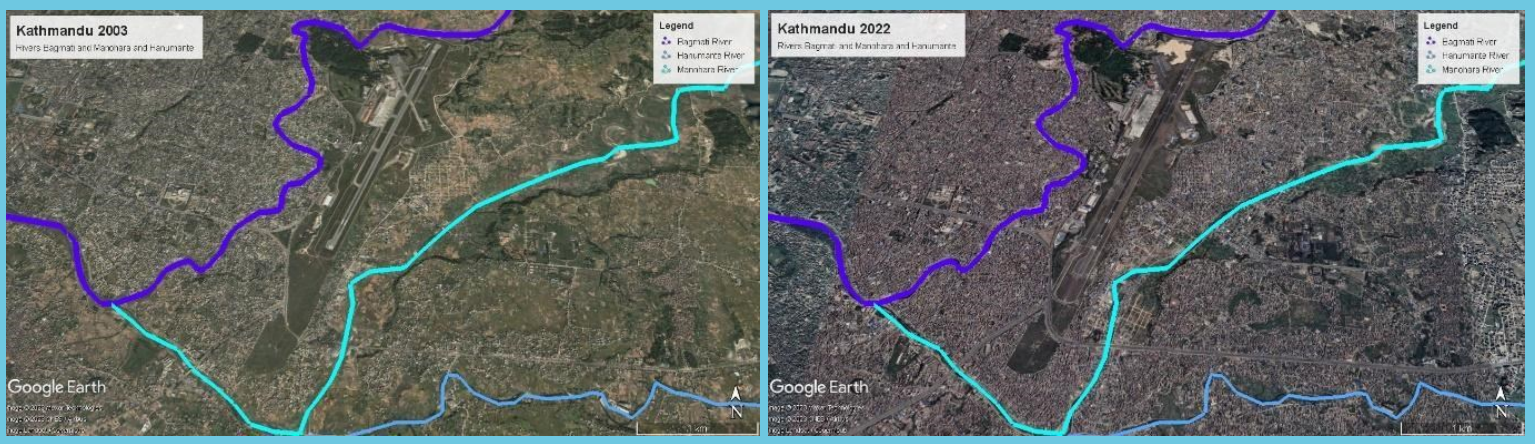


Figure 3. Changes in the land-use of low-lying areas of Kathmandu from agricultural land to settlements. Google Earth.

The same report recommended preserving the areas along the Bagmati river for agriculture. The authors noted “not only … fertile, but they have high water tables and are poorly drained. Thus, they are not good sites for urban development.” The authors warned, “If these are developed, it can be expected that the government will eventually be required to install expensive drainage schemes.” Fast forward two decades later, we are standing where the report seems prescient. With the encroachment of riverbanks for a residential explosion of build-up, the residents of the valley are facing a predicament.

## Hiti: an indigenous practice

Where water has now become a commodity; hiti pranali, continues to be the source of water for the migrants and urban poor who are not able to afford drinking water. The early civilization of Kathmandu valley had constructed their cities on the elevated hills where they had water catchments such as ponds and canals upstream from the settlement. Water would be distributed to the city dwellers through aqueducts and waterspouts. The discharged water or unused water from the spout would then be collected in a downstream pond before being released into the rivers as shown in Figure 4. These ponds acted as recharge ponds to refill the groundwater. This system is termed “hiti-pranali”. This ancient system, to this date, has been providing water to the residents to a certain extent. However, haphazard urbanisation and construction have dismantled and paralyzed the hiti-pranali, contributing to fluvial flash floods to an extent. This has not only disrupted the water supply but also the drainage of rainwater to the ground and the rivers.

The water crisis in Kathmandu valley is a ticking time bomb, and it is only a matter of time before it explodes. The neglect of traditional water conservation systems has left Kathmandu valley residents with few options for clean water. The valley's declining water sources have forced people to drink from limited sources that are polluted, which is a major health hazard. The situation will only get worse if appropriate action is not taken. The government needs to invest in the restoration of the hiti-pranali system, and it also needs to regulate urban development in order to protect the valley's water resources. Through necessary interventions, the revival of the hiti-pranali system can be a win-win for the people of Kathmandu valley and the environment. It will provide a reliable supply of clean water to quench the thirst of the valley, while also helping to conserve water resources paving a way for sustainable development.

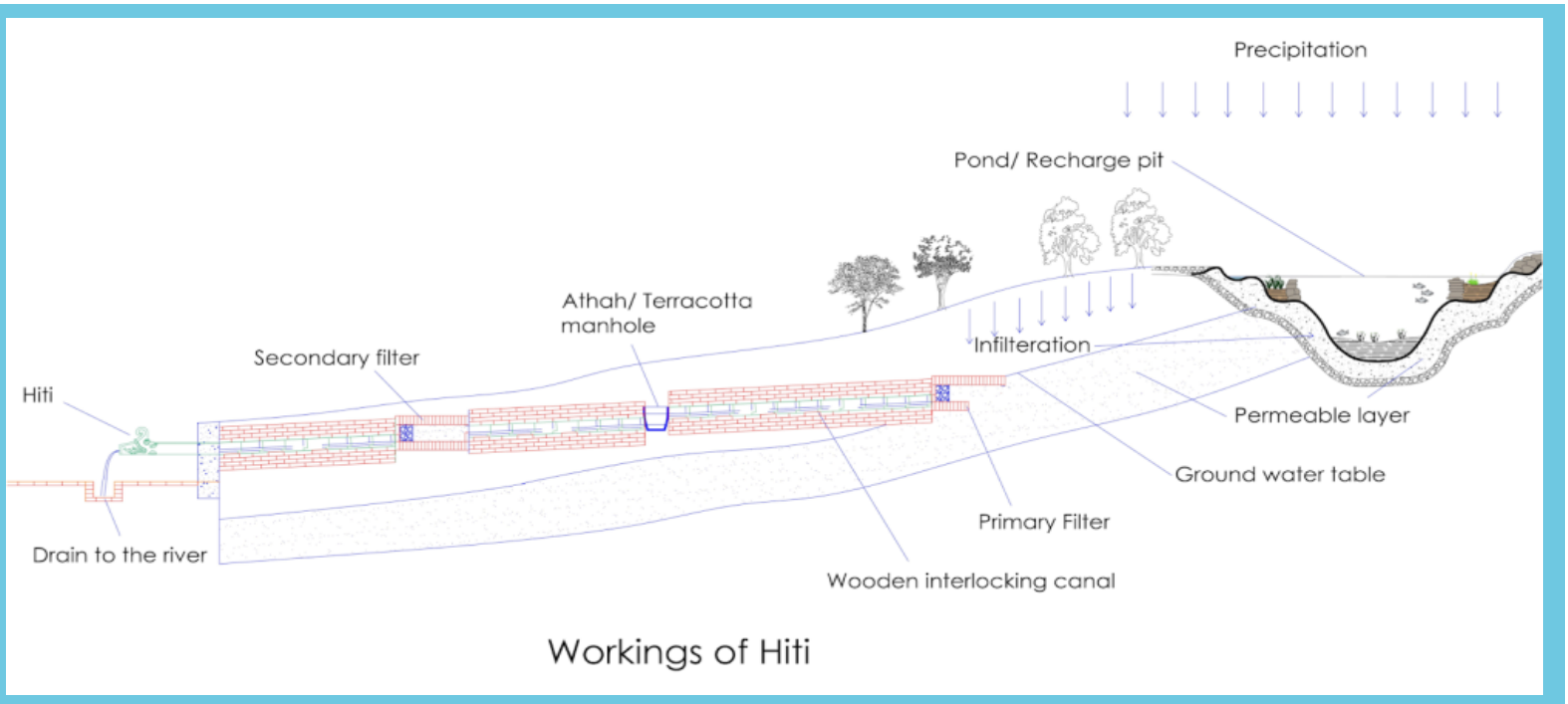


Figure 3. Sectional view representing the functioning of the Hiti system.

## Way ahead

The Kathmandu Valley is thirsty. The rivers are drying, the groundwater is depleting, and the people are struggling to get enough water. There is hope, however. By restoring the riverbanks, creating recharge zones, and using greywater, the valley's thirst can be quenched.

The riverbanks are polluted with sewage and garbage. This pollution seeps into the groundwater, making it unsafe to drink. Restoring the riverbanks would create green

zones that would filter the water and recharge groundwater. Trees could also be planted along the riverbanks, which would help to shade the water and prevent it from evaporating. Recharge wells can be created by digging wells, installing infiltration trenches, or building ponds. When it rains, the water will seep into the recharge zones and replenish the groundwater.

Greywater, which is not as dirty as sewage, can be used and reused at a household level for gardening, cleaning, and flushing purposes reducing the amount of water wasted. Moreover, greywater can be supplied to the network of recharge wells which can help improve the levels of the groundwater. In addition to these measures, it is also necessary to reduce pollution in the rivers. This can be done by discouraging the direct discharge of sewage into the rivers. Instead, more decentralised treatment plants should be built. These plants will treat the sewage before it is released into the rivers, which will help to improve the quality of the water.

Finally, water pricing schemes catering fair and equitable needs should be developed. This will help to ensure that everyone has access to clean water, regardless of their income. A fair and equitable water pricing scheme will also help discourage wasteful use of water. Together, the Kathmandu valley can become a more water-secure place. The valley's thirst can be quenched, and everyone can have access to clean water.

For a population of 3 million, Kathmandu valley is the only place that they can call home. The current and future water issues raise concerns about safety and water security. Addressing these water woes of too much and too little will ensure one aspect: an affordable and liveable city for all.

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# The metropolis of water-extremes: Karachi, Pakistan - A problem of disproportionate habitation fuelling bad decisions for water

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## Reader expectation

The article discusses the water scenario of Karachi city, an enormous land holder, but a disproportionate land user. The city contributes heavily to the GDP of Pakistan, though still gets inundated every year yielding a loss of several million dollars. This article walks you through the perspective of population and demand-driven strategies failing to address the problem, whilst living over more plumbing lines and drains than earth and soil itself. Karachi attracts many from the 63% youth population of the country for a career, requiring a mentality skewed towards a less communal approach for impulse in water stress. The article is picture-dense to create a virtual connection to the city and serve as a picture-story/tour.

## About the metropolis

Karachi stands amongst one of the most eminent megacities in the developing world. Being Pakistan's economic hub and most populous city, Karachi is responsible for generating nearly a quarter of the country's GDP. Initially, a small fishing village nestled along the Arabian Sea, Karachi, or Kolachi as it was then known, came to be recognised as a formal settlement in the 1730s and has since become one of the fastest-growing cities in the world. Karachi was known as the "City of Lights" in its glory days during the 1960s, an era in which business activities and industrial output thrived; and the city underwent massive infrastructural development, boasting of South Asia's first high-level sewerage treatment plant, among other municipal facilities. Karachi also remained the federal capital of Pakistan until the city of Islamabad became functional. However, Karachi's significance in terms of revenue

generation and its strategic importance as a port city, that still handles 95% of foreign trade in the country, has only increased with time.


Figure 1. Chaar Minaar Chowrangi (lit. Four Minarets Crossway). Bahadurabad, Karachi East, Karachi. By Saeed, D. (n.d.).

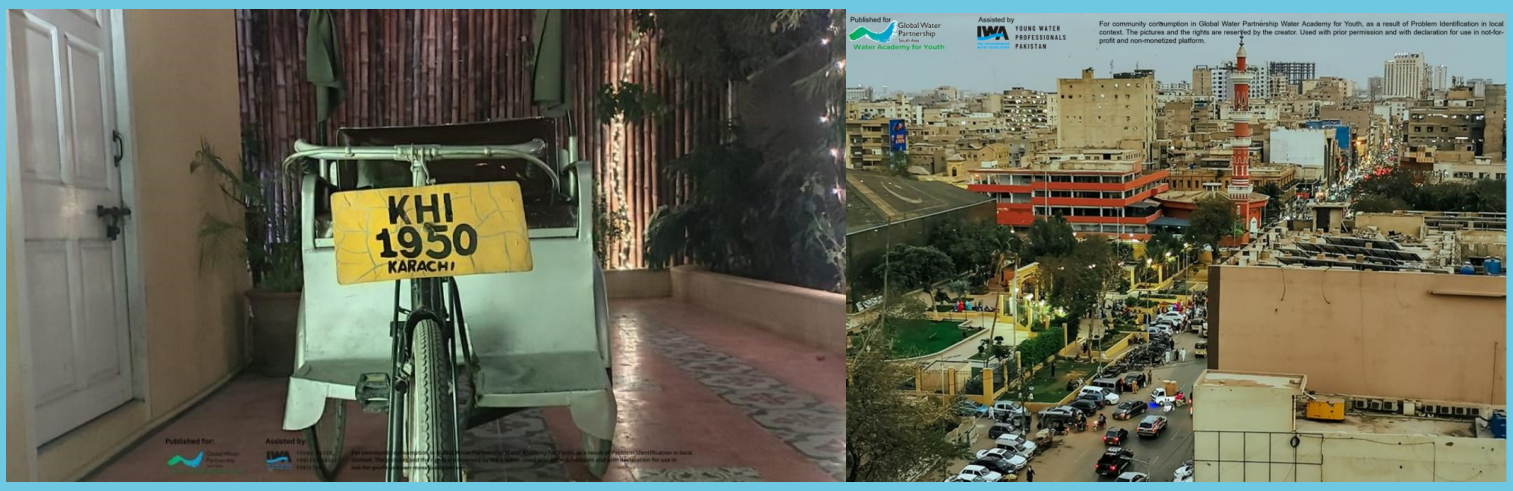


Figure 2a. A road in Saddar (lit. Head/Main) town. District South, Karachi. Iqbal, S. (n.d.). (Left)
Figure 2b. Old-school cycle rickshaw from the 1950s. Areeb, M. (n.d.).

Due to attractive economic opportunities, the city has faced high rates of rural-urban migration over the years, and this has led to uncontrolled urban sprawl as well as

congestion and unplanned development in certain "high-demand" areas. It is believed that half of the city's residents live in unplanned, informal settlements. Some planned developments, such as those in Clifton, an upscale area developed by the British during the colonial era, have been repurposed, i.e., old residences being demolished to construct high-rise commercial buildings. Although the construction of skyscrapers may be seen as a harbinger of modernity, the infrastructural capacity has, in most areas, not been expanded for increased demand. This is one of the reasons why water supply and sewerage capacity remain inadequate for the most densely populated areas of Karachi. Looking towards the north of the city, which is the general direction of urban sprawl, the expanses of land are informally populated and scarcely host maintained supply lines.

One thing remains common for citizens in both areas—they are forced to arrange their own water supply to cover the deficit. In most cases, this involves resorting to private tankers, which in turn, drives a whole circuit of water theft from the city's main supply and rumoured underhanded deals with water supply management officials. This also poses a serious health hazard for citizens since there is no mechanism to verify the quality of water being supplied by private tankers.

Government action to address Karachi's water management issues has been slow, with the only notable project (K-IV) to increase the supply by 650MGD facing numerous delays and bureaucratic red tape. Along with increasing the total supply, planners should also investigate easing the burden of consumption from the city's most densely populated neighbourhoods. This can only be done if a well-planned water supply network is developed for the sparsely populated areas up north such as Gadap Town. Until such a system is brought into place, planners should also look into promoting water conservation habits amongst citizens to reduce domestic water consumption.

Figure 3a. Sungal Nullah [flows into Lyari River]. District East, Karachi. Abbas, S. (n.d.). (Left)
Figure 3b. Inundated Korangi to FTC fyover. District Korangi, Karachi. Farooq, S. (n.d.). (Right)

## Geeky stats about the dwellers

Karachi city has been facing much turmoil lately due to mistrust of citizens in the local governments, administrative bodies, and even federally initiated programmes, such as the national census 2017, the first successor after the national census 1998. The report has been criticised for the accuracy of exact figures but unanimously followed by analysts. As discussed in the preceding text about the distribution of administrative boundaries of Karachi, we can analyse the population distribution across the administrative divisions.

The population density as published by Pakistan Bureau of Statistics (PBS), provides valuable insights into the population density of various districts of Pakistan. While the raw data might seem unrelated to water-related concerns, a closer examination reveals its relevance in the context of water supply and drainage considerations. One notable observation is the high population density in Karachi, indicating a densely packed community with a significant demand for water resources.


Figure 4a. Layers of Plastic at a drainage opening. District East, Karachi.Abbas, S. (n.d.). (Left)
Figure 4b. Roads of Clifton Beach. South (Cantonment), Karachi. Malik, S. (n.d.). (Right)

As urbanisation and population growth continue, the water demand in Karachi becomes a pressing issue, necessitating effective water supply infrastructure and drainage systems. The city's close-knit community emphasises the need for equitable water distribution and efficient drainage to prevent water scarcity, waterlogging, and flooding during heavy rainfall. In conclusion, the data on population density becomes a crucial factor in the water context. As it offers valuable insights into areas with concentrated populations that demand meticulous planning and management of water supply and drainage systems. Addressing the water related needs of densely populated regions, like Karachi, is paramount to ensure a sustainable and thriving environment for its inhabitants.

Figure 5. View from I.I. Chundrigar Road [a commercial centre road]. South, Karachi. Areeb, M. (n.d.).

Table 1. Statistics of Karachi (District Level Resolution)

Note: Kemari was declared a district in 2020. At the time of the census 2017, it was part of Karachi District West.

| Admin Units | Households 2017 | Males 2017 | Females 2017 | Neithers 2017 | Population 2017 | Population 1998 | M/F Ratio 2017 | Annual Average Growth Rate |
|---|---|---|---|---|---|---|---|---|
| KARACHI DIVISION | 2,770,074 | 8,439,659 | 7,610,365 | 1,497 | 16,051,521 | 9,856,318 | 110.90 | 2.60 |
| RURAL | 193,871 | 606,588 | 534,499 | 82 | 1,141,169 | 407,510 | 113.49 | 5.56 |
| URBAN | 2,576,203 | 7,833,071 | 7,075,866 | 1,415 | 14,910,352 | 9,448,808 | 110.70 | 2.43 |
| KARACHI CENTRAL DISTRICT | 538,983 | 1,543,950 | 1,427,349 | 327 | 2,971,626 | 2,277,931 | 108.17 | 1.41 |
| RURAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| URBAN | 538,983 | 1,543,950 | 1,427,349 | 327 | 2,971,626 | 2,277,931 | 108.17 | 1.41 |
| KARACHI EAST DISTRICT | 509,239 | 1,528,019 | 1,379,225 | 223 | 2,907,467 | 1,472,896 | 110.79 | 3.64 |
| RURAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| URBAN | 509,239 | 1,528,019 | 1,379,225 | 223 | 2,907,467 | 1,472,896 | 110.79 | 3.64 |
| KARACHI SOUTH DISTRICT | 327,518 | 943,546 | 848,010 | 195 | 1,791,751 | 1,478,047 | 111.27 | 1.02 |
| RURAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| URBAN | 327,518 | 943,546 | 848,010 | 195 | 1,791,751 | 1,478,047 | 111.27 | 1.02 |
| KARACHI WEST DISTRICT | 634,459 | 2,065,847 | 1,848,553 | 357 | 3,914,757 | 2,089,509 | 111.75 | 3.35 |
| RURAL | 44,051 | 149,220 | 134,014 | 13 | 283,247 | 73,568 | 111.35 | 7.34 |
| URBAN | 590,408 | 1,916,627 | 1,714,539 | 344 | 3,631,510 | 2,015,941 | 111.79 | 3.14 |
| KORANGI DISTRICT | 421,618 | 1,284,015 | 1,172,737 | 267 | 2,457,019 | 1,561,742 | 109.49 | 2.41 |
| RURAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| URBAN | 421,618 | 1,284,015 | 1,172,737 | 267 | 2,457,019 | 1,561,742 | 109.49 | 2.41 |
| MALIR DISTRICT | 338,257 | 1,074,282 | 934,491 | 128 | 2,008,901 | 976,193 | 114.96 | 3.86 |
| RURAL | 149,820 | 457,368 | 400,485 | 69 | 857,922 | 333,942 | 114.20 | 5.08 |
| URBAN | 188,437 | 616,914 | 534,006 | 59 | 1,150,979 | 642,251 | 115.53 | 3.11 |

The table 2 shows the population density at district level. Regardless to say, if the growth continued at the average annual growth rate between 1998 and 2017, in 2030 (the year of fulfilment of great resolutions) we will become a crab mound finding shells! The numbers speak for themselves.

Table 2. Indicators, Density and Projections

| | Area Sq. Km. | Population Density (2017) | Urban Proportion (%) | Average Household Size | Annual Average Growth Rate | Population Density (2030) | Population Increase (2030-2017) |
|---|---|---|---|---|---|---|---|
| KARACHI CENTRAL | 69.00 | 43,063.51 | 100.00 | 5.48 | 1.38 | 52,172.48 | 9,108.97 |
| KARACHI EAST DISTRICT | 139.00 | 20,685.72 | 100.00 | 5.64 | 3.67 | 34,262.10 | 13,576.38 |
| KARACHI SOUTH DISTRICT | 122.00 | 14,501.89 | 100.00 | 5.43 | 0.98 | 16,623.40 | 2,121.51 |
| KARACHI WEST DISTRICT | 929.00 | 4,205.67 | 92.76 | 6.13 | 3.25 | 6,581.06 | 2,375.39 |
| KORANGI DISTRICT | 108.00 | 23,866.26 | 100.00 | 5.80 | 2.51 | 33,768.49 | 9,902.23 |
| MALIR DISTRICT | 2,160.00 | 890.90 | 55.43 | 5.87 | 3.99 | 1,540.68 | 649.78 |

A small and straightforward analysis on the population statistics was carried out by including snapping grids onto the district map of Karachi to yield the graphical under/overestimations population density. Once we got the correct multiplier, we proceeded with the population density reported by PBS Census Report 2017. While the picture above does not really show any direct measure of population density and the water stress due to disproportionate distribution, the corrective factor did amplify the visualisation for the picture below. District Central reports the greatest number of people living in the area (like an epicentre of the population), which slowly radiates away non-uniformly, the next densest being the one near the sea, Korangi District that has appreciable slum settlements and District South, perceived as an expensive area to dwell in.

One might say how is that even a problem related to water. Well, more the people, greater the demand for water. As a result of this disproportionate distribution of citizens, the government's strategies are aligned towards areas possessing already higher populations - fuelled by political interest, which in turn attracts more house hunters towards already stuffed areas, and both the governments and the public find them in a rabbit-hole. The high-level urban planning and development strategies have failed to effectively use the land.

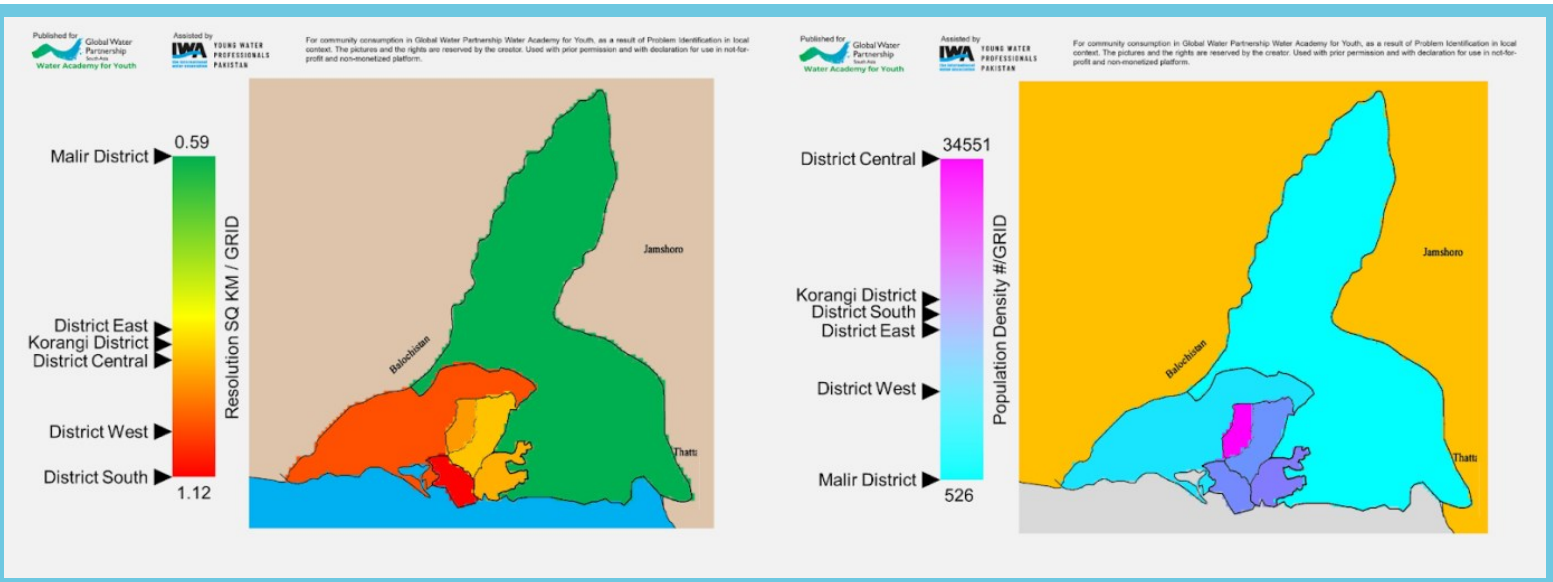


Figure 6. Left: Grid mapping on area according to PBS Census 2017 reported area. (n.d.). Pakistan Bureau of Statistics. http://www.pbs.gov.pk. Corrective multiplier; Right: Population density and implicit urban water stress as reported by PBS Census 2017. (n.d.). Pakistan

If we tend to explicitly address the water stress due to the disproportionate distribution of population/settlements in Karachi, several factors come into play, including the water pipeline networks, groundwater usage, desalination plants, operational wastewater treatment plants, water purchasing, and non-revenue water. As unfortunate as it gets, the data on many of these factors is not published, which arguably might be out of operation according to some sources. Groundwater is not moderated and boring can be done literally anywhere without prior permission from the administrative councils. Artificial groundwater recharge is non-existent to replenish the supply. Moreover, the data which is available is sold and not easily available for the analysts to work on. Institutions have a long way to go at the municipal level before we set Pakistan's water agenda straight.

According to numbers retrieved from (Hashim, n.d.) brilliant article on Karachi's water scenario, an average Karachiite uses 67.7 litres per person per day. While beyond the scope of the problem identified, you can "quench" (pun intended) yourself on the stats of our city at the latter.

Jumping to Karachi's progression on the "business as usual" scenario up to 2030, the population growth will see a massive increase in District East and a simultaneous increase in water demand. We will see why it is a problem in the subsequent section,

but as a spoiler, inundation of the Eastern District is the foreseeable future and the epicentre of a new population peak.

## About the "sunken" Metropolis


Figure 7a. Gulistan-e-Jauhar with an increasing interest of builders for new projects. Karachi. Saeed, D. (n.d.). (Left)
Figure 7b. Kerbside uncovered drainage with sludge and plastics. Karachi. Abbas, S. (n.d.). (Right)

Every year during the time of monsoon, Karachi experiences an unprecedented "natural disaster." It wreaks havoc in the city and is labelled so with reference to the rising climate change. The infrastructure gets destroyed and there are irreparable associated losses of human lives and economy. Some of the factors that are perceived to be the reason of this disaster are: the non-recognition of the actual population of the city; Modification, encroachment, and destruction of Karachi's original Master Plan; over the past several years only the 'katchi abadis' have grown in number and the waterways of the city have been encroached. But is it really climate change or man-driven destruction? Is squatter settlement the only problem that brings about catastrophic damages?

Figure 7a. Mehmoodabad Nullah. District South, Karachi. Abid, H. (n.d.). (Left)
Figure 7b. Saddar Bazaar Karachi. Areeb, M. (n.d.). (Right)

Before we draw any conclusions let's first understand the natural drainage system of Karachi. Storm water in Karachi drains into two rivers viz. Malir and Lyari River. Both the rivers begin at the foothills of Kirthar Range Mountains and go parallel together with 14-20 km in between. According to Karachi Water and Sewerage Board (KWSB) there are 64 storm water drains (nullahs). It is estimated that there are over 600 smaller nullahs that convey water from the corresponding catchments to these 64 nullahs.

The streets of Karachi are not devoid of drainage systems, even before the partition these nullahs existed. However, as the city grew chaotically and people started migrating for jobs and better opportunities, the demand for residential building increased resulting in land grabbers constructing buildings on, along the nullahs. Thus, transforming nullahs into sewage outlets and clogging the system due to formation of sludge.

Another reason for the occurrence of these flash floods is improper solid waste management. Open drains or damaged inlets of drains become informal dumpsters for people living nearby. There are two landfill sites in Karachi, both located side by side in district west. Due to long distance and travelling cost, the solid waste never reaches landfill sites; it is thrown at unofficial dumping sites and into open drains, thus causing drains to be clogged. Consequently, flash floods occur even with a moderate amount of rain as the water does not find way into the system.

Land reclamation is yet another problem in the city. Many bazaars (markets), facilities and offices have been constructed over natural drainage systems. It is estimated that over 1,000 families are thought to reside on the estimated 17 sq. km. of land that has

been recovered from the sea at Keamari, Sultanabad, Shireen Jinnah Colony, and sections of Macchar Colony. Phase 8 of Karachi has also been reclaimed from the sea. It has also been observed that the outlets of the drainage system at the sea have been blocked and/or destroyed. Some of these outlet's backflow into the system at high tide, thus causing the nearby areas to flood.

In order to create effective urban drainage and flood protection strategies, we need demographic information, maps, and expert views. Even if this data is acquired, it cannot be used widely because of restrictions on open access, lack of updates, incompatibility, and format variations. Therefore, the first step is to document the data, identify the potentially affected and float the data publicly so that viable solutions could be proposed pertaining to the needs of people.

## Crisp takeaway on the problem...

The problem is the lack of awareness/ignorance to combat the communal psychology of Karachiites and demand-driven government strategies for water supply and drainage in the very populous districts of Karachi, which causes inundation of business centres every year. Solving this will reduce load on existing drainage systems reducing inundation intensity, while the government will be steered in developing the less habited areas despite being demand-driven, and the same financial weight can be reappropriated.

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# "It is not just a tributary that flows through the town": Transforming a neglected natural water body into a beautiful space for city residents

Authors: Sithara Kumarasinghe

Keywords: *Sri Lanka, Urban Planning*

https://doi.org/

Urban populations are steadily growing day by day, month by month, and year by year. Urban areas must be prepared to accommodate this growing population. Cities and towns serve as social hubs as well as places where individuals may unwind and enjoy themselves. If that is the case, meeting the requirements and desires of the growing population will not be possible with just roads and buildings. To make cities healthier places, city planners and engineers are using more blue-green strategies. Urban heat, ecological degradation, and other issues are growing because of increased urbanisation. Then, as potential remedies for urban concerns, experts and planners aim to include green roofs, renewable energy, tree plantation, and other potential alternatives. In a similar vein, it is critical to preserve the current ecology and get used to it.

The third ordered service centre in the province of Sabaragamuwa is Balangoda (National Physical Plan 2030, Sri Lanka). It is governed by an urban council and is 143 kilometres from Colombo. Balangoda town serves as a service hub for several nearby areas. 35,000 people commute there every day. Today's issue is centred on the natural tributary, known as Dorawela Oya.

Figure 1. The current appearance of Dorawela Oya and its surrounding Ecosystem. S Kumarasinghe.

When it comes to the major problems prevailing around the Dorawela Oya that flows along the town; it is the first image that visitors to the town see upon arrival. The problem is that the stream is not only surrounded by wild bushes and wild plants, but there are also dumps of old, broken cars and piles of construction waste on one side that creates an awful view of the stream banks. Additionally, because of this situation, the surrounding water bodies, environment, ecology and aesthetic value of the place is deteriorating continuously. This water body is currently almost uninhabitable, and the issue is aggravating with each passing day.

The town area benefits greatly from the presence of the natural water body because it offers citizens and the ecosystem a wide range of advantages. From the purpose of space, it provides a blue-green environment for the town that helps to keep ambience and a friendly environment, while also being the natural runoff infrastructure of the town. Therefore, it is our responsibility to ensure its sustainability. The discussion section answers the question that why the current state of the tributary is problematic. The water tributary runs along one side of the town and if we will continue to ignore its clinging problems, it will get even worse. How? Let us investigate.

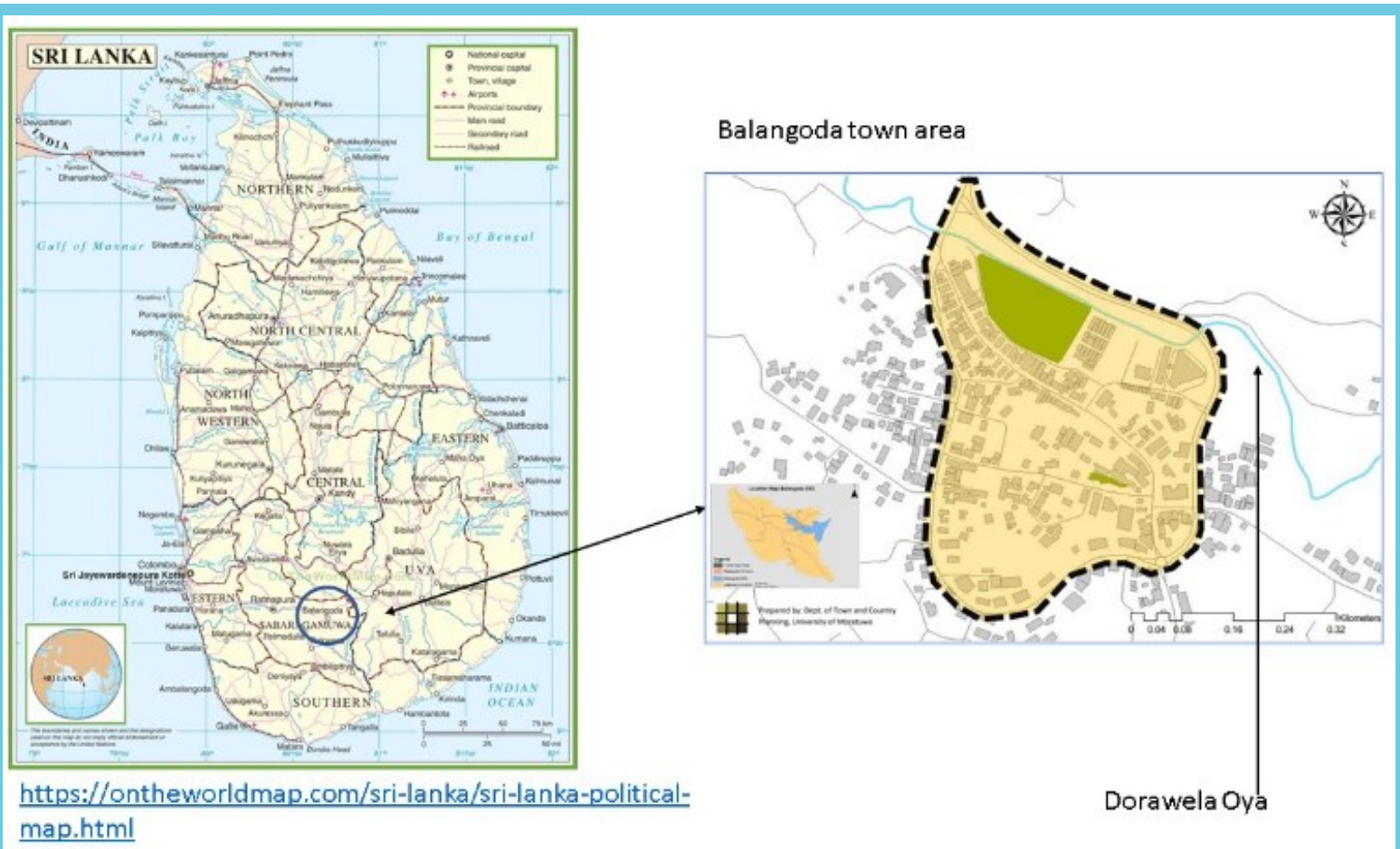
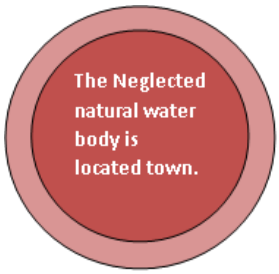



Figure 2. Location of Balangoda town and Dorawela Oya. ontheworldmap.com

The following combined effects can be faced in the future by ignoring the prevalent ones at Dorawela Oya:



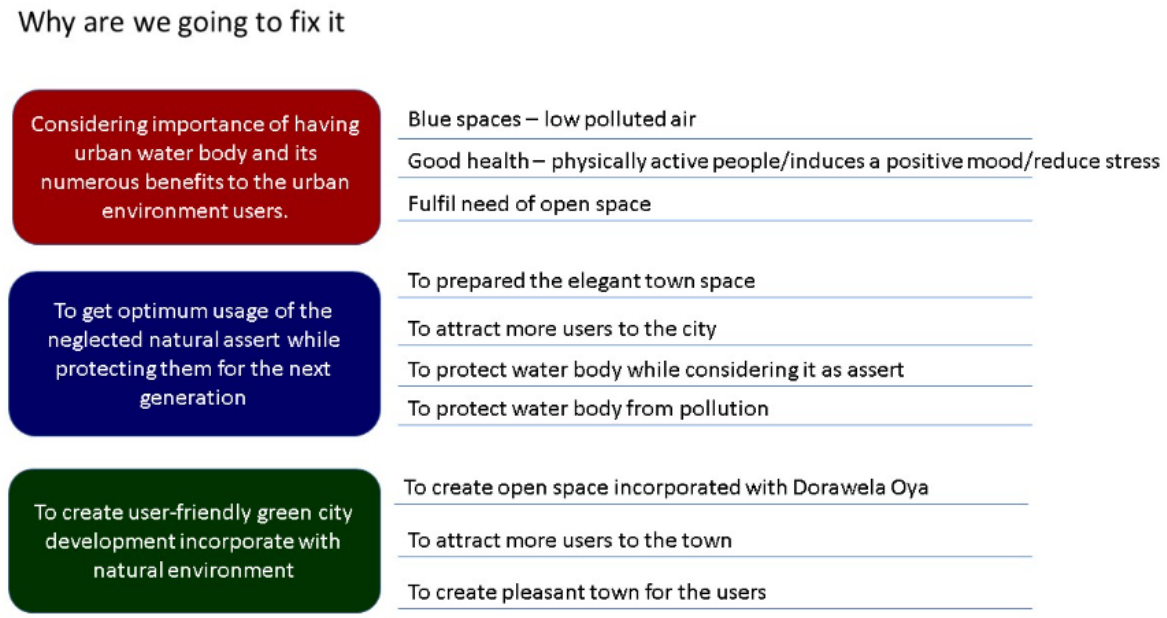

Nowadays town planners, policy makers and nature lovers concern more in blue- green infrastructure development than grey infrastructure. Making climate resilient cities, green cities are prominent due to rapid urbanisation and urban developments. In that case Balangoda urban environment enrich with elegant natural view and elements of natural ecosystem such as Dorawela oya. Nevertheless, if relevant authorities do not concern and protect those natural asserts will make malfunctioning and unpleasant urban environment to the users.


Balangoda Town is the third- order town center in Sabaragamuwa Province. Further more, it must offer service to almost 35000 floating population each day. From my own experience there are not any open space, seating area for the town users in Balangoda. After getting their main service from the town immedicably they have to leave the town because of that situation. It is not a healthy environment for the sustainability of they town. Dorawela Oya and its surrounding environment have potential to develop as open space incorporate with natural eco system. In that way It is such a waste to ignore this natural assert.


If this natural water body area neglect day by day, it will cause for it's worst. It will happen like a circle, if we neglect it more it will become less usage and it will cause for pollution. It causes to huge isolation and unpleasant situation. It will never be a iconic natural environment when we go with business as usual scenario.


Balangoda is surrounded by misty mountains with a glimpse of the bluish green. The place where Dorawela Oya is located is the one of the ideal places to feel that beauty of the city. Unfortunately, the area is not developed to facilitate that huge potential that will attract more users to the town. If we use this locational importance to this town the area can be develop as population magnet.

According to the above-mentioned facts now we already feel why we want to fix this situation. The following illustration gives more reasons for that.




As a waterfront recreation area, the Dorawela Oya area can be improved. The tributary's biodiversity will be preserved, and city residents will benefit from recreational opportunities. The town turns into a place that the inhabitants associate with happy memories. When things continue as they currently are, this urban environment will no longer attract the visitors, and will no longer be able to have or maintain a blue and green environment and will not cater the needs and demands of its inhabitants. It will change into a place where only buildings and roads are present, along with disappointed individuals. Maybe Dorawela Oya starts carrying sewage instead of clean water as a tributary.

*This article was adapted from an ArcGIS StoryMap*

# Greywater Reimagined: Transforming Waste into a Sustainable Water Source

Authors: Karma Yangzom Dorji

Keywords: *Bhutan, Water Quality, Policy*

https://doi.org/

## What is greywater, is it a matter of concern?

Greywater refers to the wastewater generated from household activities such as bathing, laundry, and dishwashing, excluding toilet waste (which is categorized as blackwater). While greywater may not be as contaminated as blackwater, it still contains traces of organic matter, nutrients, and potentially harmful substances (WHO, 2006). Improper management and disposal of untreated greywater can lead to environmental pollution, soil and water contamination, and potential health risks. It is important to address greywater as a concern and implement appropriate treatment and management practices to ensure its safe handling and minimize negative impacts on the environment and human health.

## Greywater management in Bhutan

Greywater in Bhutan is discharged directly into the storm drains or by letting it flow freely to the low-lying areas or into the nearby streams. Yet, the greywater problems don't seem to matter much at the moment. The households in rural areas of Bhutan are mostly scattered and it is common to find kitchen gardens around them. Considering the smaller built-up areas, the greywater in rural areas can be managed simply in vicinity. In urban areas, due to the topography and major built-up area, storm water flooding during monsoon season is a major issue whereas the greywater is usually overlooked.

With drastic increase in infrastructure and population growth, the mismanagement of greywater in urban expansions can result in several significant problems. Improper disposal or inadequate treatment of greywater can lead to water pollution, contamination of water bodies and endangered aquatic ecosystems. It can also pose

health risks as greywater may contain harmful bacteria and pathogens. The accumulation of untreated greywater can emit unpleasant odours, attract pests, and create unsanitary conditions. Additionally, mismanaged greywater can contaminate the soil, impacting plant growth and urban agriculture. Infrastructure damage, legal non-compliance, and the strain on resources further exacerbate the consequences of greywater mismanagement. To avoid these problems, it is crucial to implement effective greywater management systems that prioritize treatment, responsible disposal, and awareness among urban residents.

## Case Study: "Greywater Management in the Babena Community, Thimphu - Challenges, Opportunities, and Sustainable Solutions"

The greywater from households in Babena community in Thimphu is directly discharged into a nearby stream, which joins the Thimchhu river of Wangchhu basin. 100 litres of freshwater used in a household ends up producing around 70-80 litres of greywater (Peprah, Acheampong, & deVries, 2018). Furthermore, this polluted water being released from multiple households into nearby streams surges the situation to manifolds. However, it has been observed that the residents of the area are not bothered, concerned or aware about the challenges and problems posed by the mismanagement of greywater that may appear in future. Greywater has relatively fewer loads of pollutants in comparison to black water and contains negligible amounts of heavy metals and pathogens, but the substantial amount of greywater being discharged from the community is polluting the water bodies and this will slowly disrupt the ecosystem.

However, greywater can be turned into an opportunity by applying sustainable solutions rather than seeing it as a problem. Greywater can be effectively managed and reused by applying several key strategies. Implementing greywater treatment systems play a vital role in ensuring the quality of reused water. Treatment options such as filtration, disinfection, and biological processes can help to remove impurities and pathogens, making the greywater safe for reuse. These systems can be installed at the household or community level, providing an efficient means of treating greywater before it is utilized for non-potable purposes.

Allowing a separate plumbing system in buildings enables the collection and diversion of greywater for reuse. By keeping greywater separate from blackwater (toilet waste), it becomes easier to direct it to storage tanks or treatment systems. This approach

ensures a consistent supply of greywater for reuse, reducing the demand for freshwater resources. Greywater can then be utilized for activities such as landscape irrigation, toilet flushing, and industrial processes, contributing to water conservation efforts and promoting sustainable water management practices.

To ensure the success and safety of greywater reuse, it is important to raise awareness and educate communities about proper greywater management. Providing education on the benefits of greywater reuse, the selection of environmentally friendly cleaning products, and the correct handling and storage of greywater fosters responsible practices. Additionally, the establishment of regulations and guidelines by relevant authorities ensures the adherence to standards for greywater treatment, storage, and permitted uses. By combining effective treatment systems, separate plumbing, community education, and regulatory frameworks, greywater can be managed and reused as a sustainable solution, conserving water resources and minimizing environmental impact.

Featured Image: View of the Mahadayi River.

# The 'Tug of war': Mahadayi River Water Dispute

Authors: Rachana Mattur

Keywords: *India, Transboundary, Inter-State*

https://doi.org/

India is blessed with an extensive network of rivers, making it one of the countries with the highest number of rivers in the world. However, the increasing demands for water resources, driven by population growth and rapid development, have put immense pressure on these precious water sources. This pressure is especially pronounced when it comes to shared rivers, where multiple states rely on the same river system to meet their water needs. As the demand for water continues to rise, disputes between states over shared waters have become a common occurrence.

One of the primary reasons for these disputes is the implementation of water projects by upstream states and inter-basin water transfers. Unfortunately, these disputes have taken on a political dimension and have even led to violence in some cases. As India's population and water demand continue to grow, it becomes crucial to address these inter-state water disputes and implement national water management policies to effectively handle water scarcity and ensure equitable allocation of water resources.

Some notable examples of inter-state river disputes in India include the Kaveri River water dispute, Krishna River water dispute, Godavari River water dispute, Ravi-Beas dispute, and Mahadayi River water dispute.

## Mahadayi River


Figure 1. Kalasa Banduri Nala Project. The Indian Express

The Mahadayi River, also known as Mandovi River, holds great cultural significance as it means 'The great mother goddess.' It spans across three southern Indian states: Karnataka, Goa, and Maharashtra. Originating in the Western Ghats, the river starts from a cluster of 30 springs located in Bhimgad National Park, which is in the Belgavi district of Karnataka. It gracefully flows through the districts of Belgavi and Uttar Kannada in Karnataka and further passes through Cumbarjua Divar and Chorao in Goa before finally meeting the Arabian Sea. For the state of Goa, the Mahadayi River serves as a lifeline. In terms of length, the river covers an area of 81 km, with 35 km flowing through Karnataka, 45 km through Goa, and a modest 1 km through Maharashtra. As for the catchment area, it totals 2,032 $km^2$, with 375 $km^2$ in Karnataka, 1,580 $km^2$ in Goa, and 77 $km^2$ in Maharashtra.

## Dispute's Origins

The Mahadayi River water dispute between Karnataka and Goa dates to the 1980s and gained momentum when the Karnataka government proposed a project to the 'Kalasa-Banduri Nala Yojana' in 1989. This project aimed to transfer water from the Mahadayi River to the Malaprabha river basin by constructing dams and canals across its two tributaries, Kalasa and Banduri. The plan intended to provide water to Karnataka's water-scarce districts like Dharwad, Gadag, Bagalkot, and Belgavi.

However, Goa raised concerns about the potential disastrous ecological impact of such a diversion on its environment. The region where the Mahadayi River meets the sea is already ecologically fragile, with saltwater ingress and tidal influence affecting areas up to 36 km upstream. Goa feared that the proposed diversion could increase salinity and distress riverine ecology, leading to aquifer contamination.

Another contention was the fear that the stored water might be used for agricultural purposes outside the Mahadayi basin, further straining Goa's already limited water resources. Karnataka argued that the surplus water should be diverted to the Malaprabha basin to cater to its drinking, irrigation, agriculture, and power generation needs.

The diversion project also raised concerns for Goa's commercial shipping industry, as it could reduce the minimum water level required at the Cumbarjua canal used by goods-carrying ships to navigate, potentially impacting trade and economic activities in the state.

Karnataka claims that the surplus water draining into the Arabian Sea should be diverted to the Malaprabha basin to address the crucial needs of drinking water, irrigation, agriculture, and power generation in its districts. On the other hand, Goa disputes this claim, arguing that it is a water-deficient state and opposes any diversion of water from the Mahadayi River.

## Tribunal Formation

In 2002, Goa sought to create a water disputes tribunal to address the dispute, which eventually reached the Supreme Court in 2006. As per the Interstate River Water Dispute Act, the Government of India constituted the Mahadayi River Water Disputes Tribunal on November 6, 2010. However, both states faced challenges in providing reliable data to evaluate their water claims against equitable appropriation criteria as defined in the Helsinki Rules (1996) and Berlin Rules (2004).

In August 2018, the tribunal awarded 24 tmc ft to Goa, 13.42 tmc ft to Karnataka, and 1.33 tmc ft to Maharashtra at 75% dependability. It also proposed the creation of the Mahadayi Water Management Authority to oversee the implementation of these awards, subject to review after August 31, 2048.

Despite the tribunal's decision, both Karnataka and Goa challenged the award by filing references before the tribunal and special leave appeals to the Supreme Court. As a

result, the Supreme Court put a stay on Karnataka's construction of dams and canals on the Mahadayi River until the final verdict is reached.

The Mahadayi River water dispute remains a contentious issue between Karnataka and Goa. The dispute revolves around the equitable allocation of water and the potential ecological consequences of diversion projects. While the tribunal has made an award, the legal complexities continue, highlighting the need for a transparent and efficient water management framework and a collaborative approach to resolve inter-state water disputes in India.

## Legal Complications in resolving the dispute

Constitutionally, the Union has defined "any dispute or difference between two or more State Governments concerning the use, distribution, or control of the waters of, or in, any inter-state river or river valley".

While the Constitution of India grants state governments the powers to adopt legislative and executive measures over an inter-state river's water that flows through their land, it does not confer proprietary rights on any volume of water based on the river's drainage area or contribution to the flow. Unfortunately, in practice, some states have attempted to assert exclusive ownership over interstate rivers, leading to disputes and the denial of water rights of other states.

The Supreme Court of India has categorically asserted that "... the waters of an inter-state river passing through the corridors of the riparian States constitute national assets and cannot be said to be in any one State. Being in a state of flow, no state can claim exclusive ownership of such waters or assert a prescriptive right... to deprive other States of their equitable share".

To address inter-state water disputes, the Parliament of India passed the Interstate River Water Disputes Act (IWRD Act) in 1956. The act provides for the resolution of water disputes that may arise in inter-state rivers and river valleys. If states fail to amicably reach an agreement, a tribunal can be established under the IWRD Act to resolve the dispute. Once the tribunal is constituted, it assumes jurisdiction over both surface and underground water in the river basin. The tribunal's investigative decision, after examination of data, evidence, and witnesses, is equivalent to a decision by the Supreme Court of India.

The Mahadayi River Water Dispute Tribunal was constituted in 2010 and it took 8 years to grant awards to the concerning states. During this extended period, numerous farmer protests and disagreements erupted in several regions, with Nargund taking center stage as the "land of rebellion" due to its vocal opposition to the Kalasa-Banduri Nala Yojana project in Karnataka. These protests persisted for nearly three years (2016-2018) and occasionally turned violent, leaving a trail of destruction and unrest in their wake. These protests caused extensive property damage, disrupted government offices, and shattered peace in the town for over a year.

These farmer protests, not only in Nargund but also in other affected regions, highlighted the urgency of resolving inter-state water disputes and the importance of equitable water allocation. The delay in the tribunal's verdict further fueled frustration among the farming communities, exacerbating their already precarious living conditions.

The delay in the tribunal's verdict can be attributed to two factors. Firstly, the tribunal's quasi-judicial nature, resembling a court, involved the collection of data, evidence, and witness testimonies to arrive at a verdict. However, incomplete and manipulated data provided by the states significantly prolonged the investigation process. Secondly, the political level of solutions offered by the tribunal further compounded the delay. Even in this case, after the Supreme Court of India's intervention, the Central government informed the parties about the tribunal's awards.

The increasing population and its demands have led to water scarcity, posing challenges in terms of quantity, and diminishing quality for domestic, irrigation, and industrial use. The Mahadayi River Water Dispute has persisted for more than 30 years, witnessing both violent and non-violent protests. The prolonged delay in tribunal awards has resulted in loss of lives, agricultural productivity, and a sense of water security for the people of Karnataka and Goa.

## Conclusion

The Mahadayi River water dispute has been an eye-opening journey, revealing the complexities and challenges of managing shared water resources in our diverse nation. This tug-of-war between Karnataka and Goa over their rightful share of the river's water calls for a collaborative and equitable solution.

To address these pressing issues and safeguard our national interests, it is imperative for the central government to play a more proactive role in managing inter-state

waters. Fostering a spirit of cooperation among the states is vital, ensuring that each one receives its fair and just allocation of this invaluable resource.

Given the federal nature of the country, navigating through these disputes may be intricate, and it is essential to protect the rights of every citizen, including their access to water. The coutnry must make well-informed and unbiased decisions, relying on transparent data-sharing and constructive dialogues to find resolutions that benefit all.

While moving into the future, water conservation and efficiency should be at the forefront of our efforts. Embracing modern techniques and encouraging responsible water usage will be crucial, especially as water demands increase and scarcity looms. Timely implementation of tribunal awards is equally important to avoid prolonged disputes that could disrupt lives and livelihoods.

Above all, let residents cherish water as the precious lifeline that sustains our communities and nurtures our natural heritage. By standing together, respecting each other's needs, and nurturing our ecosystems, the country can forge a path towards a brighter, water-secure, and sustainable future for our beloved India. Let every drop count as we embark on this collective journey towards responsible water management and harmony.

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# Water in the Darjeeling Himalayas

Authors: Sangay Tamang

Keywords: *India, Hills, Drinking Water, Policy*

https://doi.org/

It was Saturday evening of March 2022. Some respite from the freezing cold of the winter has slowly been witnessed in the hills but the sky was still gloomy. Arman picked up empty buckets and put them in a row near the public hydrant tap. He looked at the sky and predicted that it would rain tomorrow morning and decided to move inside his house. The next day, at 4:30 am, many people in the locality were awake waiting for water supply in the public hydrant. There is only one public hydrant tap for around 17 households and every household takes 20 litres at a time and the turn rotates until the water is stopped by the line man employed by the water department of Darjeeling Municipality. There is no fixity in the flow of water; it mostly depends on the line man who controls the supply from early morning to late evening. Residents, meanwhile, wait for the water to flow into their pipe, which lasts for an hour or less. Public and private water connections have different times, yet both depend on the line man who many times redirects the flow of the water as per directions from the higher authority. In the public hydrant tab where water comes in an interval of 3 to 4 days, residents eagerly wait for their turn. Arpan also woke up early in the morning to fill his empty buckets that he had lined up last night. As his prediction of rain failed, everyone jokingly accused him of being a poor meteorologist. He hesitantly looked up to the sky and uncannily proclaimed of the changing climate. Coincidentally, the water in the public hydrant on that day also lasted for 20 mins only, leaving many with empty buckets for the rest of the day. Neither had it rained on that day nor did the water come from the public hydrant. Villagers were left with no choice but to rush with empty buckets to the nearest spring (*dhara*), which is almost in the state of drying. However, those with private water connections received sufficient water on the same day.

This disparity in terms of distribution of drinking water reflects complex political nexus between hydrological engineers, plumbers (who are also linemen), politicians, bureaucrats, rich businesspeople, and common citizens thereby making the residents of Darjeeling as what Nikhil Anand termed as “hydraulic citizens” (Anand, N. 2017). The flow of waters in the hills therefore evolves through deeply layered

entanglement of not just physical pipes that are untidily fixed across the hills, but it also flows through complex channels of social, economic, and political connections developed over decades. Beyond these hydraulic as well as political aspects of the water crisis, the disparity of water distribution in Darjeeling Hills also reflects a declining stage of community owned natural sources due to many anthropogenic as well as natural factors across the hills. The crisis of drinking or hygienic water supply has become one of the major issues in many parts of the globe, especially in urban areas where traditional water sources have been declining in an irreplaceable manner. Authorities and policy makers seek a solution through the expansion of formal piped connection thereby reinforcing disparities and marginalization in access to drinking water. The majority of our scholarly attention has also been focused towards understanding this piped connection of water formally, thereby leaving very little room for discussion on other aspects of the water crisis in the hills. In my opinion, although the crisis of drinking water in Darjeeling hills has become rampant in the last few decades; there is a need to evolve from complex historical as well as cultural factors that have gradually detached the community from their natural sources and pushed them towards the modern water system developed during the colonial period. This detachment of humans and nature not only impacted the natural flow of water, but rather it deeply altered the local perception of rain that provides water to these sources. Therefore, to understand the roots of our modern water crisis, it is imperative to engage with the entangled connection of humans, rain and varied forms of water developed in different historical times and space.

Historically, residents in Darjeeling town have relied on natural springs (*dhara*) for water. For instance, many communities in the hills consider spring water as pure or holy water (*choko pani*) that has religious, cultural as well as medicinal properties to heal different kinds of illness (Lama & Rai, 2016). The *dhara* from where the water flows has still been considered as a sacred site for performing various religious and community festivals. It is generally believed to be a place where a *Naga deity* resides. Commonly referred to as *Nag* and/or lu/lhu in Tibetan Buddhism, this particular deity is associated with a category of serpentine, whose idol image reflects half human and half snake and is mostly associated with “water” in Hinduism and Buddhism mythology. The worship of this deity traversed various religions and encompassed layers of communities’ engagement with more than the human world. The Naga deity is rarely seen but mostly imagined having resembled the image of a snake. This intangible deity has played an important role in maintaining the ecosystem of the *dhara* by constraining people from polluting its sacredness. Thus, the sentience of water in

the Himalayas entails aspects that are not merely material but also ethical actions, evolved from complex interaction of human, non-human, and sacred geography.

Over the last few years, the significance of *dhara* has declined under the duress of the anthropocene. Changes in rainfall pattern indicate tremendous changes in the flow of water in the springs, further accelerated by deforestation, concretisation as well as urbanisation. Many important catchment areas in and around the town are threatened with deforestation and concretisation that invariably affects the natural process of water formation in the spring. In Darjeeling Himalayas are blessed with rich monsoonal rain along with pre and post monsoon rain that provides considerable precipitation and maintains a moist condition in the region. However, the failure to manage it naturally, the changing landscape since the colonial intervention, deforestation as well as the increasing anthropogenic pressure is gradually affecting this natural precipitation pattern in the region. Therefore, there is an utmost necessity to understand the vitality of rain in order to understand the issue of water in the region. This understanding must stem from multiple dimensions of perceiving rain not just as a natural factor (that can be studied only scientifically) but also as an active protagonist of history, culture, and spirituality, in understanding a place like Darjeeling that is deeply embodied by rain.

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# South Asia WAY Cohort 2022

Mohammad Shahadat Hossain

This is Mohammad Shahadat Hossain from Bangladesh. I completed my bachelor's degree in economics from Jadavpur University, India in 2020. I have been selected for the Climate Action Champions Network Cohort- 2022 in August 2022 along with 100 young climate champions from Bangladesh, India, Nepal, Srilanka and Bhutan to work together on climate change issues. I am also working with a research team from UC Berkeley, USA as a graduate researcher for global water-climate policy analysis on COP26 gap analysis for COP27 policy suggestions. Previously I worked with multiple international organizations in the research and development sectors. I consider myself a young and innovative mind who cares about his community. Being an economics graduate I have freedom to look from slightly different angles so that people can benefit from all aspects. I am trying to make a solution-based bridge between food security and climate change for the climate vulnerable communities for long-term benefits.

Shadia Hamid Mim

Sadia Hamid Mim is a sophomore majoring in public health and environmental science at Asian University for Women. While assisting with a senior thesis on dye wastewater management in Gazipur, she developed an interest in the management of water resources. Sadia wants to work in the environmental industry. She enjoys reading and traveling when she is not occupied with her studies.

## Tabassum Mehnaz

Tabassum Mehnaz is an Environmental Sciences & Public Health graduate from the Asian University for Women (AUW). She was born in Chittagong and raised in Dhaka, Bangladesh. She graduated this Summer with High Honors in two disciplines very close to her heart.

She considers herself an adaptable and optimistic individual who chooses to focus on the brighter side of things. Currently, she's interning at White & Case and working as a Research Assistant in two research groups; Center for Climate Change & Environmental Health (CCCEH) and Virtual Energy & Environment Research Group (VEERG). Her research interests include river restoration, WASH, environmental epidemiology, and climate change. She likes to spend her free time reading scientific articles, brushing up on vocabulary skills, and doing sketches.

## Tashi Wangmo

Hello, I am Tashi Wangmo. I completed by master's in science in Natural Resource Management from College of Natural Resources, Lobesa, Royal University of Bhutan. I am an amateur youth activist at my own individual level and currently serving as a National Coordinator for South Aisa Students for Liberty for the Bhutan/Nepal Region. I have always been interested in research be it qualitative or quantitative despite knowing its essence before. I am an ardent and avid learner, hardworking and dedicated to the tasks I am assigned for. I enjoy talking with people from all walks of life, especially sharing ideas with them. Exploring geospatial information technology and statistical data analysis fascinates me and I find my passion in that field too. I love nature, green environment because it brings me peace and I find myself lost in the beauty that the earth has to offer to each one of us. Not to forget, I love reading books of all genres, movies (especially animations and Hollywood series) and doing arts (random sketches).

## Karma Yangzom Dorji

Karma holds her bachelor's degree in civil engineering from Lovely Professional University, Punjab, India and Master of Science in Water Resources Engineering and Management, UNESCO Madanjeet Singh Centre for South Asian Water Management, University of Moratuwa, Colombo, Sri Lanka.

Karma's recent works includes Assessment of climate risks on water resources for Water Roadmap, National Adaptation Plan (NAP) formulation process in Bhutan, Assessment of climate risks on Vulnerability Assessment for National Adaptation Plan (NAP) formulation process in Bhutan, Preparation of Chapter on Vulnerability and Adaptation Assessment for Kingdom of Bhutan's Third National Communication report to UNFCCC, Preparation of National Waste Management Strategy and Thimphu Waste Management Plan, Preparation of a Blueprint Document for "Access to 24x7 safe Water supply", etc.

## Deki Choden

A young individual enthusiastic in water and climate change with an academic background with a Diploma in Civil Engineering. I have recently served in Bhutan Water Partnership as a Project Assistant for 15 months, as a main representative from BhWP in implementing the pilot project, "Pilot low-cost climate-smart agriculture technology to address water scarcity in rural Bhutan", and as a Programme Assistant for another 8 months, developing proposals and have managed to secure another project. Earlier, I served as a Site Engineer for more than 2 years at Jigmeling Industrial Park, Sarpang in Ministry of Economic Affair, Department of Industry, Industrial Infrastructure Development Division.

I have participated in the Water ChangeMakers Award 2020 writing the water journey based on the pilot project making it to Top 12 Finalists amongst more than 350 water journeys. I have also compiled a Bhutan Baseline Youth Report 2021 for Youth and Young Water Professionals Platform South Asia organized by Regional Water Partnership, Sri Lanka.

### Sneha Shahi

Sneha is a conservationist and the UNEP - Plastic Tide Turner Champion from India. She has worked with an incredible team by her side to restore streams in Vadodara, which are habitat of Crocodiles and Turtles. She aims to inspire positive actions towards social and environmental issues. She has worked with different UN bodies in India on water policies, waste management and climate change scenarios. She is currently pursuing her Doctoral Studies at ATREE, Bangalore. Her current work focuses on Social-Ecological Systems and setting observatories for the study in Tamil Nadu along the only perennial river of the state "Tamiraparani". Sneha loves to bring forward stories of grassroots conservationists and engage with community stakeholders at various levels, her aim is to make science more community oriented and accessible for all.

### Sangay Tamang

Dr Sangay Tamang is an assistant professor at the Department of Humanities and Social Sciences, Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand, India. He received his PhD degree from the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati. More broadly speaking, his research focuses on the intersection of the environment, development and ethnicity in the eastern Himalayas. He has published in journals such as Economic and Political Weekly, Sociological Bulletin, Indian Anthropologist, Himalaya, Ethnicities, European Bulletin of Himalayan Research and has written short commentaries and op-eds for online platforms such as The Third Pole, Raiot and Countercurrent etc.

### Rachana Mattur

Rachana Mattur is currently doing an internship as a Program Assistant to Water Women Project at Water Rising Institute. Rachana is an engineer turned social scientist as she has a master's in water management and governance with specialisation in Water Conflict Management along with a bachelor's in civil engineering. She is an active member of two youth organisations- Water Youth Network and Youth for the Rhine working towards inclusion of youth's voices in decision making. She is also passionate about gender

equality, transboundary water management, water-human interactions, and action-oriented climate solutions.

### Bhavya Jain

Bhavya Jain is an Indian architect from CEPT University, Ahmedabad and is interested in the socio-ecological dynamics of lived landscapes and the built environment. She observes architecture and its allied fields as ripples into the broader functioning natural (eco)systems and strives to work with the liabilities hidden in our building practices. She has worked on research and design projects ranging from landscape design to curation and focuses on possibilities of improving the practice of building through methods of critical inquiry and research.

### Utsab Phuyal

Utsab is a young water professional with a civil engineering background. He graduated from the University of Moratuwa with a master's degree in water resources engineering and management. His research interest spans catchment water modeling, climate change studies, and hydrologic and hydraulic modeling. His thesis was focused on modeling streamflow variability using satellite soil moisture in different climatic zones of Sri Lanka. Furthermore, Utsab is one of the founding members of the International Water Association (IWA) Young Water Professional (YWP) Nepal Chapter. He is currently a lecturer at Acme Engineering College engaged in modules related to water resources.

### Ranju Ghimire

Ranju Ghimire is from Bharatpur, Chitwan and a graduate student of Aquatic Resource Management in Agriculture and Forestry University of Rampur.

### Lasata Joshi

Lasata has a master's degree in Sustainable Development from Kathmandu University after completing bachelor's degree in biotechnology from the same university. She has worked as a Product Manager for a fintech company that strived to provide access to affordable finances to grassroots entrepreneurs. She has worked as a researcher and conducted qualitative studies on topics like indigenous practices, environment, and disaster diplomacy. She is passionate to work toward sustainability and solving socioeconomic problems. Currently, in Policy Entrepreneurs Inc., she works closely with the office team and assists in research and program management.

### M Anique Azam

Anique is a PhD Scholar and researcher in unconventional water resources and decentralised potable water generation. His research includes finding new ways to extract water from the air, becoming a million-dollar market. He works his way to finding out new partnerships and securing patents and aims that his research on unconventional potable water resources will complement the conventional water resources research and in times of high demand and emergency, be a helpful addition. Having a major in Mechanical Engineering, he carries intuitive thinking of the water-energy nexus and the effects on climate for affordable drinking water. He is a strong advocate of youth leadership in water, chairs the country chapter of young water professionals in Pakistan, and eagerly looks for more collaborative actions in the technology-governance consortia.

### Dilisha Gunawardena

Dilisha Gunawardena is a graduate from the University of Colombo Sri Lanka with an honour's degree in Environmental Sciences. She also holds a degree in law from the University of London and is currently reading for her attorneys at the Sri Lanka Law College. Currently, she is working as a researcher for both the Women's Earth and Climate Action Network and the Centre for Environmental Law and Policy of the University of Colombo. Dilisha's passion and research interests lie in the areas of climate justice, human rights, disaster management and sustainable development. She also has a passion for community-based projects and has

worked closely with NGOs in developing community-based projects in Sri Lanka in the fields of solid waste management, climate change capacity building and domestic violence awareness.

### Sithara Kumarasinghe

Sithara Kumarasinghe has been working with the Lanka Rainwater Harvesting Forum since May 2022 as a project monitoring and evaluation officer. In 2021, she completed a BSc. Degree in Town and Country Planning from the University of Moratuwa in Sri Lanka. She is also a student member of the Institute of Town Planners in Sri Lanka and a freelance voice over talent. Sithara enjoys reading and researching about green infrastructure, green cities, sustainable planning solutions, disaster risk reduction, sustainable rainwater harvesting etc. In addition, she read Russian stories, and award-winning novels and is constantly striving to be the best version of myself.

# Facilitation Team

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