E-TONGUE: A SMART TOOL TO PREDICT THE SAFE CONSUMPTION OF GROUNDWATER

Project Id: 2020-164

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology Specializing in Software Engineering

Department of Information Systems Engineering

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DECLARATION

We declare that this is our own work and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

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The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor: Date

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ABSTRACT

Human body uses water in every cells, organs and tissues to help regulate body functions and temperature. It is vital that the water used by the body organs are of good quality. In Sri Lanka, reportedly 59.4% of population depends on water from natural sources which grabs the attention to make sure that these people are receiving and dealing with a safe water with a good quality for the usage. Although government is taking necessary action to provide a better quality of water, there has been always a need for a better educational session to educate people about the importance of maintaining water quality, importance of using a better-quality water and necessary precautions to be taken to avoid any health hazards. Taking this issue into consideration, it is mainly recognized that a smart solution must be implemented in order to solve the identification of water quality problem.

E-Tongue: a smart device to predict safe consumption of ground water is an attempt to assist any kind of users to identify the water quality of a groundwater sample in real time by analyzing the water quality parameters to predict the Water Quality Index. This task is achieved by designing a hardware device that embeds a set of sensors to read the value of water quality parameters which will be then transferred to cloud environment for an easy access by the mathematical model to process and identify the WQI value. It will then predict the water parameter readings that could be changed in future along with any disease outbreak possibilities. All the outputs will be finally displayed through mobile application.

Keywords: water quality, Water Quality Index (WQI), hardware device, mobile application

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1. INTRODUCTION

Water plays a vital role in making up human body, regulating body temperature and performing many wonderous functions within the body. In that context, the water being consumed by human beings must be clean and contamination free to make sure the body is disease free. One of the major sources of water for people in Sri Lanka is ground water. for 94% of water consumers, natural water sources directly or indirectly supply water where as 6% of the remaining purchase water from the vendors.

According to World Health Organization (WHO), nearly 1.8 million people worldwide dies annually due to water borne diseases including diarrhea and cholera and almost 90% are children under 5 years age. Furthermore, up to 88% of water borne diseases arise from unsafe water supplies and inadequate sanitation and hygiene.

1.1 Background

Considering people of Sri Lanka, a major importance must be given to the water quality of the consuming water since a majority of the population directly depends on ground water sources like wells and tube wells. According to the statistical report by Department of Census and Statistics [1], 40% of the entire Sri Lankan population has organized water supply facilities and 59.4 % is depending on other water sources such as rivers and ground water sources. However, the water supplied by the water supplying chains is not proven to be a quality water.

Majority of people not prefer water supplied through supply chins due to the presence of high chlorine level which is proven not safe for infants and babies. In the data gathering survey, it is proven that in Sri Lanka, the water quality assessments being conducted more like a surface level evaluation. Instead of using water Quality Indexes (WQI) to predict the quality of water, the chains are only using a reference range of the particular parameters which indeed makes the identification process a weak one.

Apart from the quality of supplied water, people who use the water for consumption and domestic purposes must possess a clear idea on the quality of water they are dealing with. In a research conducted in Jaffna, it was found out that people tend to use water from natural sources directly and without taking any precautions and pretreatments. Out of 200 participants who participated, 87% used unsafe water for drinking and domestic purposes. Also, 57% had poor knowledge on the transmission and prevention of water borne diseases.

1.2 Literature Survey

According to [1]. They have structured a real-time remote water quality observing device for aquaculture water quality. Right now, cells and lithium cells are utilized to supply the necessary intensity of the gadget. As indicated by the necessities of aquaculture industry, dissolved oxygen sensor, pH anode, temperature sensor, and alkali nitrogen sensor were utilized to test the separate parameters of the water. STM32F103 chip was utilized to process the information and GPRS and ZigBee modules were used to move the information remotely to the observing unit. Right now, information is perused out, gathered, handled, dissected, spared, and showed by Lab-view. The programming of the sensor hubs was performed by C language based on Kiel environment. This device is a decent incorporation of smelling salts, pH, disintegrated oxygen, and temperature sensors with GPRS and ZigBee transmission procedures for continuous remote checking of the nature of water for aquaculture industry. Since this system utilizes sunlight-based force for power supply. It will quit working if an overcast climate goes on for a couple of days. In addition, this device expensive for clients as far as cost [1].

According to research study conducted by Nikhil Kedia on Water quality monitoring for rural areas- a sensor cloud based economical project [2], 80% of people who has health problems due to unsafe water consumption are from rural areas. But despite the fact that they residing in rural areas the mobile penetration is higher than sanitation and drinking water. Considering the mentioned factor, the research group has developed a sensor-actuator system which later shifts to sensor-cloud model which improve the water quality and the awareness of the people in rural areas. These results had delivered to the people using SMS or by local radio stations with corporation of government [2]. However, this solution can be improved to real time system.

According to [3], classical Machine learning algorithms like Su*pport Vector Machines (SVM)*, *Deep Neural Network (Deep NN)* and *Neural Network (NN)* were used to measure the water quality with a highest accuracy of 93%. This level of accuracy distinctly indicates the importance of training the selected mathematical model under both controlled and open field conditions. It can also be stated that NN and Deep NN models are highly fitting in training a model which includes complex functions. Furthermore, it is important to note down here that out of 30 water quality variables which were defined by World Health Organization (WHO), 25 variables are used in order to achieve this highest accuracy. However, using 25 different types of sensors makes this system a little bit more expensive than it actually should have been. [4] uses 16 water quality parameters along with an *Artificial Neural Network (ANN)* with Bayesian regularizations. This study capitulated correlation coefficients between the observed and the predicted values of 0.94 and 0.77. Even though the reduction of number of used variables didn't impact on a vast difference in the accuracy and mean error, using 16 sensors on respective variables puts the progress of the study into a tight spot.

According to the research was done in forecasting of parameters of river water quality, through this research, preventing river pollution. The water quality parameters such as pH, Temperature, Turbidity, conductivity, dissolved oxygen in the river was predicted and forecasted based on the time series analysis method and ARIMA modeling [5]. Burnett River is a river which is in the Australia and its water quality parameters dataset of the year 2015 was given by the Australian government for this research. By using the dataset, the machine learning model was created and forecasted future water quality parameters values according to that values the government bodies can take necessary actions in the earliest stage [5].

According to the research carried by W.C.S. Wanasinghe and colleagues on Drinking water quality on chronic kidney disease if unknown aetiology [6], CKDu is one of the major health issues in Sri Lanka. The main responsible reason for it has not yet been identified. Among the suggested number of risk factors, it relates with the certain drinking water quality parameters strongly. The research was carried on Ulagalla cascade in Anuradhapura. Water samples were analyzed and observed the several water quality parameters such as turbidity, PH, total dissolved solids and the chemical solutions that dissolved in water. Observed results were check against the drinking water quality standards. According to the study it suggested that cumulative levels of heavy metals may aggravating the CKDu [6].

2. RESEARCH GAP

A thorough background study suggests that the lives of people who are consuming unsafe water are at risks of getting exposure to major health issues. Even though industries are taking necessary actions to provide safe water, majority of people are leaning towards untreated ground water due to the abundance of ground water resources, financial reasons and to avoid consumption of chlorinated water. It is prime time to educate the people on the quality of the water that they are dealing with. The lack of a smart device to help people find out the ground water quality using a simple water sample to avoid manual and time-consuming laboratory processes is a main goal for the research.

Even though Sri Lanka is in the verge of becoming more advanced in water quality researches and predictions, there have been still no researches done in the ground water quality analysis. According to National Building Research Organization (NBRO), more attention has been paid to surface water since the surface area that are present is high but the ground water sources have been comparatively neglected. Not only the ground water quality, but also the consequences that people face due to consumption of these unsafe water must be highlighted. Also, seasonal variation can change the quality of the water parameters which mainly affects the quality of water. Therefore, a smart device that could be used in real time identification of water quality, disease outbreak possibilities and the water quality parameter changing rate due to seasonal variation could be an effective solution for an ongoing problem.

Table 1.1: Comparison of existing systems

Features	Existing Systems				
	TDS	Zen-Test	Water quality monitoring for rural areas	Smart water	E-tongue
Basic sensors of water quality parameters	✓	✓	✓	✓	✓
Get real time values from sensors	✓	✓	✓	✓	✓
Use wi-fi to upload data to cloud				✓	✓
Analyze past data to give solution			✓		✓
Display sensor values real time		✓		✓	✓
Real time prediction of future water quality					✓

Cloud services to store sensor data and obtain results			✓		✓
Cross platform approach					✓
Real time prediction for risk of water borne diseases					✓

3. RESEARCH PROBLEM

A healthy lifestyle could be possibly ensured once the day to day activities are made clean and clear. With an abundance of ongoing researches and explorations regarding water sources, a bit more attention must be paid in analyzing groundwater.

Since the techniques that are used in Sri Lanka is manual and time consuming, an innovative solution must be put forward to identify the quality of ground water in real time. Moreover, a prediction of the changing rate of water quality parameters due to seasonal changes too plays a vital role in determining the characteristic of the selected water source in the future. This water quality changing rate prediction could be used to predict the possibility of outbreak of any water borne diseases. This solution could be used mainly by a single user or an organization in order to identify the ground water quality of specific location which will eventually lead the way for a better future.

4. OBJECTIVES

4.1 Main Objectives

The ultimate intention of this research is to design a smart device that could be used to identify the ground water quality by examining a water sample. A Water Quality Index (WQI) will be an output from the mathematical model to display the range to which the WQI belongs, to the user through a mobile application.

In order to make the device, a combination of sensors, an accuracy increasing algorithm along with a mathematical model must be combined to make it function as intended.

4.2 Specific Objectives

- To develop an IoT device by combining water quality parameter sensors to obtain readings to be stored in cloud.
- Transfer the raw sensor data to the cloud platform and store.
- Implement data stream pipelines to ingest data to mathematical models and achieve results.
- Process the ingested data to select an appropriate algorithm and train the algorithm to select the best Artificial Neural Network model in order to obtain high accurate WQI.
- Predict quality of water sources on specific location based on seasonal variation.
- Predict the risk of exposure to CKDu and water borne diseases.

5. METHODOLOGY

Proposed solution is a sophisticated smart intelligent device to predict safe consumption of ground water. The system has a completely massive studies area like Artificial Intelligence, Machine Learning, Internet of Things and visualizing technology. Research conducted similarly examine on above stated research areas, therefore this information can be used to attain the goals of the research.

5.1 System overview

To conquer the addressed problem, we have got divided our application in to four most significant additives. Each additive depends on each implemented with exclusive device to getting know machine learning algorithms, sensors and visualization techniques.

- Device and Technology
- Real-time data stream and predict risk exposure for water borne diseases
- Identifying safeness of groundwater
- Forecasting water quality parameters

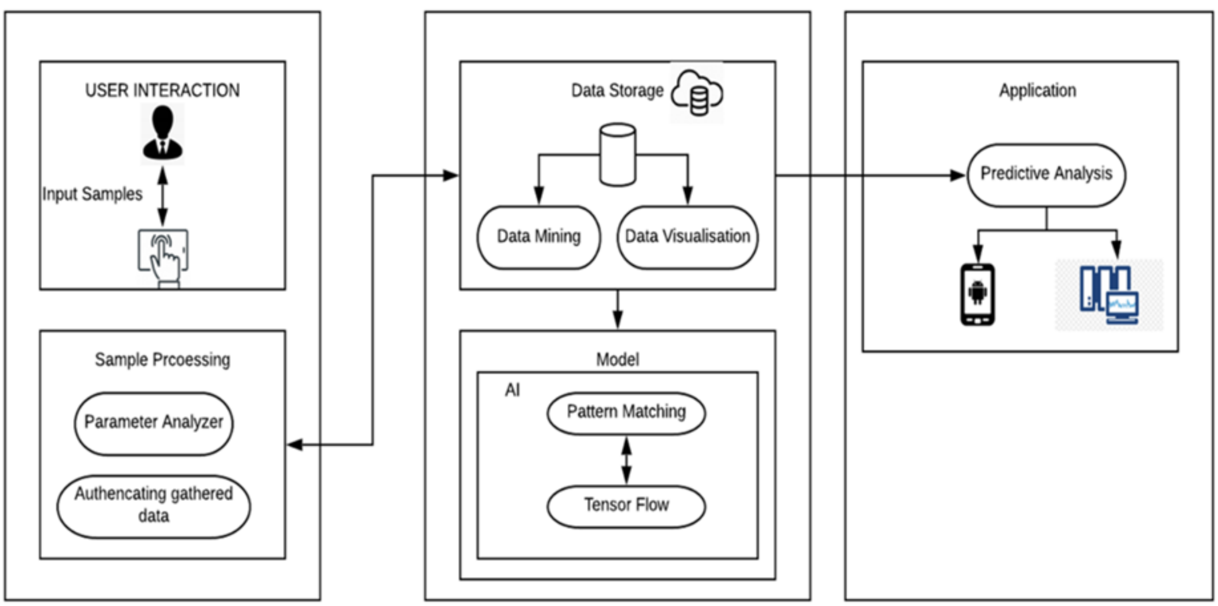

Figure 5.1: System overview diagram

The above figure 5.1 illustrate the overall system diagram of the proposed system which elaborate the safe consumption of groundwater. In order to achieve the main goal of the system we must have do every component in proper manner.

5.1.1 Device and Technology

One of the research components is to build a proper sensor device to estimate the tool to identifying water quality parameters. Through this component selecting sensors with more accuracy while comparing with another devices. A nodemcu microcontroller is applied as the fundamental controller of the system. It genuinely depicts that nodemcu (ESP 8266) is good for this IoT implementation. Due to its built in Wi-Fi capability and value-effectiveness. As we are targeting this for normal end-customers the device should be inexpensive.

The framework capacities certainly and freely as in step with the code transferred to the microcontroller. In this system, five sensors are used to degree the essential parameters. As changed into pondered from the past investigates, the most fundamental water parameters must have been found by using the ordinary customers are water pH degree, water turbidity (darkness), water temperature and turbidity to degree floor water [8][9]. Here we had been capable of upload a further calcium sensor and the overall dissolved solids sensor for the measurements of groundwater safeness. All sensors read the water great parameters and transmit packets to the microcontroller as electric signs and symptoms.

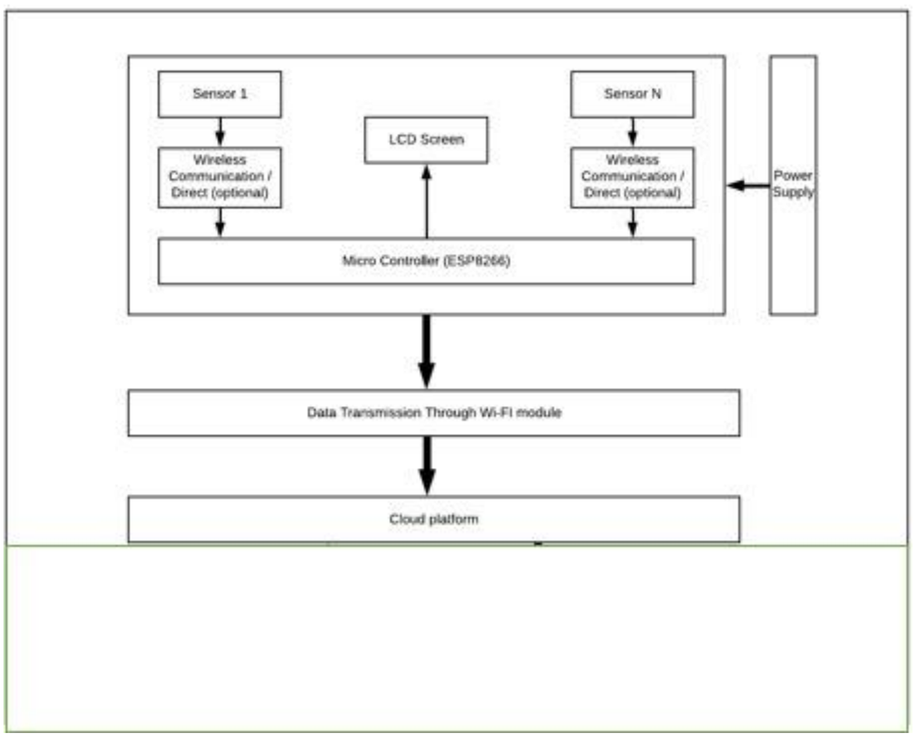

Figure 5.2: System diagram of the IoT device

Figure5.2 suggests the high-level diagram of the proposed device. Further, its presentations the wide variety of sensors we're using with an LCD display screen to expose the reading values. After getting preliminary values via the sensors, records packets could be transmitted to the cloud surroundings through the WI-FI module in real-time.

5.1.2 Real-time data stream and predict risk exposure and water borne diseases

5.1.2.a Transfer data and visualization

This segment usefulness depicts about the information moving, examination and perception of the proposed system. At first the crude information that will be gathered from sensors will be moved to the cloud stage. These information will be preprocessed and changed to an appropriate characterized structure. At that point the information will be joined with the time arrangement for the utilization of spilling information. An information spilling pipeline should be actualized to ingest the information to the scientific models for ongoing forecasts.

Since the significant capacities are deployed on the cloud platform, server-less functions will be created to trigger the pertinent usefulness. At last outcomes will be moved to mobile application and web dashboard for representation. An android versatile application and web dashboard will be produced for envision the outcomes real-time. Figure5.3 shows the essential progression of the operation.

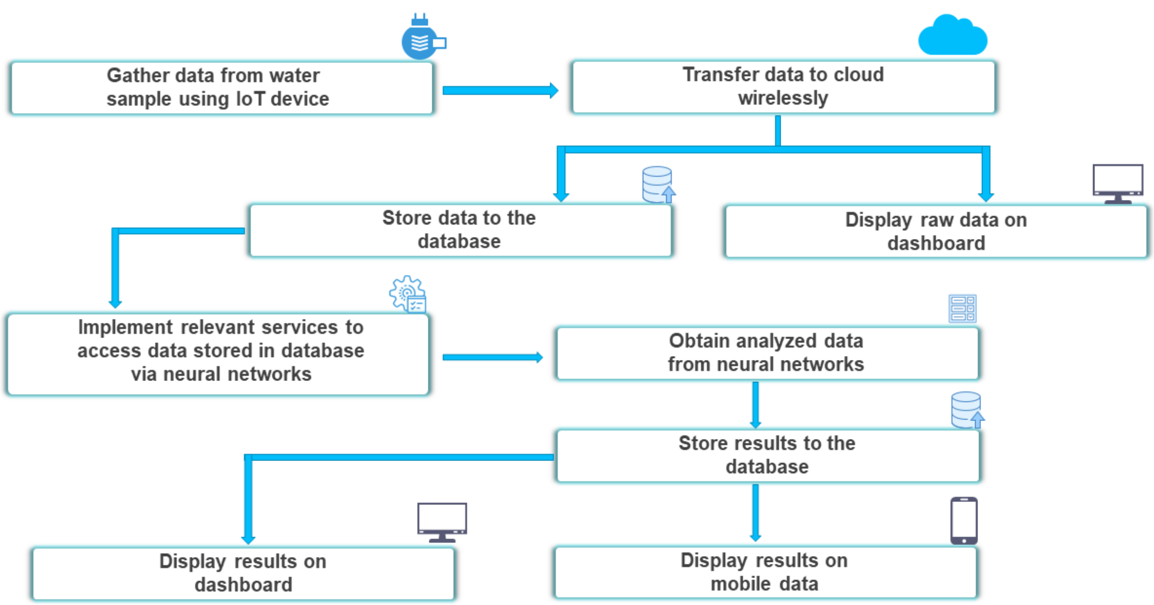

Figure 5.3: Flow diagram of transferring and visualization of data

5.1.2.b Predict the risk of exposure to CKDu and water borne diseases.

Anticipating whether client will be presented to the CKDu and other water borne infections by devouring the water asset that water test is gathered is the principle usefulness of the part.

There is huge measure of infections that brought about by pathogenic small scale living beings that are transmitted in water which are known as water borne sicknesses. Along these lines, an exhaustive report should be acted so as to discover and choose which water borne malady can be distinguished utilizing the proposed arrangement.

The outcomes will be acquired utilizing a machine learning approach and the informational index which will be utilized to prepare the model will be taken from Department of Irrigation of Sri Lanka, Water Resources Board and emergency clinics. Once the dataset is gathered model should be made. ML model will be prepared utilizing gathered dataset and various calculations so as to decide the most appropriate calculation for the arrangement. Utilizing prepared ML model, the danger of presentation to CKDu and water borne ailments will be predicted. Figure 5.4 shows the fundamental progression of the function.

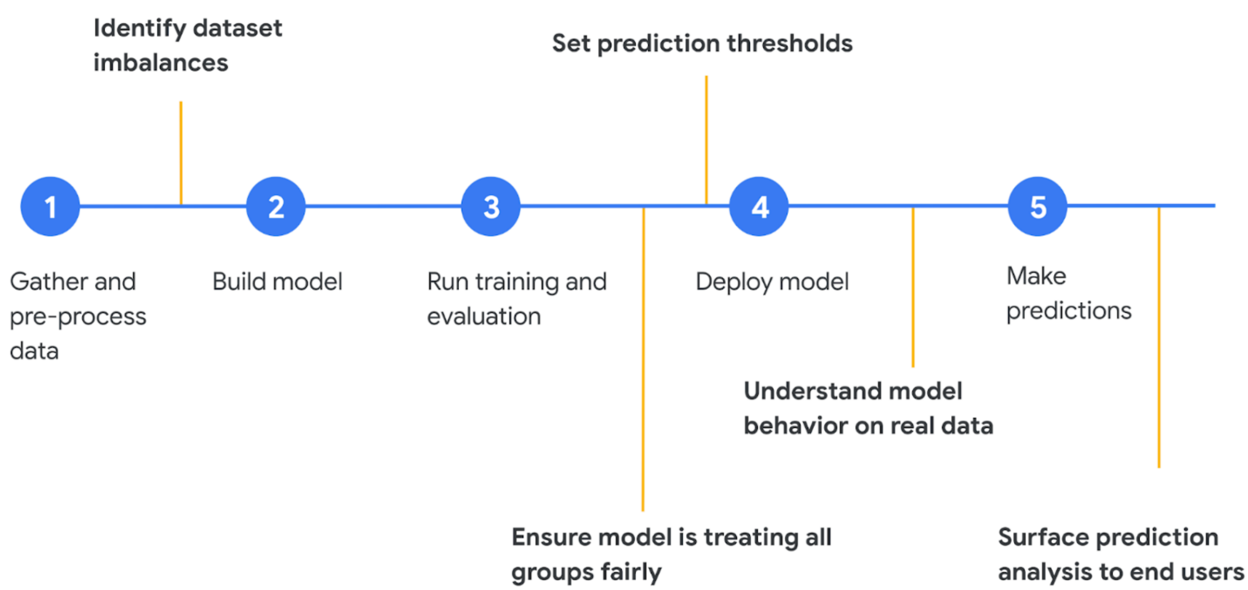

Figure 5.4: Flow diagram of predicting risk of CKDu and water borne diseases.

5.1.3 Predict the quality of the sample ground water

The fundamental functionality of this component is to investigate the water sample and predict the quality of the groundwater which has been taken. From this aspect is carried out by the usage of an advanced Artificial Neural Network approach (ANN) wherein a fixed of neural network models are trained and a suitable best model will be chosen with minimize the error rate.

The dataset as a way to be used to train the ANN model could be accrued from the Department of Irrigation of Sri Lanka and Water Resources Board that includes the beyond facts of the water quality variable values and the water quality of a particular location which can be used to decide the pleasant of the water sources.

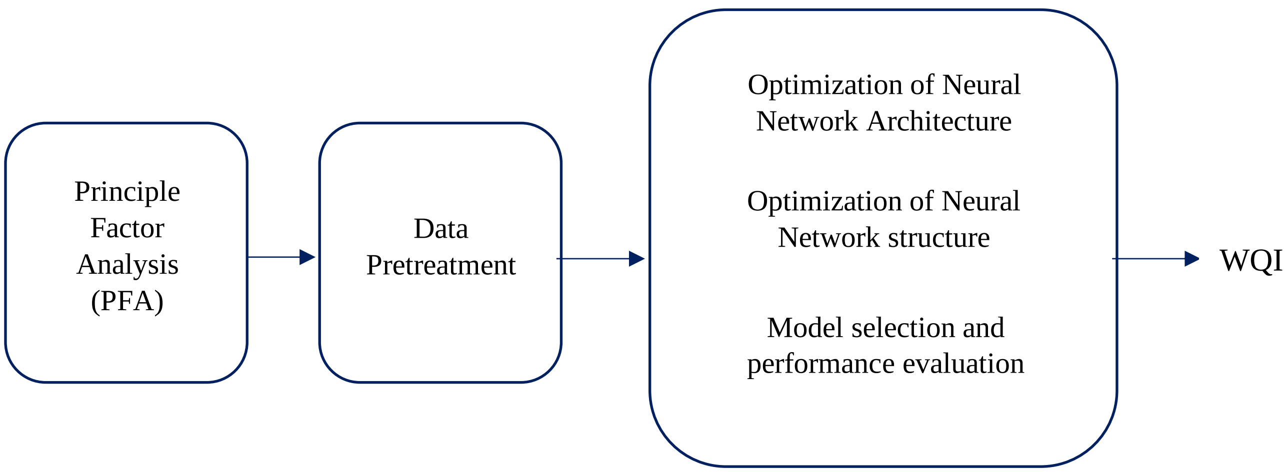

Figure 5.5: Flow diagram to obtain water quality index

Once the data has been collected, a *Principle Factor Analysis (PFA)* will be immediately performed on the data to simply reduce a somewhat large set of WQVs to a smaller and more manageable number while preserving as much of the overall variance as possible [7].

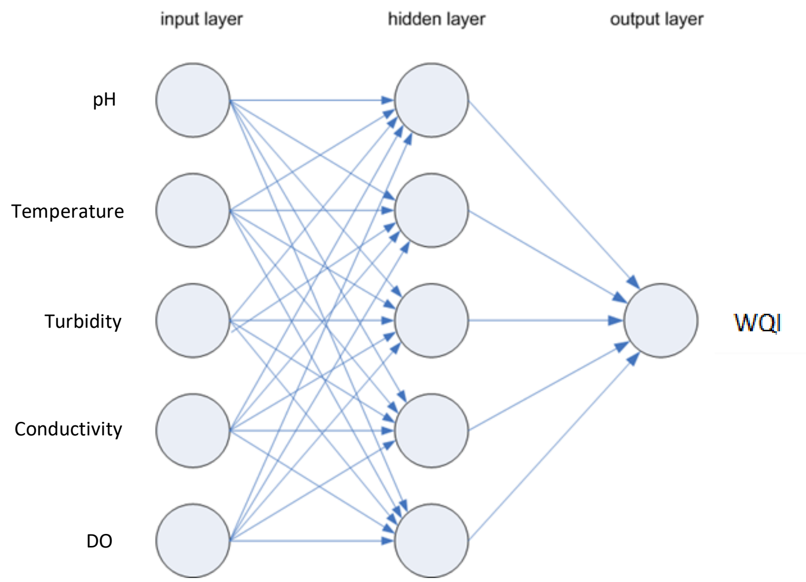

Figure 5.6: Structure of an ANN model

Figure 5.6 explains the pattern of an ANN model, giving a sample idea of the number of input, hidden and output nodes that might be used in a model design. The subsequent step, Optimization of the network shape pursuits in particular at figuring out the most reliable schooling set of rules, mastering rate, quantity of iterations and education stopping situations. If a suitable algorithm was identified, then the network model will start inside the Model selection and performance assessment section. Selecting and training an optimal ANN model then will be used to gain WQI as the output.

The results are sent to cloud where the mobile application could access and display the WQI value and the reference range to display it to the user about the quality of water.

5.1.4 Forecasting water quality parameters

Another functionality of this proposed system is forecasting water quality parameters. Consumers capable of forecast the water quality parameter on before. Further, they capable of perceive nearby satisfactory of water assets primarily based on seasonal version. Generate the map (heat map) to visualize the nearby best quality of water sources. Figure four illustrates the go with the flow of this aspect.

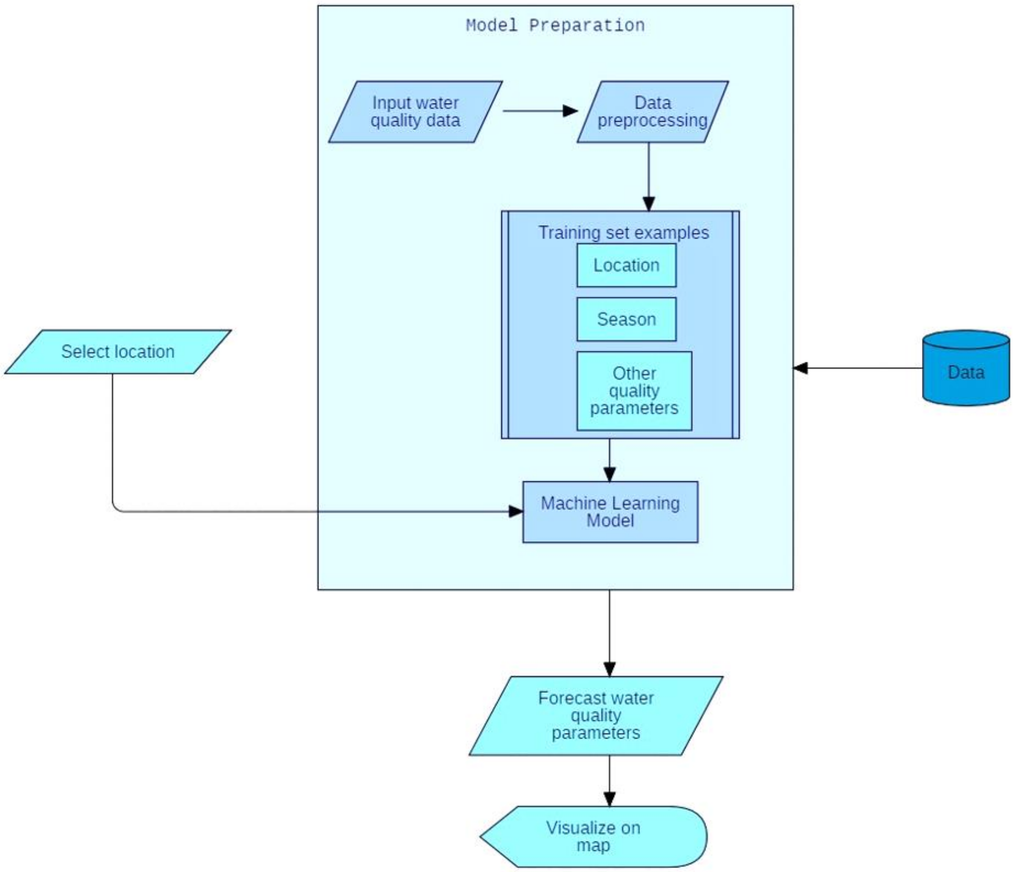

Figure 5.7: Flow diagram of seasonal prediction

The end result of this thing could be water quality parameter value for future. When the user locates their location, application can be proven the water quality parameter for destiny. Hence, the user selects the season, it generates the heat map on located place which incorporates nearby quality of groundwater sources. Here, place is the primary input for getting output of this selection. This particular input sends to model which attempts to forecast water quality parameter by way of using historical water quality information via Machine Learning algorithm.

- Water quality parameter dataset: - It has historical dataset of water quality parameters of specific place water sources which are used to calculate the water quality index. This has been maintained in Department of National Water Supply and Drainage Society.
- Algorithm: - It will be a time series prediction, therefore Auto Regressive Integrated Moving Average (ARIMA) is a best algorithm to predict time series data.

6. DESCRIPTION OF PERSONAL AND FACILITIES

Table 6.1 Task Allocation

Member	**Component**	**Description**
A.M.P.B.Alahakoon	Device Implementation and Technology	• Developing a smart IoT device for measure hardness of water • Developing data transmission media to transfer data • Calibrating sensors to give away readings with minimum error fluctuation • Implement an inception environment for the research team to test water samples
Nibraz M M	Identification of the Water Quality Index by selecting the best algorithm and the best Artificial Neural Network model.	• Carrying out an extensive study on water quality and the water quality variables. • Selecting the best set of water quality parameters to be used in training the model. • Finding a suitable set of algorithms that could be used in this specific scenario. • Setting up Python 3.5 and Tensor flow Lite through the Anaconda distribution. • Training the mathematical model to obtain an optimum result. • Pulling the sensor readings which are stored in cloud. Collecting water samples from specific location to test the accuracy of the real time performance.
Gunarathna PMSSB	• Predict the risk of exposure to CKDu and water borne diseases by consuming the given	• Perform a feasibility study to identify the requirement of the component.

	water sample resource for a longer time period. • Transfer data and visualization	• Identify the dataset that will be used in mathematical model. • Perform a thorough study on water borne diseases and identify the major diseases that can be identified using the solution. • Identify the most suitable algorithm I order to produce the results. • Test the mathematical model with dataset that has known results in order to obtain the accuracy. • Transfer raw sensor data from IoT device to cloud services. • Preprocessing and transform raw sensor data in to a structured format. • Implement data streaming pipelines to ingest the data to mathematical model and obtain results. • Develop an android mobile application and web application in order to visualize the outputs.
Thenuja S	Forecasting water quality parameter and visualize quality of water sources nearby location based on seasonal variations.	• Feasibility study to perceive the requirement of the aspect. • Identify the dataset which will be used in machine learning model. • Perform a thorough study on water borne diseases and identify the major diseases that can be identified using the solution. • Identify the most suitable algorithm in order to produce the accurate results. • Test the developed machine learning model with dataset that

		has known results in order to obtain the accuracy. • Gathering seasonal variation data. • Preparing machine learning model with accuracy. • Implementing visualizing technique to show the outputs. • Develop a mobile application in order to visualize a heatmap.

7. BUDGET

Table 7.1: Overall budget for the proposed solution

Description	**Quantity**	**Amount (LKR)**
ML model deployment		2300
Data Services		500
Nodemcu ESP8266	1	1200
pH sensor	1	3000
Turbidity sensor	1	6000
TDS sensor	1	4500
Temperature	1	400
Soldering wires	1m	150
Rechargeable battery	1	500
Jumper Wires	50 pins	450
Miscellaneous		2500
Total		18,700.00

8. WORK BREAKDOWN STRUCTURE

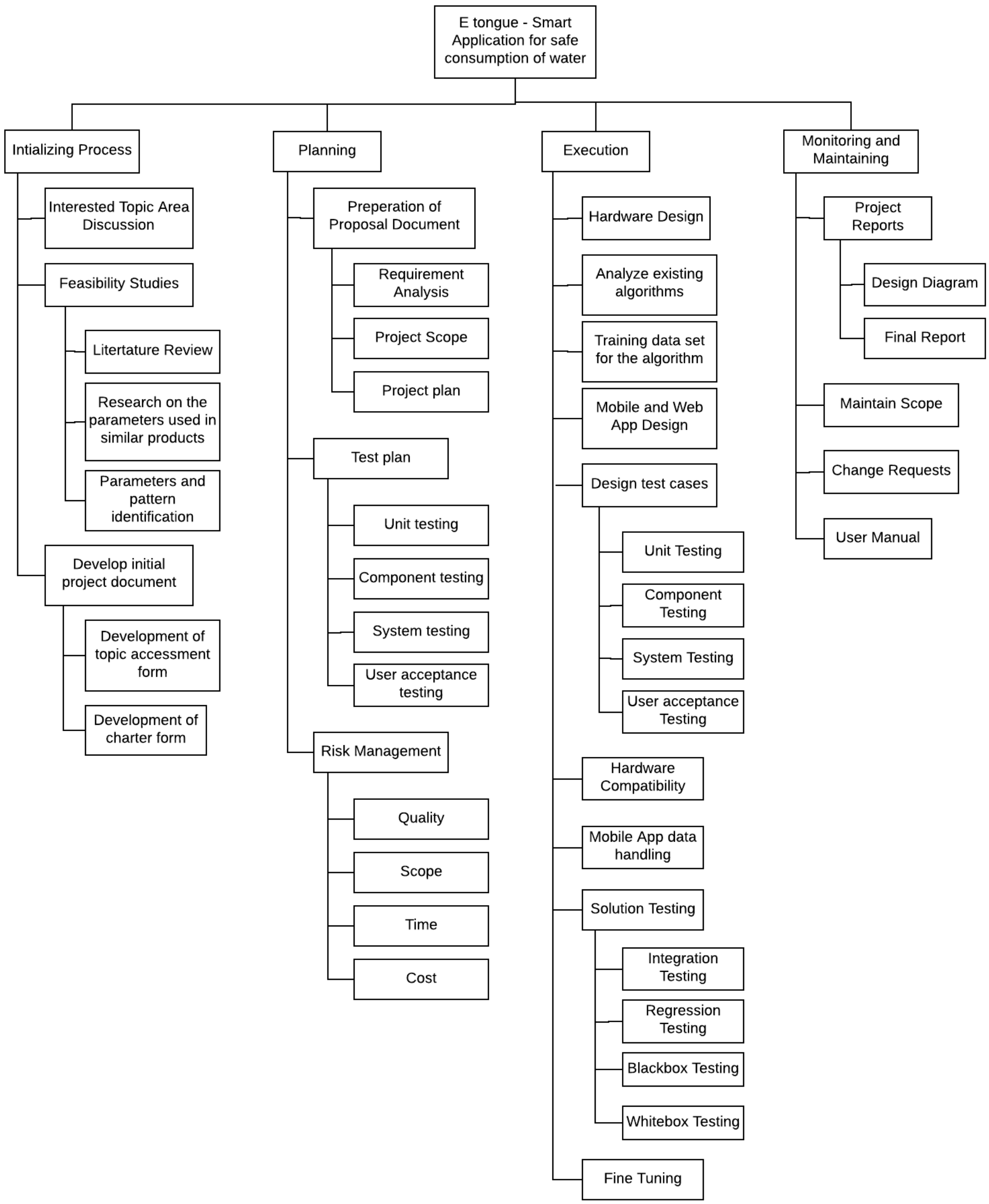

Figure 8.1: Work breakdown structure

9. GANTT CHART

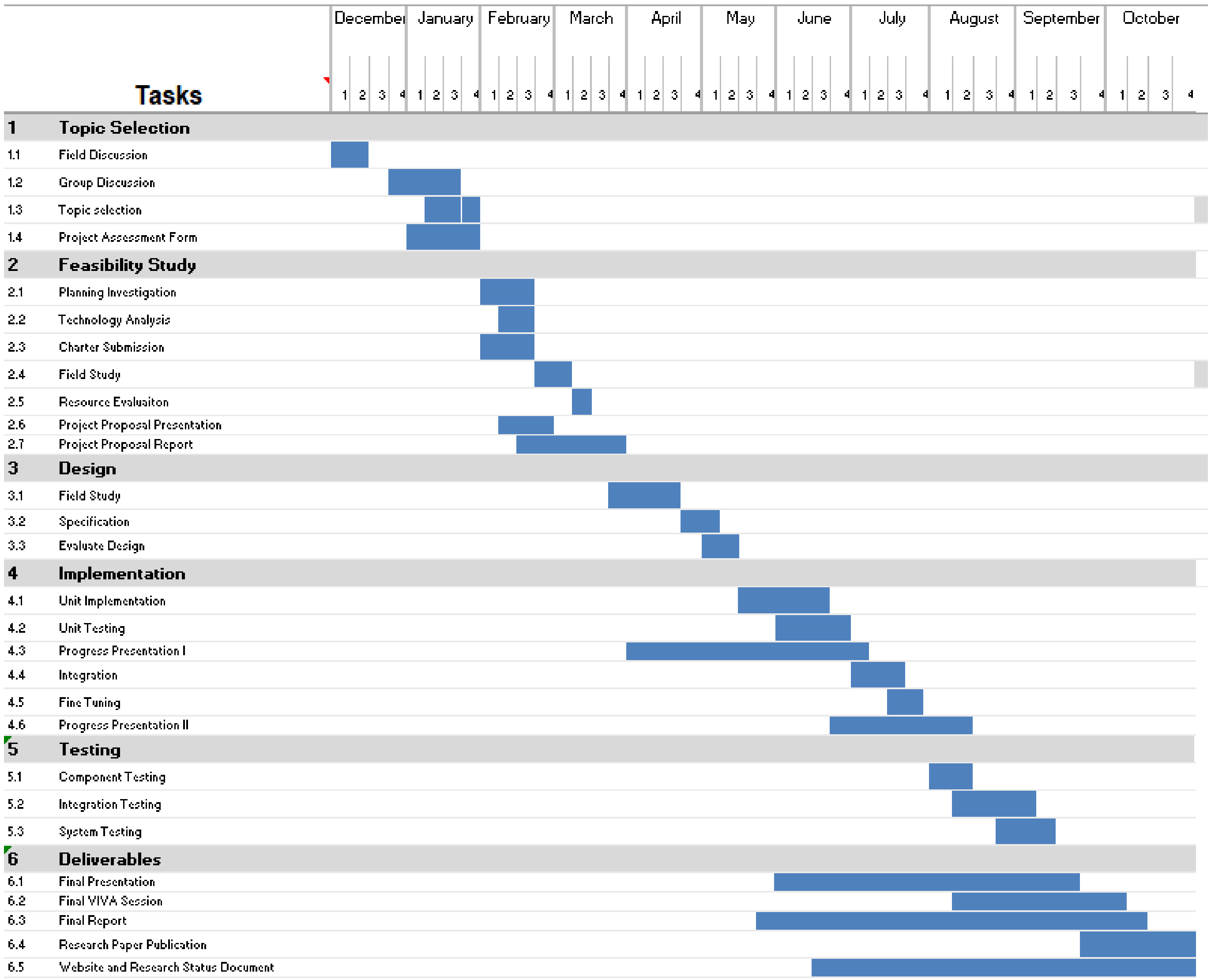

Figure 9.1: Gantt chart

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