Integration of Spatial Technology and Mobile Application for Re-Imagining Urban Rivers Through Citizen Participation: A Case Study of River Hooghly

MRIGNAYANI CHANDRA
Student,
Amity University Uttar Pradesh, Noida

MADHURI KUMARI
Professor,
Amity University Uttar Pradesh, Noida

RAVINDER KUMAR TOMAR
Professor.
Amity University Uttar Pradesh, Noida

JYOTI VERMA
Senior Research Specialist,
National Institute of Urban Affairs, New Delhi

Abstract

Extensive use of our water resources has led to a decline in the water quality and volume of water in our rivers. Urbanization has been a major cause of several environmental problems and one of the most neglected aspects of nature are our rivers. To find an environment friendly sustainable approach to clean rivers, this study encourages nature-based solutions to improve the water quality of our rivers and the usage of solar powered boats and biofuels. This study further focuses on River Hooghly in the Howrah region of Kolkata and gives an idea of the river status by using the QGIS (Quantum Geographic Information System) and secondary data, which is subjected to heavy footfalls mainly due to daily religious activities, transportation, and tourism. Unlike the earlier eras where civilization started from rivers, now urban developments are moving further away from them.

There is a need to re-imagine our urban rivers and to develop the citizen and river connect. Remediation of rivers is kept low in the priority list. Hence, to promote citizen involvement in

mitigating pollution-based challenges for rivers, an app user interface (UI) is built by using Flutter Flow which promotes cleaning of rivers through an app-based approach. The app is further editable and extendable and shows how it can be used to make data accessible to citizens and encourages them to clean the river and its banks and contribute to nature.

Keywords: Nature-based, Flutter Flow, River, Citizen Participation

Introduction

Increase in the population of India has led to over exploitation of our water resources and degrading the status of rivers. The increasing demand for water has put a lot of pressure on our rivers as well as on other water resources. Many rivers have dried out due to over extraction of water as well as groundwater from nearby regions. The mitigation measures of floodplains and interference with the riverine ecosystem without understanding what the river demands, has had negative impacts on the environment.

Rivers are one of the most neglected natural resources and are low in the priority list for remediation. Several factors have led to the poor condition of our rivers. The perception of a river varies according to different people from different fields. A river system includes river sources, its tributaries, the riverbed, channels, floodplains, riverbanks, deltas, wetlands, and hydraulics of the river. If any component is affected, it affects the entire river.

There is an immediate need to cease sewage dumping and polluting our rivers and to act responsibly. The effort to look for a cost-effective, less labour-intensive alternative which affects the environment less is continuing.

There is a shift towards Nature-based Solutions with people increasingly trying to utilize nature to remediate the damage that has been done. Nature-based Solutions include bioremediation and phytoremediation. The use of solar energy for ferry services and biofuel is being tested and is highly encouraged. Citizen participation needs to be more focused as citizens are the main culprits in this sin of damaging the environment. Hence, we should look for more ways to involve citizens in mitigating the issues related to rivers.

This study focuses on promoting citizen engagement through an app that is dedicated specifically to rivers so that people know more about rivers and become sensitive towards polluting them. The status of River Hooghly has been analysed by using secondary data from the West Bengal Pollution Control Board (WBPCB) website to study the water quality and to better understand the river. Also, a framework has been proposed to utilize NbS and renewable energy to improve the water quality of the river along with engaging the people for the same.

Status of Indian Rivers

According to the Composite Water Management Index issued in June 2018, more than six hundred million people in India face severe water shortage. Around three-quarters of the country's households do not have access to safe drinking water.

India ranks 120 out of 122 countries in the water quality ranking, with roughly 70% of its water being contaminated. Every year, thousands of people flock to the Ganga's *ghats* (banks) to bathe and pray. This is why it is one of the world's most polluted rivers. It also has alarming quantities of pollutants and sewage waste dumped into it every day by over 1,100 industrial units and many municipalities that are located along its banks. According to a recent assessment by the Central Pollution Control Board, the water in River Ganga is unsafe for bathing, let alone drinking. The apex environmental monitoring agency, the National Green Tribunal (NGT), has ordered Jharkhand, West Bengal, and Bihar each to deposit Rs 25 lakhs for failing to take appropriate steps to reduce pollution in the River Ganga.

The Brahmaputra, a 2900-kilometre-long river that serves as Assam's lifeline, is currently suffering from water pollution that is caused by sewage waste and oil spills. Currently, it is lifeless due to rapid urbanization and lack of efficient infrastructure for trash disposal. According to a recent estimate, at least twenty-eight kilometres of the river in Assam is extremely contaminated. The Yamuna which was once the lifeblood of Delhi and one of India's most revered rivers, has now become one of the world's most polluted rivers. The Yamuna water is exceedingly dangerous to drink because of heavy metal discharges and excessive amounts of Coliform, a disease-causing bacterium.

River Cauvery, which rises in Karnataka before it flows into Tamil Nadu, is subject to intense coastal conflicts and is in a state of decline. Once stable, the river is now a sea of sand, dotted with rocks and bushes on a dry riverbed. Along the entire course of the river, the ecosystem has been destroyed by human activity. The riverbed is severely affected in several sections on both sides. Given the controversy between the two riverbanks, less attention has been paid to the various other creatures of the river. Fish, otters, birds, and butterflies are examples of wildlife that depend on the Kaveri River for food. Populations of fish species such as Masir have declined significantly due to the reduced river water flow. The decrease in flow rate has also led to an increase in pollution. People often bathe in the shallow waters of the Kaveri River but they may not be aware that the levels of faecal coliforms in the water are so high that it is not suitable for bathing.

The River Gomti and its marine life, formerly an important supply of water for the city of Lucknow, are now nearly extinct, due to high pH levels of the water. The state's biggest challenges are indiscriminate groundwater exploitation, sewage disposal, and municipal garbage dumping on the riverbanks. According to ecologists, the installation of diaphragm walls on the river's banks has harmed the river's natural flow and self-cleaning capabilities. The Musi Riverbank is now a dumping ground for many and is slowly disappearing due to severe drought. It has become one of the most polluted rivers in the country. Successive attempts by the government to cleanse the river have been unsuccessful.

River Remediation Practices in India

Plans to restore the spread of polluted rivers can be done by improving the river flow through intervention in basins/catchment areas for preservation and strengthening of stormwater. This concept works by reducing pollutants in the rivers and streams which in turn reduces concentrations to desirable levels. Evaluation of water quality which is provided by water

resources in the long-term gives information on the extent of rivers that do not meet the water quality standards and are identified as contaminated.

Evaluation studies conducted at the source of the river pollution have highlighted the need to build infrastructure facilities (STPs/CETPs/ETPs) for wastewater treatment according to the low flow rate or no flow rate of freshwater in the rivers and streams. The sewage stream makes it a perennial river. To increase the availability of water outside the monsoon for a complete upper-level watershed management requires four phases. These proposed stages of Basin Management are:

- Recognition phase
- Recovery phase
- Protection phase
- Improvement phase

The polluted river stretches throughout the country have been identified for restoration of water quality through identification of the pollution sources and interventions by treatment of municipal and industrial effluents. The river restoration action plans intend to control pollution and restore the river. The infrastructure development for sewage treatment of wastewater generation to improve the quality of water always falls short. The ever-increasing population and the increased use of water in urban areas outpaces the plan for its creation. Even though river action plans have not improved the water quality, in the absence of such plans, the quality of aquatic resources also deteriorates further.

The methodology for river restoration includes:

- Managing catchment areas
- Restoration of the course of river
- Reconnecting floodplains and creating wetlands
- Instream enhancement

Role of FlutterFlow and Application of QGIS for Conceptualizing and Building River Focused Application (App)

As technology has advanced, there is an exponential rise in screen time. Apps have replaced real life interactions. The idea is to turn this virtual curse into a boon by conceptualising an app to help our rivers. This app mainly focuses on democratizing real time data of the river's parameters, incentivising citizens to engage in activities related to improving the condition of rivers, organising events and involving maximum number of people, and lastly, promoting greener alternatives for the river transport network. The app can be designed by using FlutterFlow where it shows how we can build a prototype of the app which can be used for reimagining our rivers.

FlutterFlow is an interface to build an app by using a browser which facilitates a drag and drop feature. It is a faster and easier way to build apps in an effortless way. It is a visual builder that helps to choose the elements from its list and drag and drop them in the desired location on the page. It enables us to easily and smoothly integrate data and API. FlutterFlow has a multi-language app

building facility as well. One can build custom widgets and include customised functions. After all this is done, we can download our code and deploy it in app stores. In this study it has been used to build the app with the purpose of promoting citizen participation.

QGIS is a free open-source graphic information system application for PC that is used for visualizing, editing, printing, and analysing geospatial data. It is also used to export and compose graphical maps. It supports raster, vector, and mesh layers. The point, line, and polygon features are stored as vector layers, and the aerial photographs and satellite images are stored as raster data. In this study QGIS is used for visualizing the study area and understanding its geographical details. Through this platform the app can be used to introduce a new mode of interaction between the citizens and the river which will benefit the environment thus giving a scope to improve the lost connect between the people and the river.

Statement of the Problem

River Hooghly is a major source of potable water in Kolkata. There are several ghats along the banks of river Hooghly which are being used for various purposes such as transportation, religious practices, and tourism. Some are very well managed and well developed but do not address the issue of river pollution. The river is used for procuring potable water while people use it for transportation. It is subjected to contaminants from burning fuel as the river is used extensively for ferry services. The water quality of the river is getting degraded not only due to the contaminants from fuel but also from the tourists who pollute the river and its banks. There is a need for an environment friendly solution to this problem.

The lack of citizen and river connect has also led to an increase in pollution of the river. All this is putting a lot of pressure on the treatment plants and affecting the lives of aquatic species. The BOD of some stretches is so high that it almost makes it impossible for fishes to survive. Most parts of the river are also unsuitable for bathing. It is also noticed that the Dakhineshwar stretch of the river experiences a footfall of over fifty thousand people daily. Hence, it has become imperative to reconnect the people to the river and encourage their contribution towards cleaning it.

Objectives of the Study

The first objective of the project is to quantify the pollution in River Hooghly and propose a framework for improving the water quality and cleaning its banks. The intention is to explore the possibility of employing selected Nature-based methods to minimize the environmental impacts of the remediation process. Bioremediation and phytoremediation are two Nature-based Solutions to the problems that are associated with the polluted river.

The second objective is to carry out feasibility studies of biofuel powered boats and ferry services, and the use of solar powered boats. This will help in energy conservation and decrease the pollutants of fuel in the river. Shifting towards Nature-based sources of energy will help to reduce the environmental deterioration and promote the usage of green energy.

The third objective is to develop spatial technology supported by app-based solutions to monitor, report, and clean plastics and develop the polluted area. The app will help in mobilizing volunteers

in location-based groups who can come together to clean the area. This will help in encouraging public involvement and controlling pollution of the river banks and the surrounding areas.

Scope of the Study

This study will cover all the steps that are involved in designing a UI for the app. The study will be extended to understand the status of the river. In that context, a comparison between the years of 2020 and 2021 has been done to understand the extent of the pollution. QGIS is used to visualize the study area. Further, it gives a framework for utilizing Nature-based Solutions for the remediation of River Hooghly. The scope of solar powered and biofuel powered boats have also been studied to promote a green initiative.

Study Area

The Farakka Feeder Canal, rather than the river's natural source at Giria, provides most of the water that flows into the River Hooghly. The Farakka Barrage is a dam that redirects water from the River Ganges into the Farakka Feeder Canal near Tildanga in Murshidabad district, forty kilometres upstream from Giria. It forms the border between Bardhhaman and Nadia districts South of Baharampur and North of Palashi, but while the border has remained the same, the river is now frequently East or West of its former bed.

The river continues South, passing through Katwa, Nabadwip, Kalna, and Jirat. It originally formed the border between Nadia and Hooghly districts in Kalna, and then between Hooghly district and the North 24 Parganas district further South. It runs through the towns of Halisahar, Chinsurah, Naihati, Bhatpara, Serampore, and Kamarhati.

The study area covers the Dakhineshwar stretch of River Hooghly where religious events take place, till Babughat which is used for ferry services. The case study area taken is a 15 km stretch of the river. The bank is digitized using QGIS.

Figure 1: Digitised Map, Dakhineshwar Stretch of River Hooghly
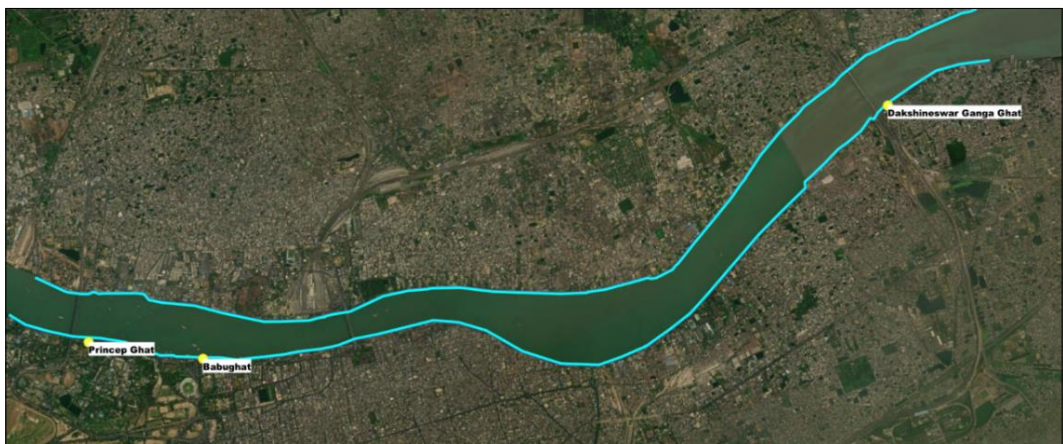

Source: Google Earth Image

River Hooghly – The Lifeline of Bengal

The Bhagirathi-Hooghly River is a life saver for individuals of West Bengal. It was through this waterway that the East India Company cruised into Bengal and laid out their exchange settlement, Calcutta, the capital of British India. Individuals from different nations like the French, Dutch, Portuguese, and so forth undeniably had their exchange settlements by the banks of this waterway.

The water is a perpetual inventory of the plains of West Bengal for its water system and human and industry utilization. The waterway is traversable and a significant vehicle framework in the district with an enormous traffic stream. From here onward, indefinitely for quite a while, the Calcutta Port was the greatest port of India. Albeit in the past its importance had gone down, of late it is at third position in the rundown of Indian Ports. The innovative compartment port of Haldia, on the crossing point of lower Hooghly and Haldi rivers, presently conveys a significant part of the district's oceanic exchange.

Though contaminated, the fish from the waterway are a means for the neighbourhood economy. The Hooghly waterway valley was the main modern territory of Bengal. Due to the declining jute industry, which was once a well-established business of this district however, is yet one of the greatest modern areas of India. It has a number of little urban communities which frame the Greater Kolkata agglomeration, the second greatest Indian city and the previous capital of the country. In September 2015, the Government of West Bengal declared that redesigning of the Hooghly riverfront in Kolkata will be completed with the assistance of the World Bank subsidizing under the National Ganga River Basin Project Scheme.

Figure 2: Hooghly River Water Quality Measurement at Millenium Park, Howrah
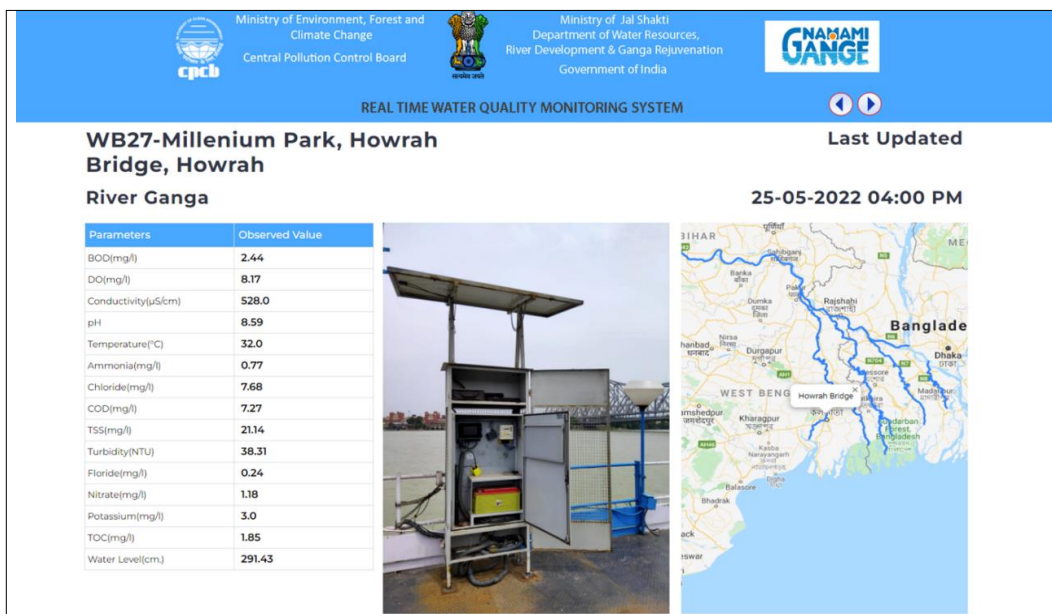
Source: Department of Water Resources, Ministry of Jal Shakti, Government of India

Figure 3: Methodology of the Study
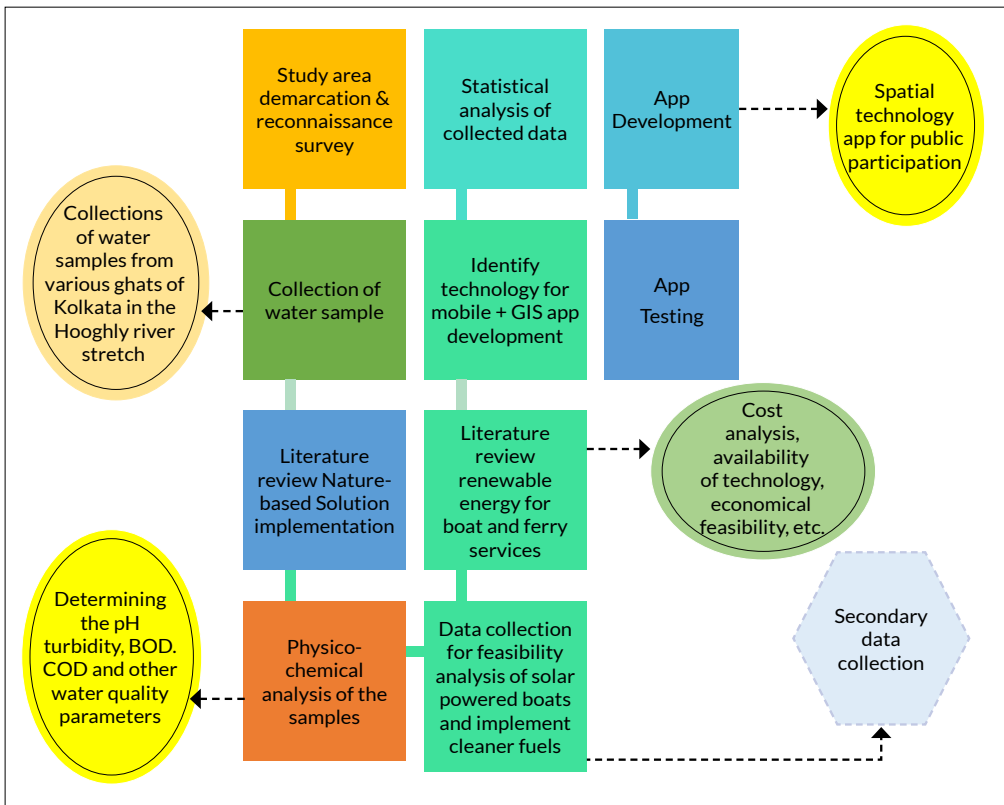
A survey of the Dakhineshwar stretch of the river was explored and observed to understand the study area, for an assumption regarding the pollution status of the river as well as the banks.

A thorough literature review was done to understand the current status of the rivers in India. Through the literature review it was evident that pollution has been degrading our nature and environment. Indian rivers are in a tragic state due to several anthropogenic activities and climate changes. Intervention is required to cease such activities that are ruining the water quality and affecting the survival of aquatic species in our rivers. The literature gives us an idea of the effectiveness of NbS and the possibility and feasibility of NbS in our country. It gives us a glimpse of how we can contribute towards our environment by using greener fuels and renewable sources of energy for ferry services.

Water quality assessment was done using secondary data that was obtained from WBPCB site

and the status of the river was assessed. Water quality parameters included TSS (Total Suspended Solids), TDS (Total Dissolved Solids), turbidity, pH level, E. coli, Faecal coliform, etc.

The platform to build a UI for the mobile app was decided and FlutterFlow was used for designing the User Interface of the app. The UI was developed and the framework was built. The platform enables us to edit, and it is further extendable to be developed into a fully functional app using FlutterFlow.

Data related to the water quality parameters was collected from WBPCB (West Bengal Pollution Control Board). The data was collected from their monitoring stations that are located in the Dakhineshwar region.

Figure 4: Demarcation of the Case Study Area Using QGIS Software
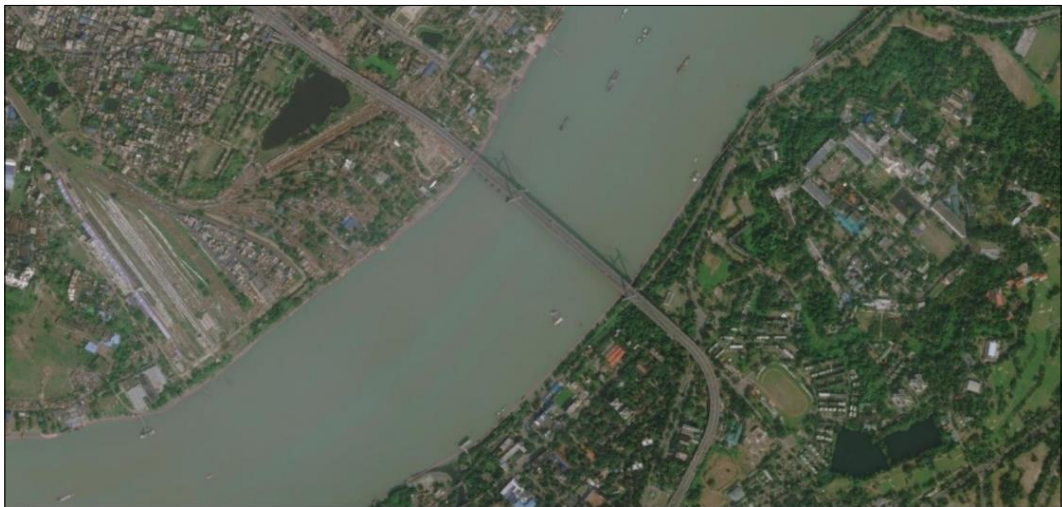
Source: Google Earth Maps

To get the ESRI (Environmental Systems Research Institute) map, the ESRI Satellite option needs to be selected after clicking on search from the quick map services under the Web menu. The plugin for QSM (Quality Systems Management) needs to be installed to access it. After the map is added, the desired location can be searched in the map. To digitize the study area, the edit mode has to be turned on and using the add line feature one can digitize the bank line and mark the stretch of the river. To add locations for ghats, Google My Maps was used, and the layer was exported in QGIS.

Building User Interface (UI) for the Application (App)
The app UI was built using FlutterFlow. You see the Project Dashboard when you sign into FlutterFlow. The Dashboard page assists you in dealing with your undertakings in FlutterFlow. You can make, copy, or erase your undertakings from this page. The page has connections to

different assets that assist you in building applications through FlutterFlow. Your record data and plan subtleties are additionally available from this page.

The point when you are inside any undertaking, this page can be reached by utilizing the home symbol on the navigation menu.

The Widget Panel gives admittance to all the UI components on FlutterFlow. Fundamentally, these are Flutter gadgets that can be relocated on the material. The pursuit bar is convenient to rapidly look for a particular gadget that you need to add to your application.

Widgets (elements) are accessible from the Widgets tab. They are sorted into five categories:
- Most Frequently Used Elements
- Layout Elements
- Base Elements
- Page Elements
- Form Elements

One can use custom UI components in their FlutterFlow project. These custom components are accessible from the Components tab. A new project on FlutterFlow comes with more than 50 pre-built components including sign-in buttons and some other styled layouts. For a new custom component, you can create a custom components section.

The components are also sorted into five categories:
- UI Elements
- Bottom Sheets
- Headers
- Card Views
- Content Views

Figure 5: Project Interface on FlutterFlow
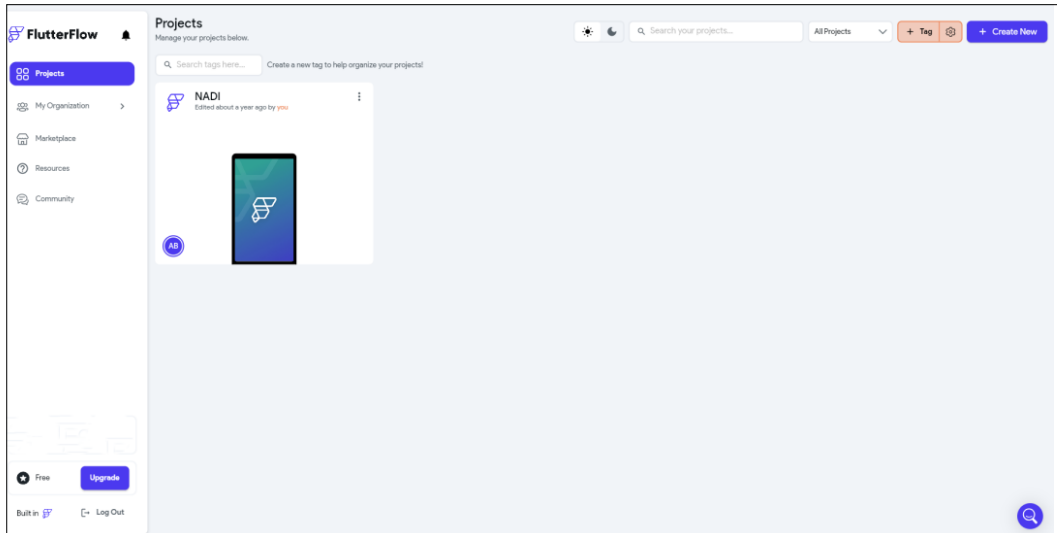
Firebase is a versatile application stage which has coordinated and brought together client libraries in different portable programming dialects. Firebase's different Backend-as-a-Service (BaaS) assists in growing great applications, developing a client base, and bringing in more cash. Each element works freely, but they work far better together. To utilize the Fire store's portable/web client libraries and other Firebase highlights, we need to add Firebase to our current Google project. Hence, Firebase is added to the project.

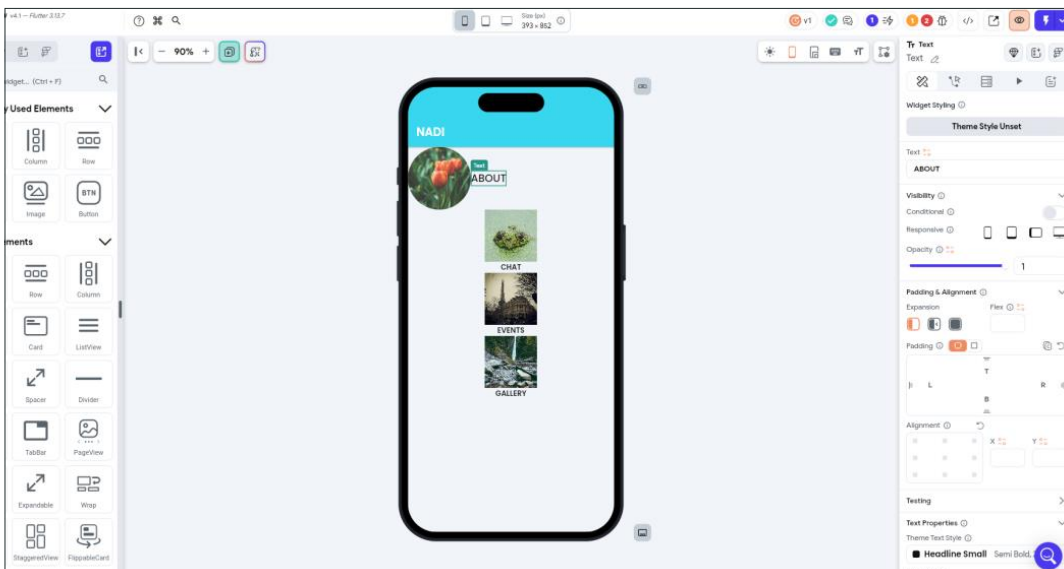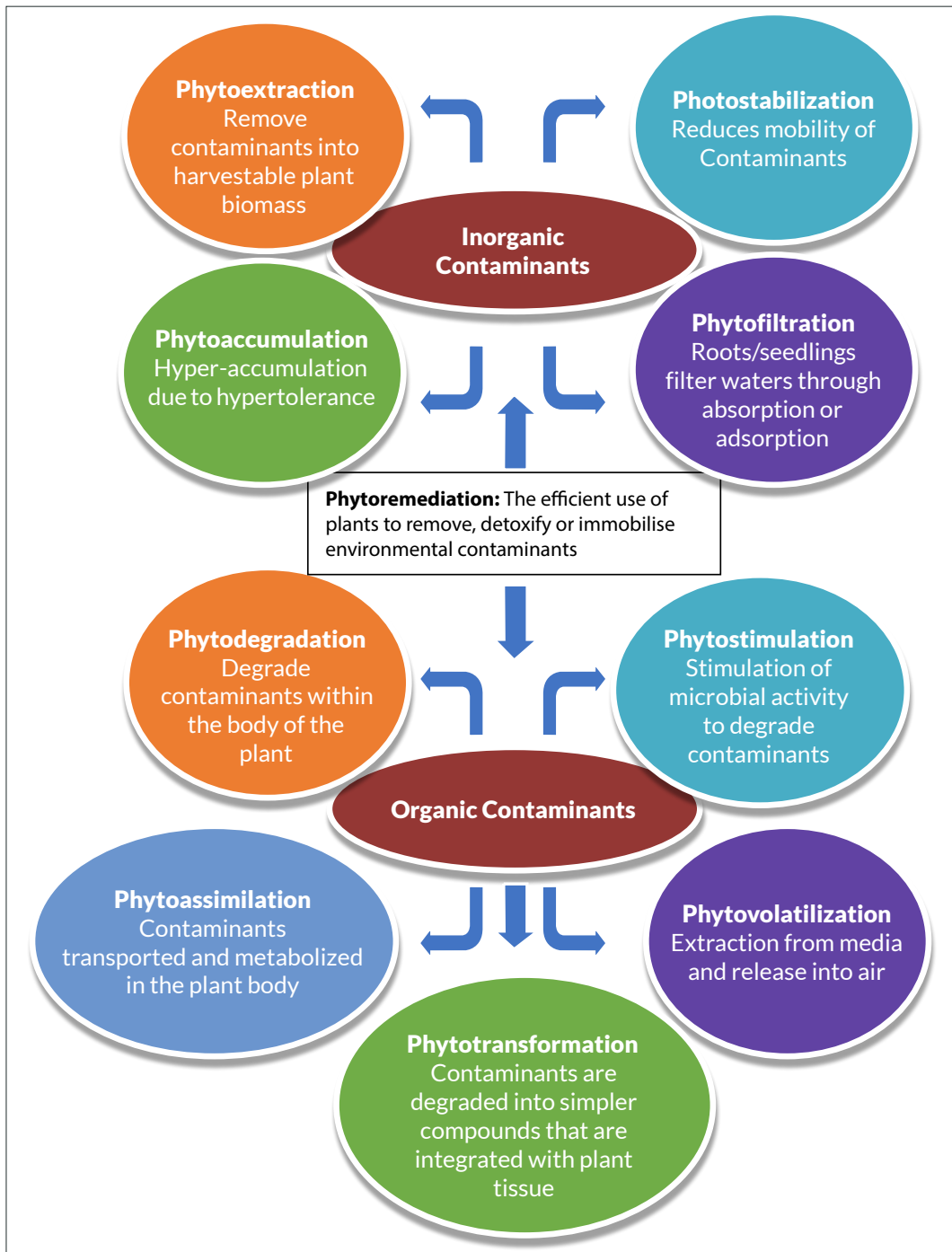**Figure 6: Application Interface on FlutterFlow**

Figure 7: Nature-based Solution

Phytoextraction
Remove contaminants into harvestable plant biomass

Photostabilization
Reduces mobility of Contaminants

Inorganic Contaminants

Phytoaccumulation
Hyper-accumulation due to hypertolerance

Phytofiltration
Roots/seedlings filter waters through absorption or adsorption

Phytoremediation: The efficient use of plants to remove, detoxify or immobilise environmental contaminants

Phytodegradation
Degrade contaminants within the body of the plant

Phytostimulation
Stimulation of microbial activity to degrade contaminants

Organic Contaminants

Phytoassimilation
Contaminants transported and metabolized in the plant body

Phytovolatilization
Extraction from media and release into air

Phytotransformation
Contaminants are degraded into simpler compounds that are integrated with plant tissue

Nature-based Solutions

Phytoremediation: A Plant Based Eco-Accommodating Innovation

United Nations Environment Program (UNEP) characterized phytoremediation as "the productive utilization of plants to eliminate, detoxify, or immobilize natural foreign substances" (UNEP, 2019). Phytoremediation is an eco-accommodating and worthwhile strategy for cleaning defiled media. The components include retention of poisons through roots, gathering body tissues, and decaying and changing contaminations to less hurtful structures. This procedure is utilized effectively in tidying up water pollution, and has acquired genuine consideration by researchers, government and non-government bodies.

Nonetheless, use of plants in the treatment of wastewater began quite a while back (Carolin et al., 2017). Diverse types of sea-growing plants have been confirmed and perceived for their effectiveness to aggregate inorganic and natural pollutants from the waters through aquaculture or field applications. Likewise, the progress of a phytoremediation framework relies upon factors that are related to the seriousness of the contamination.

Besides, different phytotechnologies like phytodegradation, Phytostabilization, rhizofiltration, rhizodegradation, and phytovolatilization have been used for polluted biological systems. Further, the underlying foundations of specific plant species gather, adsorb, and encourage toxins in the dirt and water through the immobilization process. Plants have extraordinary capacity to consume and volatilize foreign substances straight into the environment through the phytovolatilization process. The plants utilize the impurities by certain mixtures that are delivered inside the plant tissues through phytotransformation/phytodegradation process.

Table 1: Oceanic Macrophytes in the Phytoremediation of Natural Poisons

| S. No	Plant Name	Response to contaminants	Reference
1	Lemna minor L	Reduced enzymatic activity, photosynthetic efficiency, chlorophyll, roots and shoots growth	Radic et al. (2010) Razinger (2008)
2	Eichhornia crassipes	Reduced growth, chlorosis, wilting, decreased plant height and root length, death of the plant	Theeta et al. (2018)
3	Pistia stratiotes L	Reduction in the root volume,chlorosis, cell membrane damage, reduction in growth rate, photosynthesis, increase in enzyme activity specially such as superoxide dismutase (SOD), catalase (CAT), peroxidase (POX) and ascorbate peroxidase (APX)	Vidal et al.(2019), Theeta et al.(2018)
4	Ipomonea aquatica	Increase in root size and decrease in root length	Jung-Chun et al.(2010)
5	Isoetestaiwanensis	Inhibition of root and shoot growth	Li et al.(2005)
6	Echinodorus amazonicus	Reduced growth, plant height and root length decreased, chlorosis	Theeta et al.(2018)

Source: Ansari, Abid Ali, M. Naeem, Sarvajeet Singh Gill, Fahad M. AlZuaibr (2020). Phytoremediation of contaminated waters: An eco-friendly technology based on aquatic macrophytes application, Egyptian Journal of Aquatic Research, Volume 46, Issue 4, Pages 371-376.

Free drifting macrophytes viz. Salvinia, Lemna, Eichhornia, and Pistia showed their phytoremediation. The HMs like Cd, Zn, Pb, Mn, Ni, and Co up to a scope of 100-1000 times are gathered by the hyper aggregators when contrasted with non-gathering plants. The bioavailable part of metal particles is expanded by the activation components. For example, microorganism growths and microscopic organisms exist in close relationship with the roots of for example rhizosphere and assume a critical part in disposing of the natural pollutants (Erdei et al., 2005).

Oceanic macrophytes in water bodies adjust the physio-synthetic climate of the body. The presence of other oceanic photosynthetic autotrophs cut down the degree of disintegrated CO_2 in water during high photosynthetic movement. These increments disintegrate oxygen in wastewater which causes expanded water pH levels.

E Crassipes or Water Hyacinth as Phytoremediator

The system of Planted Floating Beds can be made by two thick bamboo tubes (TBT). One TBT should have poked holes and the plant is relocated in the upper openings. The other TBT is utilized to fix TBT with openings and make a drifting. Two TBTs are fixed together, and the net is pulled up. It is critical to note that the temperature of the nursery should be within 10 to 20°C as done for River Guxin.

Figure 8: Water Hyacinth as Phytoremediator
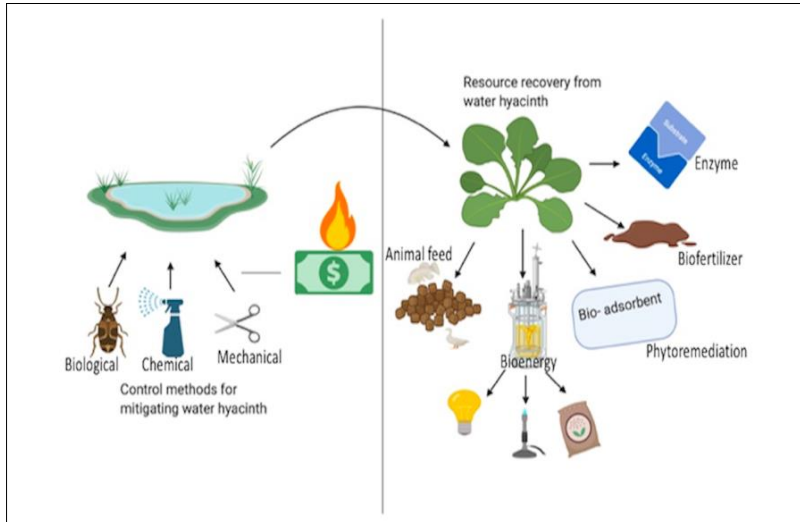
Planned Planted Floating Beds give a good climate to the plant. Eichhornia crassipes grow well in summer. The outcomes (Wang et al. 2011) showed that NH3-N, COD, TP of the study stream decreased 48.6%, 20.0%, 63.3% individually. The commercial development of Eichhornia crassipes decreases the turbidity by adsorbing a mass of residue from the stream and work on the look and feel of the water body. Therefore, Phytoremediation is a successful method for eliminating natural matter from the contaminated waterway.

Solar Powered Boats and Promoting Green Initiatives

A solar boat configuration process is unique as compared to an ordinary boat. It begins with characterizing useful and execution needs. Typically, such useful and execution determinations are made to match the customary boats. Solar powered boats are successful as traveller boats where the impetus power required is less (not normal for high velocity boats, pulls, fishing vessels, freight vessels).

A productive solar boat requires two unique yet basic features:
- Decrease in propulsion power
- Improvement in the energy of executives

Economic Analysis: Huge solar ships are multiple times costlier than a customary single structure steel ship. If one raises the ergonomics and security guidelines of the regular boats to that of solar ships the proportion is nearly three to one.

The consumable expense (fuel) is approximately Rs 3 million for a huge customary ship as compared to zero for solar ships. Diesel motors and steel frame structures have higher support in comparison to electric engines and FRP bodies. The all-out working expenses of an ordinary ship are approximately Rs 3.5 million each year.

A contextual analysis of 75 Pax Solar Boat from a case study shows that to move 75 travellers across a 2km backwater stretch of Kerala at 5.5 knots speed in a solar ship worked under class. The energy stockpiling size has to be intended for the radiant condition to decrease the expense (diminish the size of the battery bank). For opening the seating of 75 travellers and 3 groups, a sailboat with a deck area of 15m length and 5.5 knots expansiveness is adequate. After numerous emphases, it was found that around 20 kW solar charger power is expected to give energy to the executives. For this reason, the boat size was characterized to 20m length and 7m breadth.

After different emphases, the heaviness of the boat in completely still air was 23 T. A sailboat structure which was chosen gave the best presentation with minimal opposition. This determination of structure depended on improvement of the utilizing computational liquid elements (CFD). This frame needed around 16 kW to drive at 5.5 knots and around 22 kW for a brief period prompting normal 18 kW utilization. Two engines of 20 kW power were chosen that guaranteed 100 percent overt repetitiveness. At full power, the boat will journey at 7.5 knots.

Figure 9: Criteria for Useful Solar Ships
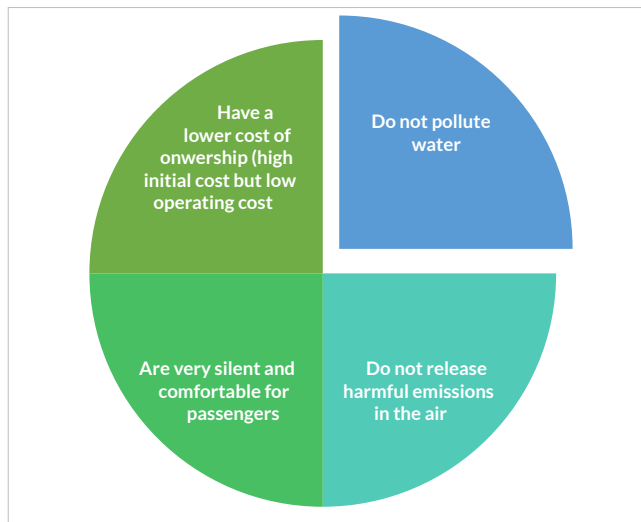
The typical solar energy creation from 1 kW of the sun-powered charger is 4 kWh of energy each day considering the framework effectiveness and standard sun of the area of 5.72 (found the middle value of consistently). Thus, the energy from the sunlight-based chargers is 80 kWh. The absolute energy needed to work the ship for 5.5 hours is 110 kWh. A 50-kWh battery bank of lithium iron magnesium phosphate is chosen for simplicity of game plan and to give energy support. The hole in the energy is given by the lithium battery that can give up to 40 kWh (80% release) from the complete limit of 50 kWh.

An ordinary 75 traveller ship that must be worked with comparable ergonomics and well-being guidelines under order of society endorsement would cost approximately Rs 18,00,000, with a twin 50 HP fundamental motor and utilization of 12 litres diesel each hour overall, and a sum of

120 litres each day (motors running constantly). The current cost of diesel (Rs 90 per litre) adds up to Rs 900 each day and Rs 3,30,000 each year (350 days running). The diesel cost is expected to consistently increase by 5%. The greasing-up oil can be taken as 10% of fuel cost, which is Rs 33,000 consistently. Support cost for motors is another 5% which is approximately Rs 17,000 each year. Complete working expense each year will be about Rs 4,00,000 (barring work and different costs that are same in both). These are supposed to develop 5% every year. For sun-powered ships, a working expense that comes at regular intervals is the substitution of battery banks of 50 kWh. This can be taken as Rs 35 lakh. An everyday network charging of 40 units (kWh) at the expense of Rs 480 (@11/unit of business power) and a sum of Rs 1,60,000 annually which is expected to develop at 5% each year.

Solar powered boats have higher forthright expenses, but the all-out cost of possession is lower. This boat has an earn back of the original investment time of only three years. Additionally, the boats are intended for a long time, consequently the investment funds will gather. The complete reserve funds in a boat in its 20 years lifetime is Rs 93,50,000. Hence, a similar kind of green solution can be considered for Kolkata's ferry services that could save a major portion of contaminants from ending in the rivers and save money for fuel and promote the usage of green energy.

Current Situation of River Hooghly

Comparison has been shown based on the secondary data that was obtained from WBPCB.

Figure 10: Water Quality Parameter Data Comparison - 2020 (in blue) and 2021 (in green)

BOD

E-coli

Fecal Coliform

Total Coliform

Dissolved O2(DO)

pH
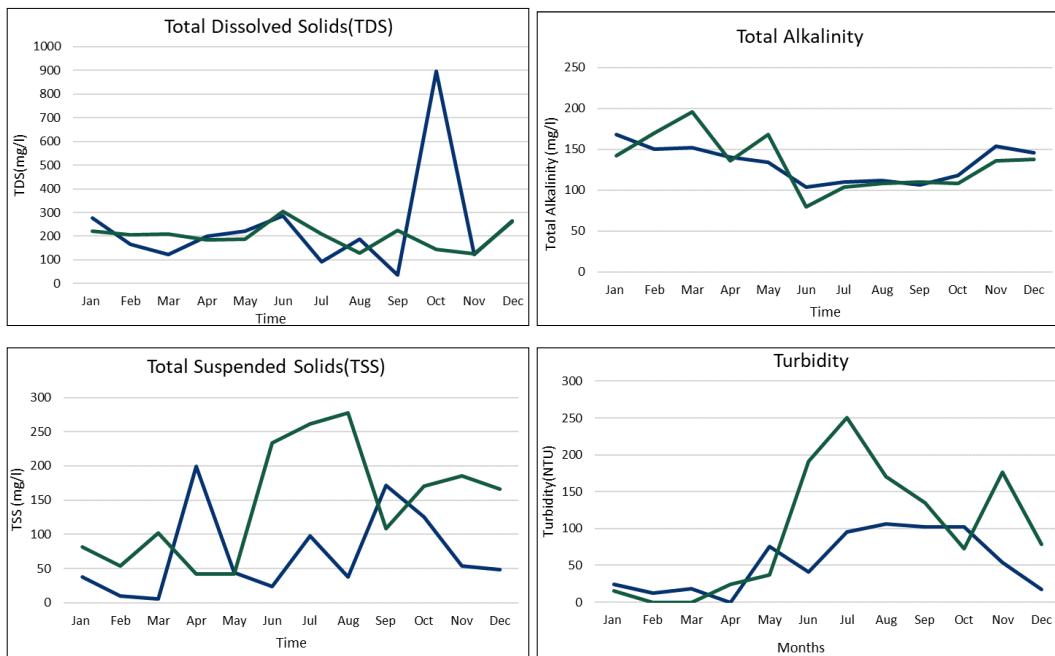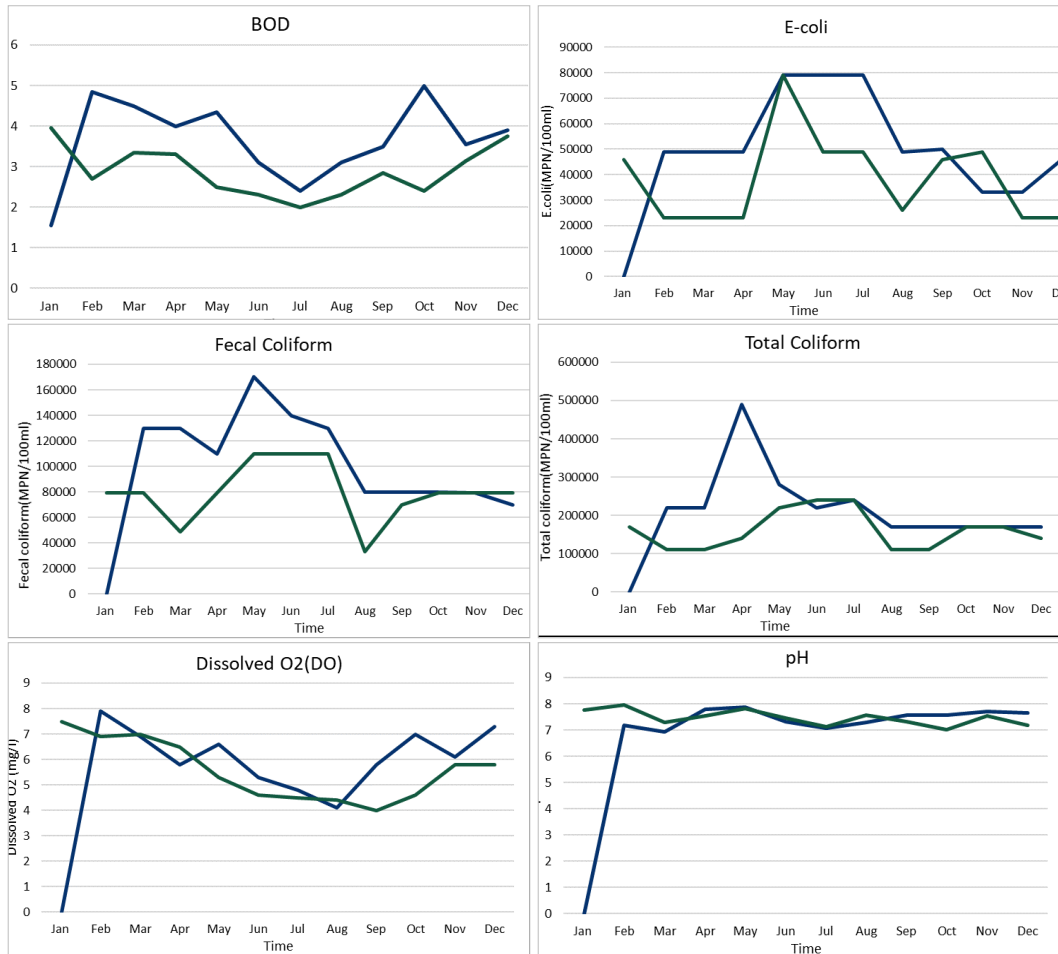
Source: WBPCB

The water quality parameters compared in this study are Total Fixed Solids (TFS), Total Alkalinity, Total Suspended Solids (TSS), Turbidity, BOD (Biochemical Oxygen Demand), E-coli, Faecal Coliform, Total Dissolved Solids (TDS), pH, Total Coliform, Dissolved Oxygen (DO).

Absolute solids are disintegrated solids in addition to the suspended and settleable solids in water. In stream water, disintegrated solids comprise of calcium, chlorides, nitrates, phosphorus, iron, sulphur, and other particles that go through a channel with pores of around 2 microns (0.002 cm) in size. Suspended solids incorporate the residual and earth particles, tiny fish, green growth, fine natural garbage, and other particulate matter.

A high centralization of all solids makes drinking water unpalatable and unfavourably affects individuals who are not used to drinking such water. Additionally, complete solids influence the water clearness. Water warms up more quickly and holds more intensity which unfavourably influences the oceanic life that has adjusted to a lower temperature system.

Turbidity alludes to how clear the water is. The significant presence of turbidity in the vast water zone of most lakes is normally phytoplankton, however nearer to the shore, particulates may likewise be muds and residues from coastline disintegration, resuspended base silt, and natural garbage from streams or potentially wastewater releases. Digging tasks, channelization, expanded stream rates, floods, or even too many bases taking care of fish (like carp) may work up base dregs and increase the darkness of water.

Fine particulate material can stop or harm the delicate gill structures, decline their protection from illness, forestall appropriate eggs and larvae, and possibly slow down the molecules that take care of movements. Similarly, decreased photosynthesis brings about lower daytime oxygen into the water. To sum up, the impacts on phytoplankton development are perplexing as they rely upon an excessive number of elements. In general, extremely elevated degrees of turbidity diminishes water clearness. Running water, because of its beating, breaks down more oxygen than still water, like in a repository behind a dam.

Wastewater from sewage treatment plants contains natural materials that are decayed by microorganisms which use oxygen simultaneously. Oxygen consumed by these life forms in separating the waste is known as biochemical oxygen demand or BOD. Other wellsprings of oxygen-polishing squander incorporate stormwater overflow from farmlands or metropolitan roads, feedlots, and bombing septic frameworks. Oxygen is estimated in its disintegrated structure as broken up oxygen or dissolved oxygen (DO). Assuming that more oxygen is consumed than is created, broken up oxygen levels decline, and a few delicate creatures move away, debilitate, or die.

DO levels change occasionally in a 24-hour time span. They differ with water temperature and elevation. Chilly water holds more oxygen than warm water and water holds less oxygen at higher heights. Generally, amphibian creatures are helpless against decreased DO levels in the early morning on warm midyear days when streams are low, water temperatures are high, and oceanic plants have not delivered oxygen since dusk.

Coliform microbes are available in the climate and dung of all warm-blooded creatures and people. Coliform microbes do not cause ailments. Most microbes that can taint water supplies come from defecation of people or creatures. Testing drinking water for all potential microorganisms is intricate, tedious, and costly. It is simple and reasonable to test for coliform microscopic organisms. Waste coliform microbes are a subgroup of aggregate coliform microbes. If infection causing microbes are present, the most well-known side effects are gastrointestinal diseases and general influenza like side effects such as fevers, stomach issues, and looseness of bowels.

The presence of algal growth prompts expansion in pH levels and oxygen fixation. Expansion in both boundaries demonstrate impediments to waste coliforms (Davies-Colley et al., 1999, Awuah et al., 2001). It is assumed that within sight of light, poisonous types of oxygen atoms are created (peroxides and singlet oxygen). The centralization of these atoms increases with expanded broken up or dissolved oxygen (DO) focus. They harm the cytoplasmic layer of the microbes (Awuah, 2006). Waste coliform increments are harmful with changes in pH levels. Research studies have shown that algal poisons assume a part in the inactivation of waste coliforms.

## Conceptualization of 'NADI – The River Dedicated Application'

NADI is an app which has been conceptualised for involving the people of the city in mitigating issues related to our rivers. It will not only promote the issues but also help in including people in resolving those issues and make them a part of improving the condition of our rivers. The app facilitates engagement of users and enables them to participate in mitigation measures and help the government to address the river issues.

Wireframe

A wireframe is like a field blueprint within the style process. It is a point of reference for practical specifications and offers the merchandise team a basis to start making screens. The wireframing step should not be skipped as the design prioritizes the user's visual experience. An honest computer program is functional, dependable, and comfortable to use. Designers use user-centric designs (user interviews, direct observations, etc.) concerning their target audience and make sure that the visual language they introduce within the UI is well-tailored to suit them.

It is necessary to create an aesthetically pleasing UI because interfaces that have nice aesthetics are perceived usable by end-users as they are in step with the aesthetic–usability effect. Since users are fastidious where apps are concerned, they use them and then abandon those that they do not enjoy. Thus, it is essential to spend time and energy in making excellent user experiences. The higher the design, the better the prospects that users will interact with it and therefore keep using it.

- **Visualize the structure clearly**: A wireframe is the first real method of a project. It turns abstract ideas into something tangible while not distracting.
- **Clarify the options of interface:** A wireframe provides a transparent communication to the user on how these options will function, where they will be on the particular page, and how they will function.
- **Facilitate to refine navigation:** A website wireframe allows individuals to check run a new site: to visualize how straightforward or tough it is to find the target pages; to see whether the dropdown menus clarify or confuse the users; to search whether the breadcrumbs are useful or distracting; to know whether the direction theme is intuitive, incomprehensible, or somewhere in between.
- **Build the iterative planning method:** Rather than attempting to mix the functionality/layout and creative/branding aspects of the website in one step, wireframes ensure that these components are taken one at a time.
- **Save time and effort:** Wireframing saves time in several ways. The styles are calculated; the development team understands what they have to construct with the blueprint in mind. Content creation becomes much clearer.
- **Build effective content development:** Wireframes offer a summary of the contents. It helps in organizing fonts, numbered lists, bullets, and heads that show neatness and are aesthetically inclined.

Figure 11: User Interface (UI) of the 'NADI– The River Dedicated Application'
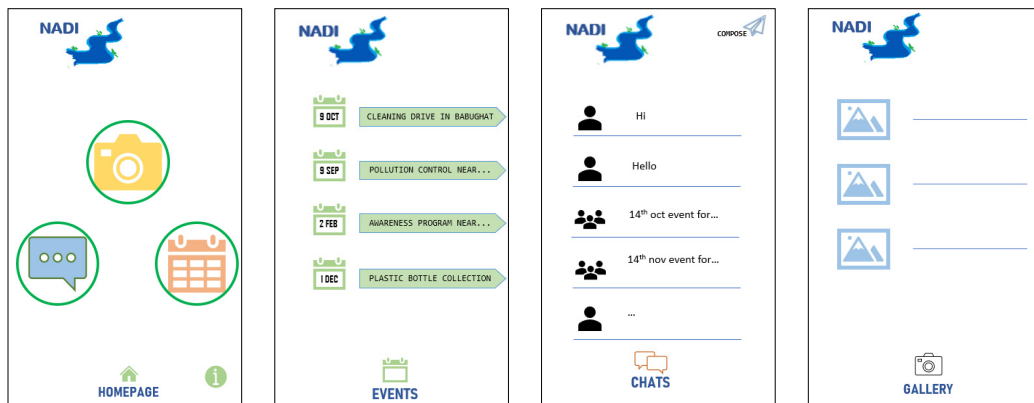

Building Application's User Interface (UI) using FlutterFlow

The app UI is designed in a way where citizens will be able to access information on current assessment of pollution, and they can even plan for events from the events page. Through this app, the pollution status of the river can be checked with the public contributing to the gallery of the app. A person can upload photos along with the location of the place that requires a clean-up and people can volunteer and plan to clean the area. The app can also be used to tie up with any non-governmental organisation (NGO) and make it even more effective in preventing river pollution. The UI features a homepage from where other pages can be accessed, which is followed by the About page, Events page, Gallery page, and Chat page.

The homepage is built in such a way that the purpose is understandable, easy, and simple to use. If the Pollution Status page is clicked, the About page opens to up-to-date status of the river which shows the current river water quality data, where it shows that the river quality is fit for bathing or not and similarly for other activities. The About page reveals the motive behind the app and lets the user understand how and why it is necessary to promote river sensitive developmental strategies for a better future. Pictures can be uploaded which help WBPCB to gather data on the polluted river stretches and banks and helps them to remediate as soon as possible and quantify pollution.

Next is the Events page where different types of events can be planned and accordingly the citizens can arrange for cleaning drives to contribute towards maintaining effective cleanliness in keeping our rivers clean. The solar-powered ferry service page enables users to book tickets and earn rewards. It also shows the details of carbon footprints and the fare chart.

Figure 12: UI Options on the 'NADI– The River Dedicated Application'
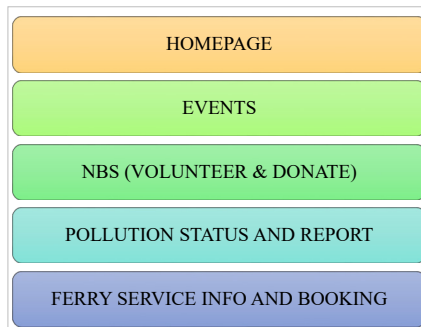
The final page is the NbS page, where the users can choose their desired solution to be applied and donate for their desired NbS. The following screens are found in the app:

Figure 13: Different Pages on the UI of 'NADI – The River Dedicated Application'
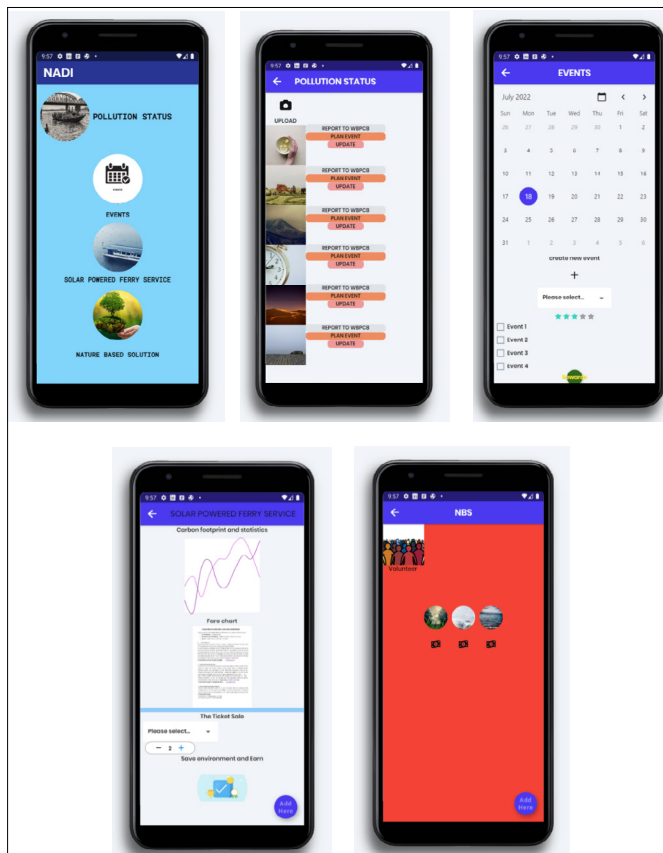
Discussion

The constant increasing pressure on our natural resources is resulting in increased natural disasters. We must all be more cautious and sensitive towards nature. While thinking of remediation and mitigation of resources, rivers are way down the list. River issues should be prioritized as rivers are the life-line of a city. They provide us with one of the most essential elements on Earth and that is water. The river waters and banks have been severely polluted and according to secondary data there is an unhealthy amount of faecal coliform bacteria which suggests disposal of sewage in the river.

Other than that, the BOD is also above the normal range. Essentially, we need to focus on Nature-based Solutions so that while undergoing remediation there is minimal impact on the environment. To bridge the gap between rivers and people or citizens, the app will help in organizing events for cleaning the river and involving people so that everyone can contribute towards improving the water quality and rebuilding the citizen river connect.

As seen in the graphs (Figure 10), the level of total dissolved solids rises during the month of October at the time of the Durga Puja festival. Idol immersion in the river is a potential cause of increase in dissolved solids. Wastewater discharges and wastes from religious events lead to an increased turbidity in the river which is more pronounced during the festival months. The BOD was almost ideal in January of 2020 but it varied throughout the year. The highest BOD value was observed to be 5 mg/l. Alkalinity should be between 100-250 and for both the years it was within the permissible range.

Faecal coliform was present at exceedingly elevated levels due to sewer disposal into the river. Faecal coliform had the highest value of 1,70,000 MPN/100ml during 2020 which made the water unfit for anything. The pH level should be between 7-8 and it was within the permissible range. E. coli was also present at remarkably prominent levels and during the year 2020 it was seen for a maximum number of months.

Dissolved O_2 was present above the permissible limits for most months during both the years. The values of both the years vary greatly due to covid during 2020. At that time, the river water quality had improved and during 2021 when the situation started improving, the water quality values increased above the permissible limits.

The proposal is to approach the government with the idea of promoting citizen participation. The app can help the government in collecting data or maintaining the environment with the help of people. This app can be of use in places where the government requires assistance with data collection or information and to make the citizens more responsible.

The app can also be utilized for fast action of cleaning and improving the river and its banks. The app facilitates event creation and spreading awareness through social media. It is aimed to be a connect between the citizens and the river and to engage them for data collection and remediation of polluted sites. The app will promote incentives to make citizens participate and engage in such activities.

Engagement of citizens in improving the condition of rivers has become necessary in the current scenario. An App-based approach is a pre-eminent solution. It suggests how a user-friendly app can be easily developed and designed by using FlutterFlow. While this app can become revolutionary in remediation of our water bodies, there are challenges in developing such an app. With rapidly advancing technology it expects an app developer to upgrade with the latest trends. It requires constant learning and investing to adapt in order to build a sustainable app. User experiences and App performance are the most essential factors that will help in making the app successful. It has to go through several optimizations and testing to be able to perform in a comprehensive manner.

A feedback system needs to exist throughout the life-cycle of the app to address any issue. Diverse range of devices, sizes, and OS forms a challenge for developers to make it accessible through any device. The dicey part is the final stage when the app becomes live. It needs marketing, monetizing, and increasing its appeal for maximum users.

The main challenge in developing river-focussed apps is managing the data. There needs to be an incentive-based approach so that people will willingly contribute to the cause and use the app to increase engagement. There must be sufficient awareness about which matters should be handled by the government authorities.

Nature-based Solutions are an emerging technology and a way of curing the environment without impacting it further. The techniques are being executed and tested everywhere to see how efficient they are and how fast the problems can be resolved by using these bioremediation techniques and phytoremediation. It has been noted that where the water is stagnant and of smaller volume, Nature-based Solutions work, but for a river which is an entire system with fluctuating volumes along with dynamic nature of contaminants, it becomes difficult to propose an effective way to utilize NbS for such a cause.

Rivers require an effective system of remediation soon before some of them start disappearing. For future work, the aim will be to develop the app in such a way that it is a collaboration with another government app that citizens are mandated to download. The app development will be followed by approaching the idea with the motive of increasing public involvement in saving the environment. The need for such a framework is extremely important as the environment is gradually degrading and due to increasing population and climate changes it is degrading at an even faster rate.

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Conflict of Interest

Authors have no conflict of interest to declare.

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