Finflow

IoT Enabled Smart Pond Monitoring System

SILICON LABS' SOCIAL ENTREPRENEURSHIP CHALLENGE

Inter IIT Tech Meet | Team 11

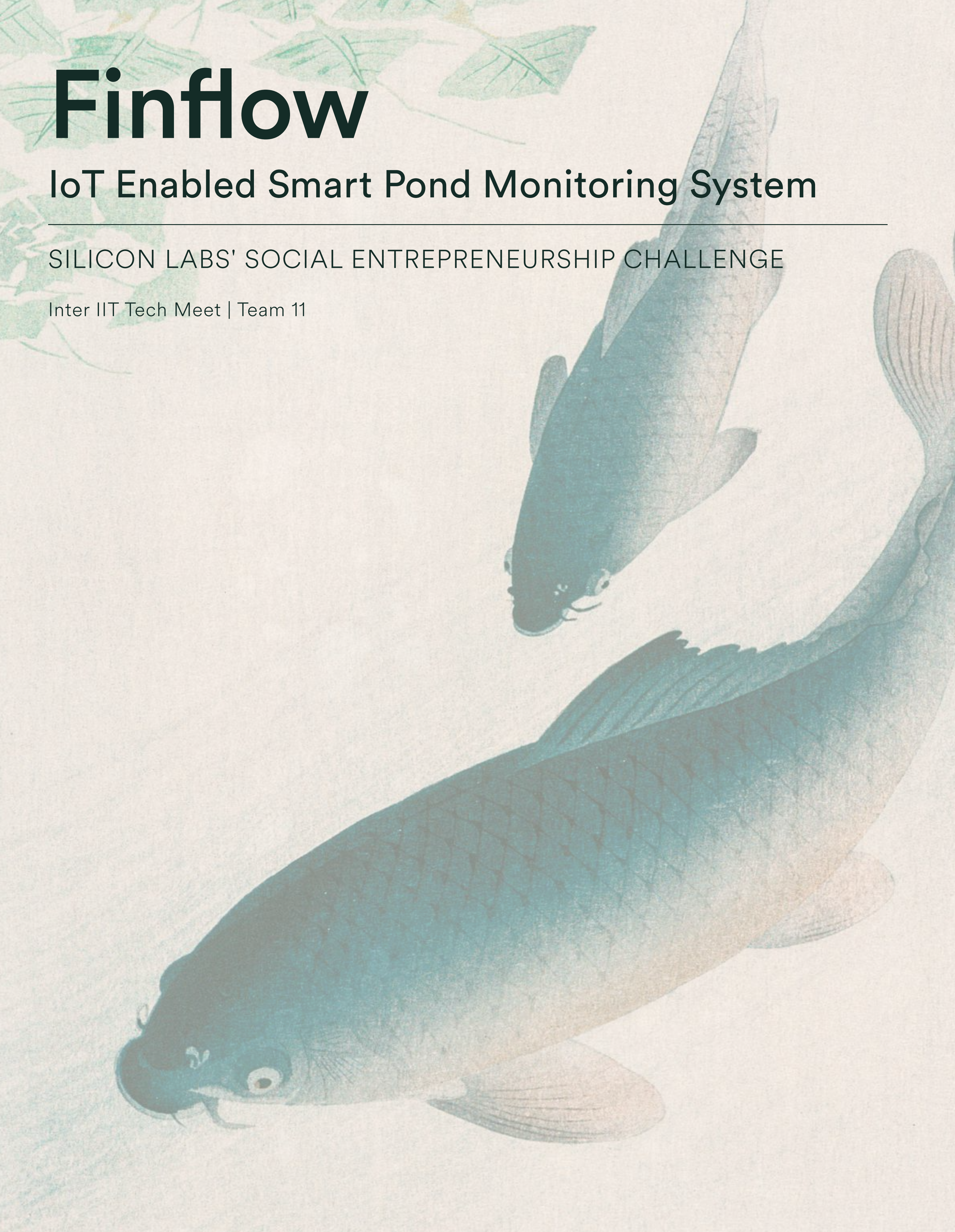


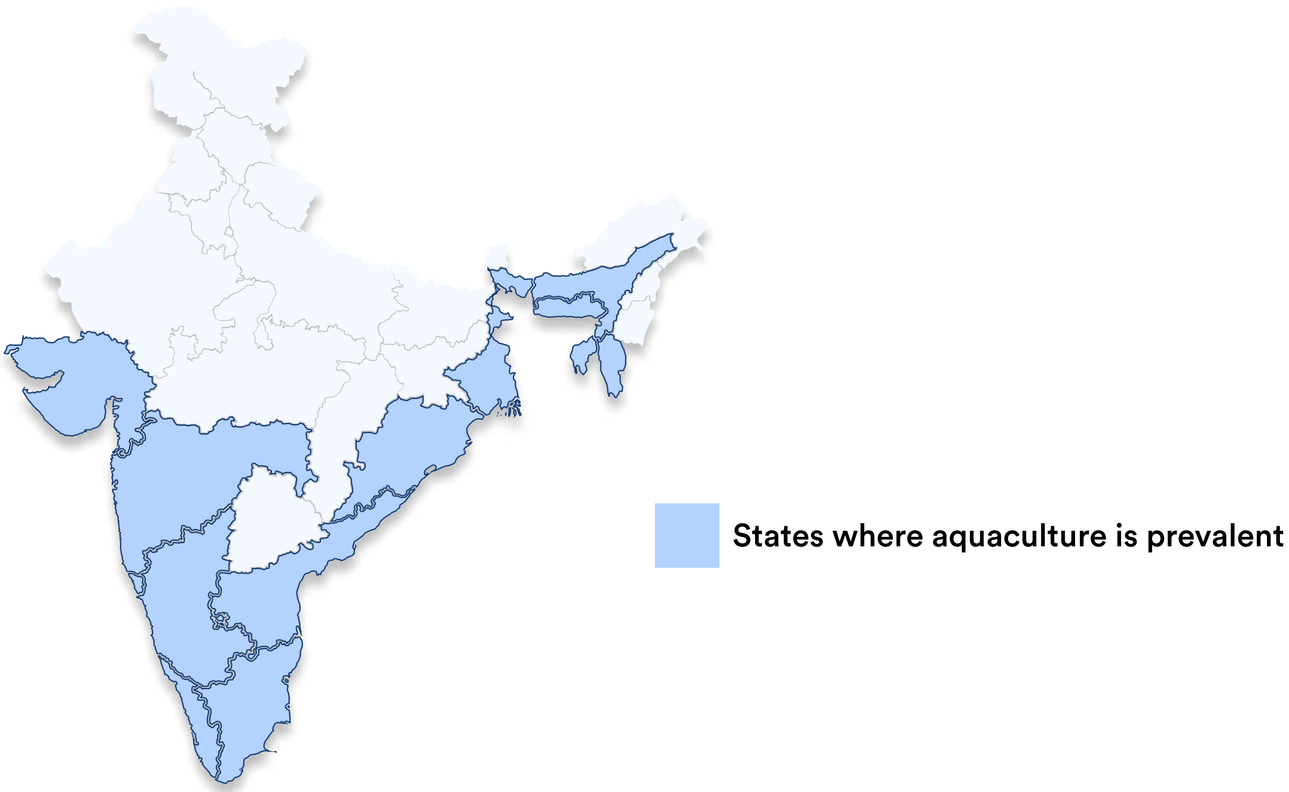
Table Of Contents

1. BACKGROUND

While you may enjoy your Prawns extra spicy, they are likely to have come from a nearby fishery pond. India has around **2.36 million hectares of Tanks & Ponds**[1] area where the culture-based fishery is predominant and contributes to the maximum share in total fish production. In fact, India is the 3rd largest fish producing and 2nd largest aquaculture nation in the world after China.

In the recent past, Indian fisheries have witnessed a paradigm shift from marine-dominated fisheries to inland fisheries, with the latter emerging as a major contributor of fish production from 36% in the mid-1980 to 70%[1] in the recent past. Within inland fisheries, a shift from capture to culture-based fisheries has paved the way for a sustainable blue economy.

As per DoF (Department of Fisheries, GoI) data, there are currently more than **23 million inland fish farmers**[3] in India and they rely on culture fishing to meet their nutritional and economical requirements. The sector has benchmarked from a domestic activity in Eastern Indian states of West Bengal and Odisha to an enterprise in the states like Andhra Pradesh, Punjab, Haryana, Maharashtra, etc. taking up fish culture as trade and enterprise.



Aquaculture pond

Aquaculture, also known as aquafarming, is the controlled cultivation of aquatic plants and animals in fresh, brackish, or saltwater. Fish farming ranges from large-scale industrial framing to 'backyard' subsistence ponds.

Freshwater aquaculture involves the breeding of freshwater fish like carp, catla, rohu, magur, freshwater prawn, freshwater pearl culture, and ornamental fish farming. The size of an Artificial fish pond varies from 0.05 – 0.1 ha with water depth of 1.5 – 2.0 m. Carp and shrimp farming is a family business and farm sizes reflect this fact.

In shrimp farming, 91 percent[1] of the farms are less than two hectares in size. History explains why fish farms are still small and family-run affairs. Farming carp in rice fields and ponds is a century-old tradition in India.

Shrimps

Raising exotic carp species in tanks and reservoirs only started in more recent times. As the demand is growing rapidly, we believe that the whole process can be optimized with technological intervention.

Two farmers practising Aquaculture

2. PROBLEMS FACED BY FISH FARMERS

Although being a potential industry, there are specific problems hindering the growth of Culture Fisheries which include the poor physical condition of resources (especially the water quality and quantity), lack of diversity in cultural practices and species, lower productivity, inadequate regulatory mechanisms, increased incidents of disease.

2.1 Health of the fish is directly affected by water quality

Fish farmers have been experiencing about 26% production loss due to diseases and poor management in the freshwater aquaculture sector. Rural resource-poor farmers with little or no knowledge of fish health management and skills to prevent and control disease outbreaks are the most sufferers, incurring a huge economic loss. In aquatic systems, disease management is a difficult proposition due to the unique ecosystem, where the pathogen is always looking for an opportunity when the health status of the host is compromised.

Bacterial fish diseases are very common and are one of the most difficult health problems to deal with. **These bacteria are generally saprophytic in nature and only become pathogenic when fishes are nutritionally deficient, or there are other stressors, i.e., poor water quality, which allow opportunistic bacterial infections to proceed.** Apart from bacterial infections, fungal infections like Epizootic Ulcerative Syndrome (EUS) are also of major economic importance in freshwater agriculture.

Bacterial disease in Fish

It has been indicated that ponds receiving water from rice fields and river/ditch had a high relative risk of EUS. Many other parasitic diseases are directly or indirectly related to the water quality of the ponds.

Evidently, water quality is of utmost importance in fish and shrimp farming. Regardless of the particular aquaculture system used, maintaining balanced levels of water quality parameters is fundamental for both the health and growth of farmed aquatic species. In the case of India, most of the fish farmers are still very technically backward and go by intuition or guesswork to monitor the health of fish.

Manual Water Quality Test

2.2 Inefficiencies in Existing Solution

Now, slowly and gradually, small and medium-scale fish farmers have started to realize that regularly monitoring the water quality can improve their production significantly. Currently, they are employing local consultancy services to assess water quality which is checked by parameters like pH, the concentration of Ammonia, Nitrate, Nitrite among others.

Fish dies due to Nitrite Toxicity

These consultancies charge Rs. 2000 - 4000 per pond for measuring the aforementioned parameters. These parameters need to be continuously monitored as they are affected by the life processes of fishes. Toxic ammonia comes from major waste products of shrimp and fish and uneaten feed. Nitrite (NO_2^-) and Nitrate (NO_3^-) are other forms of nitrogenous compounds that result from feeding and can be toxic to shrimp and fish.

Ideally, all these parameters need to be checked at least once every 3-4 days for proper management of fish but, with such a high cost of third-party services, these tests are mostly done biweekly or once in three weeks. So, employing these consultancies to monitor the condition of water and fish incurs a **recurring cost which can amount up to Rs. 30,000** (minimum) per pond per year. Even after paying heavy fees, farmers are not able to monitor their fish at the optimum frequency.

2.3 Takeaway

This calls for a need to make an affordable system that can give real-time updates of important parameters which directly affect the health and growth of fish. There's a need for scientific intervention and better management practices to prevent frequent occurrence of disease and production loss in rural aquaculture in India. These measures will directly impact the socio-economic development of 23 million inland fish farmers in India.

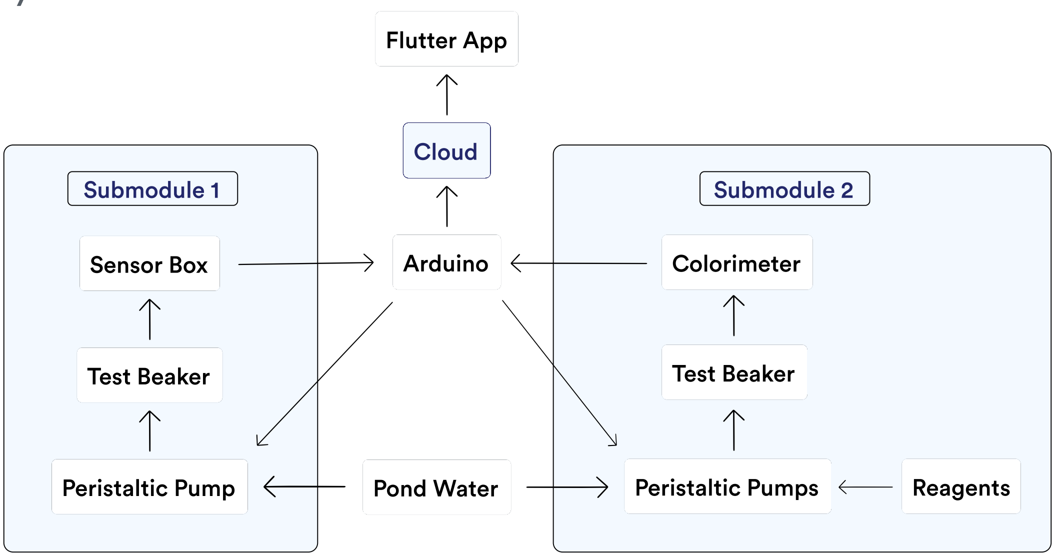
3. OUR SOLUTION

3.1 Finflow - Smart Water Monitor

To address the aforementioned issues, we propose a smart pond monitoring system. We have tried an unprecedented method where we use sensors and automate volumetric titrations to check the levels of water quality parameters, which were previously done manually. The values of these parameters get stored in the cloud and sent to the mobile app where the farmer is warned whenever a parameter is at a dangerous level.

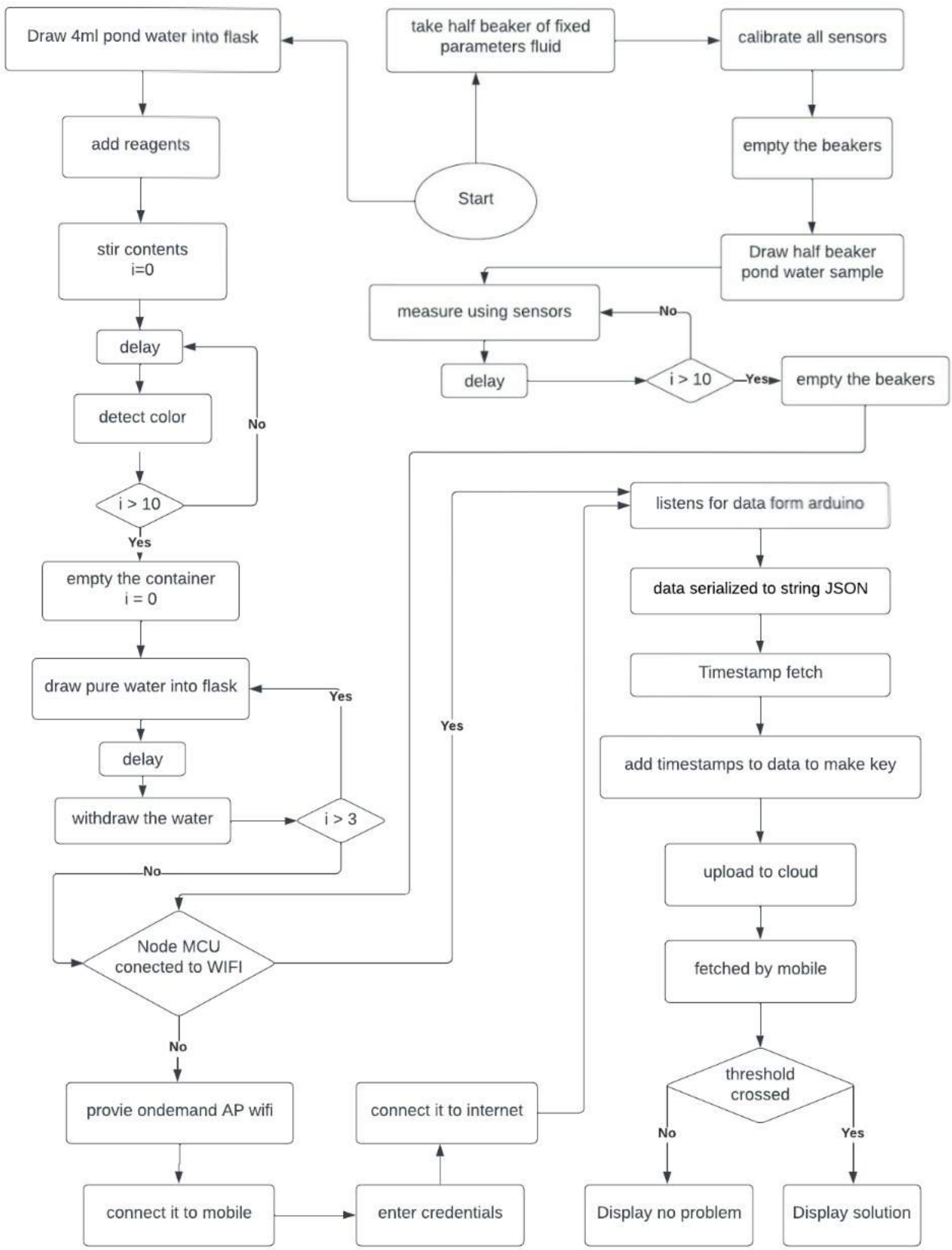
3.2 Workflow

The proposed system has both Hardware and Software counterparts that will carefully observe the water quality by assessing crucial parameters whenever required by the user.



Workflow of different Modules

4. SYSTEM DESIGN



Detailed Workflow of different Modules

4.1 Hardware Module

In the sensor apparatus, we have two sub-modules that are integrated into the microcontroller, one of which has sensors to monitor the following parameters.

1. Dissolved Oxygen
2. Salinity
3. Temperature
4. pH
5. Turbidity

The other module, which performs volumetric analysis in accordance with a colorimeter, provides the following parameter readings.

1. Ammonia (NH_4+)
2. Nitrite (NO_2-)
3. Nitrate (NO_3-)

With the help of a microcontroller, all of these raw signals are processed and converted into digital signals. Now, this digital data is sent to the cloud (Firebase) for processing, where it is analysed to check if any values have crossed the standard thresholds. Then, these actionable parameters are highlighted on the flutter-based mobile application, along with solutions for restoring the toxic values to normal levels. The whole module is powered by a 12 V power supply

Next, let us understand how all of these modules will work.

4.1.1 Sub-Module 1: Sensor Setup

In this setup, there are 2 steps :

1. Calibration:

Before every calculation, all the sensor probes are to be calibrated. We used a peristaltic pump (we used peristaltic pumps to get a controlled flow rate, in this case, 10.5ml/ min) to draw in water into the beaker before each calculation. The parameters of water used for this calibration are fixed. Using these values, our sensors are calibrated. After a slight delay, this water is drawn out again using the same pump.

2. Sensor data collection:
After calibration, pond water is drawn into the beaker. Now, each of the sensors gives its readings.

All of these sensors provide analog data. Using a microcontroller, these readings are converted to digital signals. These readings are taken 10 times per test and averaged from the middle 6 values when arranged in ascending order. A peristaltic pump is then used to empty the pond water from the beaker.

4.1.2 Sub-Module 2: Automated Volumetric Analysis

In this setup there are 3 steps:
1. Volumetric titration:
A peristaltic pump is used to draw 4ml of pond water into the flask after it has been cleansed. Peristaltic pumps control the adding of the required liquid reagents to the flask in precise amounts. Powdered reagent is added using a lead screw (measures in a precise amount) fitted just outside a funnel.All of these peristaltic pumps are attached to the flask's cork with capillary tubes.

Ammonia Test	
Reagent 1	5 Drops
Reagent 2	5 Drops
Reagent 3	5 Drops

Nitrate Test	
Reagent 1	1 Scoop
Reagent 2	4 Drops
Reagent 3	4 Drops

Nitrite Test	
Reagent 1	3 Drops
Reagent 2	1 Scoop

We use the magnetic pellet inside the flask after addition of these reagents and stir it with a magnetic stirrer for about 30-40 seconds using the delay element. The solution now takes on a colour depending on the parameter's value.

2. Color sensing:
We detect the obtained colour using the Colorimeter, and these calculations are repeated 10 times per test. The test results are arranged in ascending order and middle 6 measurements are considered and averaged over to give the final value. We check whether the parameter level is harmful or not based on the threshold

value. The water in the flask is emptied using peristaltic pumps after these tests.

3. Cleansing:

The beaker is washed 2-3 times with water using a peristaltic pump before each titration.

Sample Collection

A predetermined amount of water is taken from pond into beaker using peristaltic pumps.

→

Reagent addition

Appropriate reagents are added.

→

Stirring

A magnetic stir bar homogenizes the solution.

↓

Measuring Color

A colorimeter is used to measure the wavelength of light coming through the solution to detect the color.

←

Emptying Test Beaker

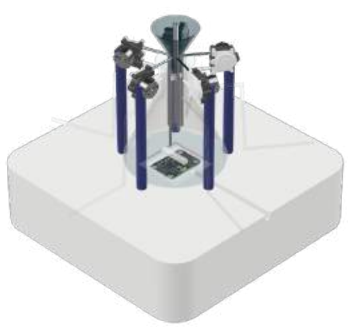
The mixture in the beaker is emptied through a capillary reaching the bottom of the beaker.

←

Multiple Washings

To prevent contamination between readings, the beaker is filled and emptied with water multiple times.

4.2 Data Transmission to Cloud



Volumetric Analysis Conical Flask

Sensor Beaker Module

All the parameter readings noted on the microcontroller are serially communicated to the cloud using NodeMCU. NodeMCU, when started, initially tries to connect to the saved SSID and Password repeatedly. When connected successfully, it runs a loop and listens for data from Arduino (microcontroller). The data collected by Arduino (microcontroller) through the sensors over time is transferred to NodeMCU via serial communication.

The data received by NodeMCU is serialized string JSON. After receiving the data first, it fetches the current timestamp from NTP Server, and then it uploads the received string data with the timestamp as a key. This key is now uploaded to the firebase. Each product will have a unique ID (in this case, ID1) by which it uploads the data in the database so that it can be fetched by the app using the same ID. Anytime during the functioning if anyone wants to change the Wi-Fi network of the NodeMCU it can be easily done.

On pressing the button NodeMCU acts as an Access Point and starts a webserver. User can connect to the "OnDemandAP" Wi-Fi network and they will be automatically redirected to a webpage where they can choose the SSID and then enter the password to connect. The NodeMCU then saves the details in its memory and reboots.

4.3 Data computation

The flutter application fetches this parameter data uploaded to the cloud(firebase). Further processing is done on these parameters to find any of them is over the threshold values. This information is displayed in a very simple application interface and the solutions to bring back the stability in the parameters. Threshold values of the different parameters are as follows.

4.3.1 Sub-module 1

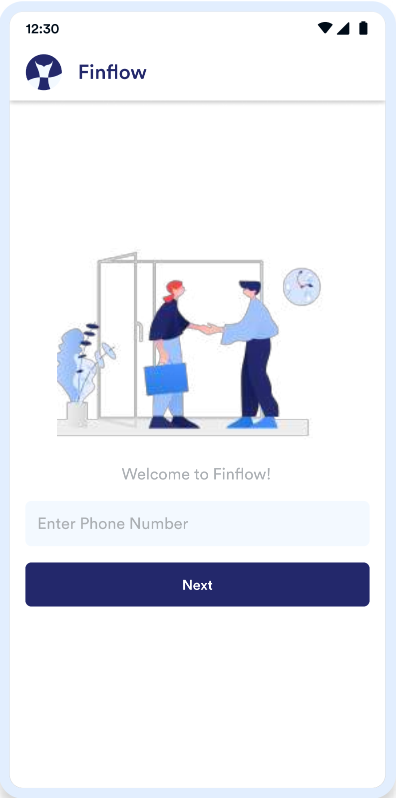
#	Parameter	Standard Values	Method used
1	Nitrate (NO_3^-)	< 80 ppm	Volumetric Titration
2	Nitrite (NO_2^-)	< 0.75 ppm	Volumetric Titration
3	Ammonia (NH_4^+)	< 0.5 ppm	Volumetric Titration

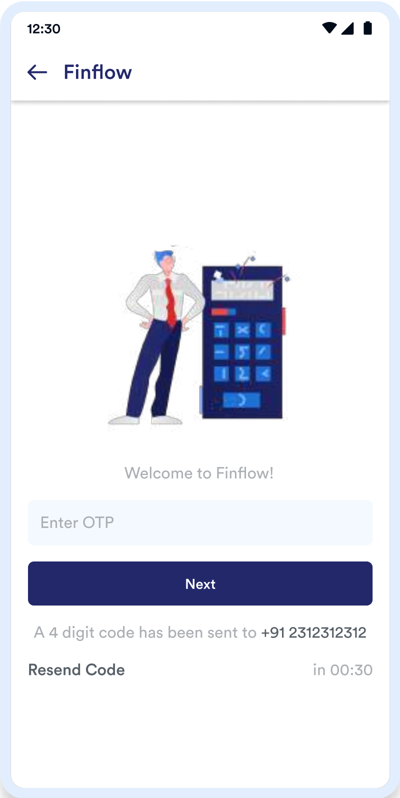
4.3.2 Sub-module 2

#	Parmeter	Standard Values	Method used
1	Dissolved Oxygen	> 4.0 mg/L	Sensor probe
2	Salinity	15 - 25 ppt	Sensor probe
3	Temperature	23-35 (Species dependent)	Sensor probe
4	pH	6.7 - 8	Sensor probe
5	Turbidity	Site dependent	Sensor probe

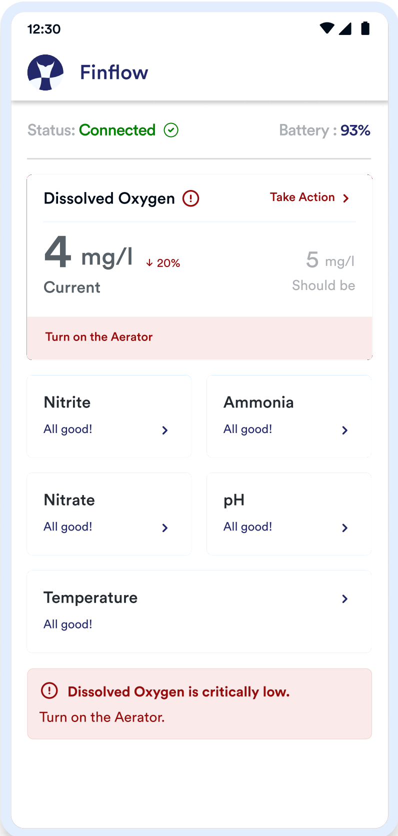
4.4 Software Module

The data is sent to the Android App after all the cloud computations get completed. As you can see, the User friendly UI is made keeping in the user persona we are dealing with.





A mobile number will be the unique identifier of the user.

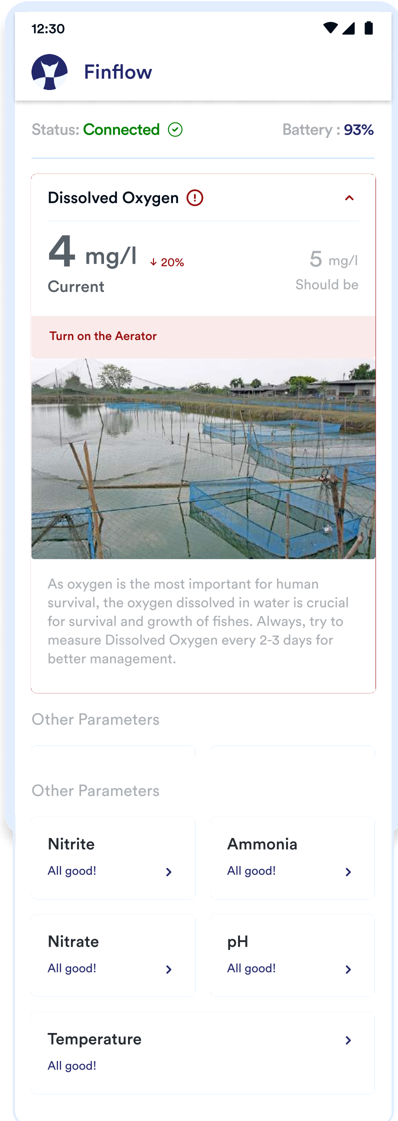


After logging in the app, the user can see the dashboard where all the real-time parameters data is shown.

A parameter card will get highlighted if there's any action required for that particular parameter.

Upon clicking the parameter card, the user can see an image of the solution required to control the given parameter.

Additionally, some basic information about how the particular parameter affects fish is shown.



5. SUMMARY

Through the means of this report, it is now clear that inland aquaculture in India has untapped potential and an excruciating need to inculcate scientific practices, like water monitoring systems, to improve and optimize fish production. We have also observed that more than 23 million fish farmers depend on this industry and can be benefitted socio-economically if they leverage technology in fish farming. Evidently, the poor quality of the pond water directly affects the growth of fishes and makes them prone to lethal diseases, so the water quality needs to be continuously monitored to provide a suitable environment for fishes to grow. Farmers, being unfriendly with technology, hire consultancy services for monitoring the water quality of their pond. These consultancy services add a recurring cost of Rs. 30,000 (minimum) per pond per year and even after paying heavy fees, farmers are not able to monitor their fish at the optimum frequency. Hence, comes our solution.

Light-weight and Portable

Affordable

Real-time tracking

We propose an IoT-based device that can track crucial parameters like Ammonia, Nitrate, Nitrite among other at an affordable one-time cost of Rs. 20,000 - 25,000. The solution costs around Rs. 15,000 to build with the retail prices of all the components involved, and even after considering distribution costs, we can make huge profits selling the device. This is a win-win situation, as the farmer is getting a permanent and easy-to-use solution at a fixed cost. Moreover, we can make a marketplace on the app which can be used by fish farmers to directly sell the fish. We can combine it with the data stored in the cloud and pave the way for farmers to use this data to process organized sector credit. The possibilities are endless here!

REFERENCES

1. Department of Fisheries. Inland Fisheries | Department of Fisheries, GoI. (n.d.). Retrieved March 19, 2022, from https://dof.gov.in/inland-fisheries
2. Aquaculture Systems and SPECIES1. Aquaculture Systems and Species. (n.d.). Retrieved March 19, 2022, from https://www.fao.org/3/ab412e/ab412e07.htm
3. Www.dof.gov.in. (n.d.). Retrieved March 19, 2022, from https://www.dof.gov.in/sites/default/files/2021-09/PDF_032.pdf
4. Present status of fish disease management in freshwater aquaculture in India: State-of-the-art-review. (n.d.). Retrieved March 19, 2022, from http://www.heraldopenaccess.us/openaccess/present-status-of-fish-disease-management-in-freshwater-aquaculture-in-india-state-of-the-art-review
5. How to achieve good water quality management in Aquaculture. The Fish Site. (2022, March 17). Retrieved March 19, 2022, from https://thefishsite.com/articles/how-to-achieve-good-water-quality-management-in-aquaculture
6. Water Quality / Bioremediation. Biomin. (n.d.). Retrieved March 19, 2022, from https://www.biomin.net/species/aquaculture/water-quality-bioremediation/#:~:text=Water%20quality%20is%20of%20utmost,growth%20of%20farmed%20aquatic%20species.