E- TONGUE A SMART TOOL TO PREDICT SAFE CONSUMPTION OF WATER

Project ID CDAP 2020-164

Project Proposal Report

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DECLARATION

I declare that this is my 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 my 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.

Name	Registration Number	Signature
S. Thenuja	IT16170780	

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: ……

ABSTRACT

Groundwater quality is a comprehensive complication in all over the world. This proposed E-tongue is a smart intelligent tool to predict the safe consumption of groundwater. Forecasting groundwater quality parameters in the future also visualize the quality of nearby water sources in specific areas based on seasonal variations is one of the main features of this system. Moreover, people who are in dry zone area they are struggling to consume safe groundwater for drinking. This proposed system mainly concentrates on dry zone areas and select groundwater sources to identifying water quality parameters for training and testing. In addition, this proposed model able to predict the groundwater quality parameters effectively and meet the requirements of consumers. It would be a favorable assistant for enhance decision making for future sustainable quality of drinking water.

Keywords: - *water quality parameters, E-tongue, groundwater*

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LIST OF ABBREVIATIONS

Abbreviations	**Description**
ML	Machine Learning
AI	Artificial Intelligence
IoT	Internet of Things
ANN	Artificial Neural Network
WHO	World Health Organization
LSTM	Long-Short-Term-Memory
COD	Chemical Oxygen Demand
ARIMA	Autoregressive Integrated Moving Average
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
EC	Elective Conductivity
WQI	Water Quality Index
SDLC	Software Development Life Cycle

1. INTRODUCTION

1.1 Background Study

Since groundwater demand has been rapidly increased for the past few decades all over Sri Lanka particularly in rural areas. Groundwater is one of the main water sources for drinking. Due to usage of groundwater being continuously increased for major sources of rural water supplies primarily for Industrial, household and drinking purposes. Figure 1 shows drinking water coverage in Sri Lanka. There are 94% improved drinking water access and the remaining 6% is unserved. Besides, 80% of rural domestic water supplies depend on groundwater which from dug wells and tube wells.

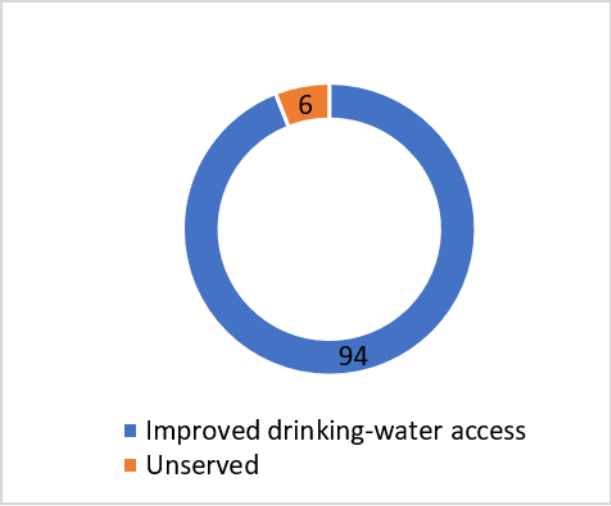

Figure 1 Drinking water coverage

Climate experienced in Sri Lanka for twelve months period is categorized into four seasonal variation as follow

- First Inter-monsoon Season (March - April)
- Southwest -monsoon Season (May - September)
- Second Inter-monsoon Season (October-November)
- Northeast -monsoon Season (December – February)

Groundwater of dry zone areas consume is raised rapidly as well as it will be affected by seasonal variation [4]. Sri Lanka is mainly divided into three climatic zones such as wet zone, dry zone, and intermediate zone. Figure2 shows the department of geography in Sri Lanka is divided into

climatic zones [2]. Hence, there is around 75% comes under dry zone areas also the absence of rivers in that area therefore consumers depend on groundwater for drinking and agriculture.

In research have been conducted in dry zone area specifically in Jaffna district of 200 participant, 57.5% population had poor knowledge on the transmission and prevention of water-borne diseases, although they are drinking uncertainty quality of water [6]. Consequently, 87% used unsafe water for drinking and domestic purpose. Up to 88% of water bone diseases arisen from unsafe water supplies and inadequate sanitation and hygiene [1].

World Health Organization (WHO) has own water quality index to check the water quality in all around the world. Forecasting water quality index of the located place is more advantageous to create awareness among the population. Besides, identifying the quality of water sources based on seasonal changes is more significant to prevent seasonal water diseases.

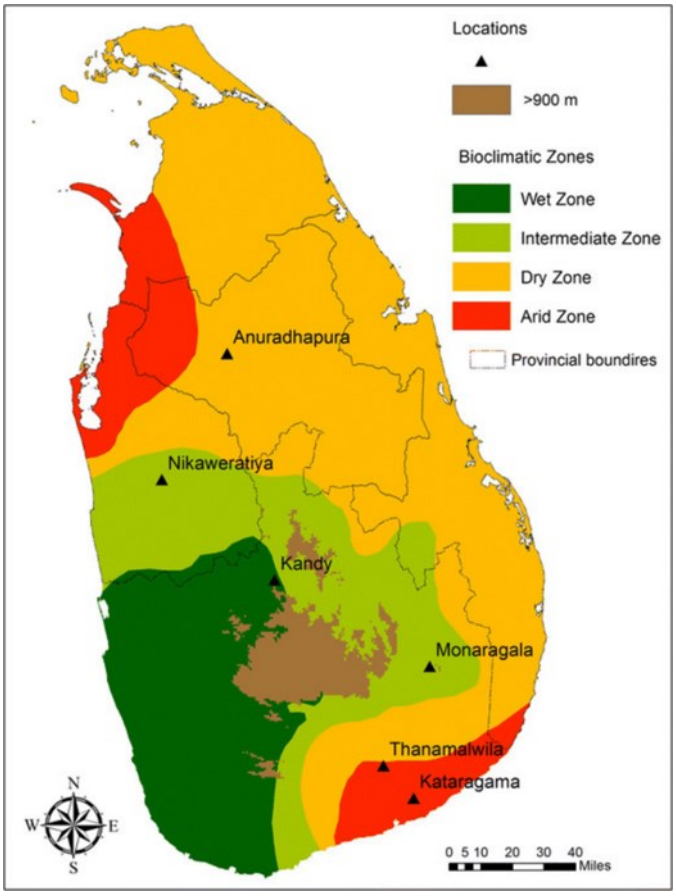

Figure 2 Climatic zones of Sri Lanka

Therefore, we are planning to develop a smart intelligence device to predict water quality in real-time as well as forecasting water quality parameters in the future. Accordingly, every people able to check the quality of water sources related to their area based on seasonal variation. Best quality of water sources nearby location in future visualizing on heat map. Alert the people when the water quality index in low. It will be a necessary application for most of the people who have been suffering from bad quality water.

1.2 Literature Survey

There are various kind of researches have conducted to gather requirement for the predicting water quality parameter and identifying water quality sources based on seasonal variation also improve forecasting water quality in future, therefore I have found interesting several research papers, articles and journals related to this domain even though extremely different features are identified while comparing with proposed system. Several significant details are gathered via these papers.

In 2017, the Water quality prediction method based on the LSTM Neural Network [3]. Mainly it has focused on water prediction and prevention of water pollution, it was a time series prediction. This developed system is used as a new method which is based on LSTM (Long- and Short-Term Memory) Neural Network for predicting quality of water inaccuracy in surface water in Taihu Lake.

A research was conducted to predict and forecast quantitative characteristics of water bodies by using Artificial Neural Networks (ANN) [7]. Salinity, temperature, dissolved oxygen, and chlorophyll-a were the interested variables considered in this domain. The ANN model can target both linear and non-linear relationships and then these relationships can be directly learned from the model which was being built using the data. The study in this domain particularly focuses on the Singapore Coastal water sources [7].

As well, Time series analysis of river water quality [8] is another research had conducted in this domain. Here, predicting the quality of river water by using the time series model and forecasting water quality for a particular river, which is surface water quality parameter, they mainly focused on water pollution and identifying water quality parameter which is going to be affected when the water was polluted [8]. Although the result of this research to generate a model which includes the water pollution factors and water quality parameters to prevent water pollution. Even though it will not suitable for groundwater and that does not consider seasonal variations.

This research depicts the time series of innovative models for water resources management can be built using both linear and non-linear patterns [11]. Certainly, Non-linear relationships cannot be dealt with the ARIMA model and both linear and non-linear patterns cannot be handled by neural network model. This approach proposes a hybrid ARIMA and neural network model along with a conjugated training algorithm [11]. Hence the model can be able to produce accurate predictions for the time-series data to the water quality predictions.

While gathering data on seasonal variation and get an idea about how the seasonal variation impacts the water quality, there is another research article was found [5]. In 2015, fifteen sampling centers were taken for investigation about chemical parameters which was conducted on pre-monsoon, monsoon and post-monsoon seasons [5]. The result of this research identifying water quality parameters which were impacted by seasonal variation.

In addition, there is another kind of research in time series model for forecasting of water quality of River Godavari, this research was done to forecast monthly basis water quality parameters such as pH, temperature of the water and Dissolved Oxygen in the water of river Godavari [12]. Time series analysis of past water quality data was learned to predict the future values. For each water quality parameter, they were calculated minimum, maximum, mean, standard deviation and variation for Actual measured, past (2009 to 2012) and future (2012 to 2015). After that, the various values of actual, past and future were compared with each other then made some conclusions such as there are some variations for past water quality values and the actual values the reason is the damage of the water in the current period. Their conclusion was water quality parameters affected by seasonal variations and trends [12].

Hence, another 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 were predicted and forecasted based on the time series analysis method and ARIMA modeling [13]. Burnett River is a river that is in 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 parameter values according to that values the government bodies can take necessary actions in the earliest stage [13].

In order to predict the water quality parameters of Karoon River (Iran) by artificial intelligence-based models, in this research the machine learning model was created by using 17 years (1995 to 2011) past dataset to predict future values of dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) levels in the water by using nine parameters such as PH, Ca, Mg, EC, Na, Turbidity, PO4, NO3 and NO2 [14].

Further, another research conducted in time series analysis of water characteristics of streams in Eastern Macedonia – Thrace, Greece, this research was done to predict maximum water temperature in the future [15]. The temperature of the water affects the maximum dissolved oxygen density in the water and speed of the chemical and biological reactions. Therefore, the machine learning model was developed by using datasets of April 2013 – July 2016 to predict the temperature of the water in the future. The forecasting values of the water temperature will be helped scientists and responsible parties to make good decisions about river pollution in the earliest stage that will save the lives of many living things which are depend on the water.

1.3 Research Gap

Numerous researches have done in this domain and some products are currently using in the software market. Further, all application has several limitations and it was focused on water quality prediction in real-time as well as mainly concern about predicting water pollution factors. The main intention of this proposed system to forecasting water quality parameters in the future and predicting consumable nearby water sources based on seasonal variations in a specific location.

Before start to implementing features of the system, we must have a deep analysis of relevant systems or products that were in the market. Implementing a new application which has the same features, it will be wasted time to implement the application. By analyzing the applications which are already available at the market, it is the most valuable to cut down the workload.

Table 1 Comparing with other applications

Features	Existing Products / Research				
	MeraBhujal [9]	**Water Quality 4Thai [10]**	**Time series analysis of surface water quality [8]**	**A new forecasting model for groundwater quality based on short time series monitoring data [11]**	**E-Tongue**
Location wise prediction	✓	✓	✓	✓	✓
Seasonal wise prediction	✗	✗	✓	✗	✓
Forecasting water quality parameter in future	✗	✗	✗	✗	✓
Visualization	✓	✓	✗	✗	✓
Predict consumable nearby water sources in the future	✗	✗	✗	✗	✓
Alert the consumer when water quality parameter having the danger values	✗	✓	✗	✗	✓

MeraBhujal[9] is an android application which provides location-wise water resources information to users and it's giving what is the availability of groundwater and how much consumed as yearly basis moreover it's providing the quality of the water-based on salinity, chloride, fluoride, iron, sulfate and nitrate values and its showing to end-user visually. Even though it doesn't have functionalities of Seasonal wise prediction, giving future water quality index, predict consumable water sources in the future, Alert the consumer when water component having the danger values.

Water Quality 4Thai [10] is an android application whenever the user searches a location it is providing water quality information for that location. The result contains province details, WQI values, and summation and we can filter the result by alphabetical order, province, WQI value and summation. Moreover, it's giving notification to the user if water pollution happens. Even though it doesn't have functionalities of Seasonal wise prediction, giving future water quality index and Predict consumable water sources in the future.

Time series… [8] is a research machine learning model that was created by using 9 water quality parameters such as TDS, EC, HCO^{3-}, $SO4^{2-}$, Mg^{2+}, Ca^{2+}, Na^{+}, pH and SAR. And by using that future water quality values were predicted.

A new forecasting … [11] is a research which was created a machine learning model to predict the chemical oxygen demand (COD) and predict hydrogen ion concentration (PH) values of five different cities.

These features have created a research gap which is opened a research space for us to come up with a fashioned application by using Machine Learning and Neural Network.

1.4 Research problem

Water quality prediction has more significance not only for the management of water sources but also for the prevention of spreading diseases such as diarrhea, cholera, Kidney Failure and Typhoid [1]. People are advised to drink quality or purified water. Most of the dry zone area people depend on the groundwater sources for drinking also they have a lesser number of water resources. Although seasonal variation impacts the water quality [5]. Besides, the result of water quality deterioration is intensified water scarcity in the future. Hence, people unable to forecast the water quality in early stage.

A smart intelligence device to predict the water quality is proposed to develop a final year research project.it will be predict the water quality for the future and visualization of water quality sources based on the seasonal changes on the heat map. If forecasting the water quality parameters of the groundwater in the dry zone area, then it will favor for people who are suffering from bad quality of water based on seasonal variation. Through this system, alert the consumer when the water becomes a low water quality index. Therefore, they able to take better precautions for purifying water.

While doing research on this domain I found some interesting research problem

- How people forecasting water quality?
- How to identify the quality of water sources based on seasonal variations?
- How to predictable to consumption of water sources in the future?
- How to get overall groundwater quality in the dry zone area?

To overcome the above-mentioned problems, gather data from the Irrigation department and water supply department in dry zone areas. As well as developing machining learning algorithms to predict water quality parameters and identifying the quality of water sources based on seasonal variation and forecasting water quality in the future. Through this research creating awareness among people who are affected by seasonal variation.

2. OBJECTIVES

2.1 Main Objectives

E-Tongue (A smart tool to predict the safe consumption of groundwater) is facilitated by forecasting water quality parameters in the future and predicting the quality of water sources on specific locations based on seasonal variation. This system provides other facilities for identifying water quality in real-time. Hence, it will give results with more accuracy and sustainable water quality parameters. Through this research mainly concern about predicting water quality parameters.

2.2 Sub Objectives

In order to accomplish the primary goal of this proposed system has consecutive sub-objectives need to be obtained.

- Collect the specific set of requirements in order to continue the project plan.
- Gathering data from the National Water Supply and Drainage Board, Irrigation Department in Sri Lanka.
- Exploration of the data set for data cleaning and understanding of the data.
- Extract features of the set of water quality parameters for forecasting water quality.
- Training the machine learning model by using different algorithms, then select the best suitable algorithm with high accuracy.
- Predict the water quality parameter for five years with high accuracy.
- Identifying water quality parameter which will be affected by seasonal changes.
- Predict the nearby quality of water sources in a specific area based on seasonal variation.
- Test the model by using the test data set.
- Implement graphical user interfaces and system logic based on the system specifications.
- Generate the heat map for visualizing places that have consumable water on a specific area.
- Alert the consumers when the water quality parameters are having bad values.
- Validate and test the implemented application whether the application has been completed the user requirements or not.

3. METHODOLOGY

This part illustrates the methodology for approach the proposed system's related functions. This is a methodological way of research. Follow the software lifecycle model to implement the system. The result of this system is a smart intelligent tool to predict the safe consumption of the groundwater.

It has many momentous research areas such as Machine Learning, Artificial Intelligence, IoT devices (Sensors) and Visualizing technologies. Research has conducted more studies on the above research areas. Hence, the gathered information will be used to achieve the main objectives and sub-objectives. Figure3 is shown the system architecture diagram of the proposed system.

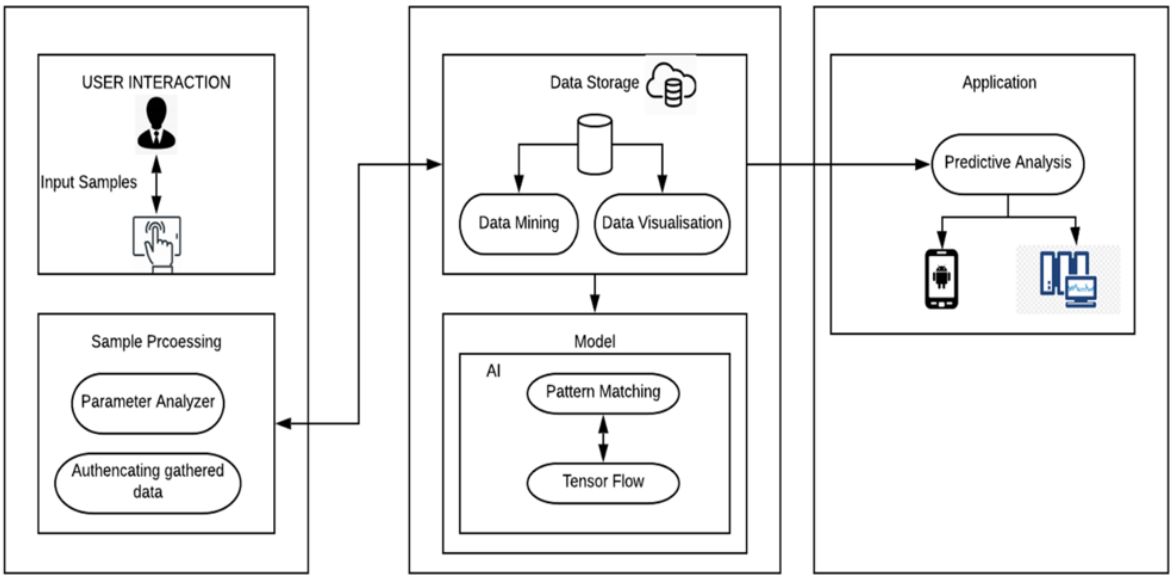

Figure 3 System Diagram

3.1 Procedures

3.1.1 Component Overview

According to the conclusion from the literature review, technology selection and software solutions are the most important part of this research. Forecasting water quality parameters in the future is one of the components in this proposed system. Consumers able to know the water quality parameter before. Further, they able to identify nearby quality of water sources based on seasonal variation. Generate the heat map to visualize the nearby quality of water sources. Figure 4 illustrates the flow of this component.

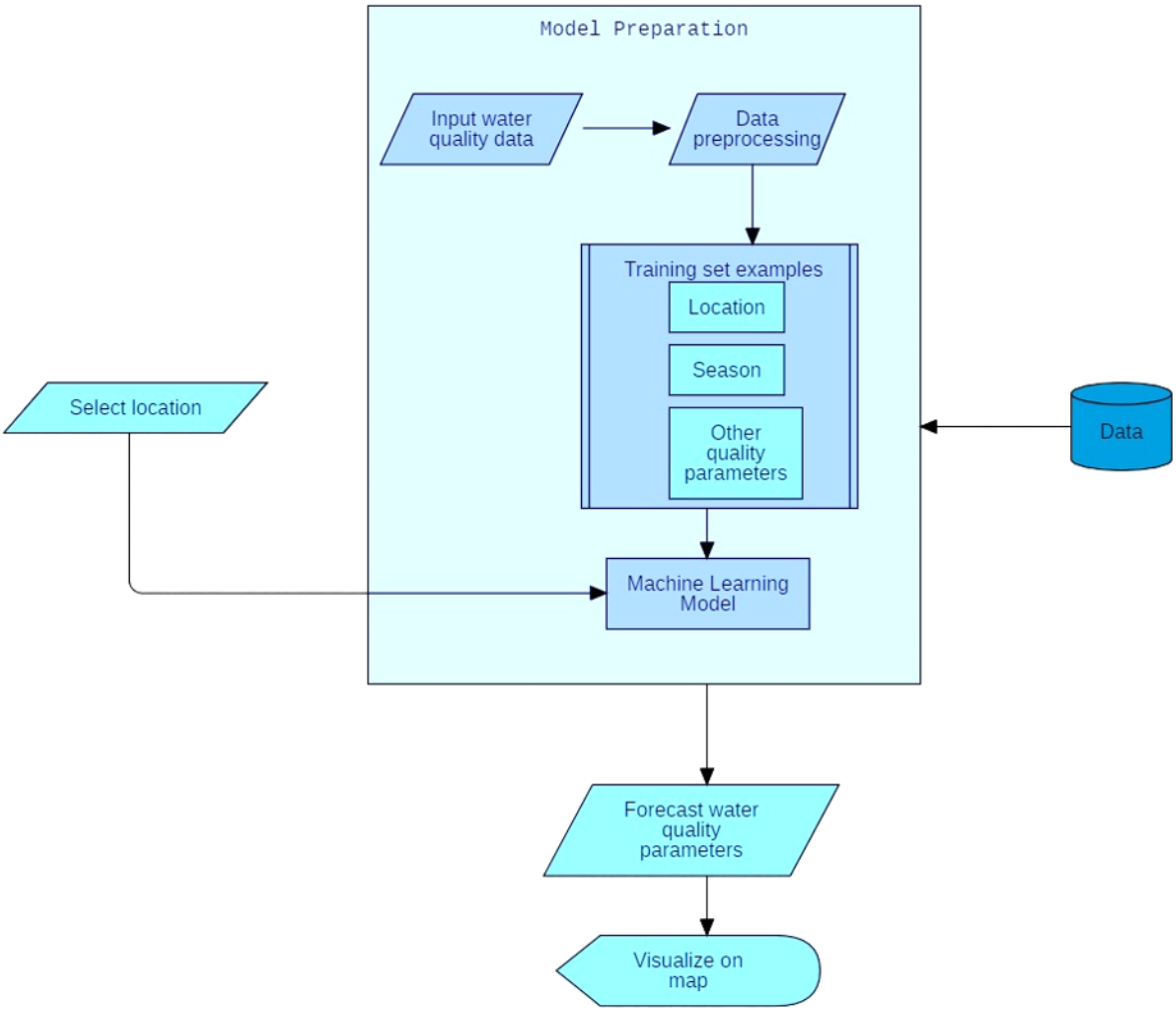

Figure 4 Flow of the component

The result of this component will be forecasted water quality parameter value for the future. When the user locates their location, the application will be shown the water quality parameter for the future. Hence, the user selects the season, it generates the heatmap on located area which includes nearby quality of water sources. Here, location is the main input for getting the output of this feature. This input sends to model which tries to forecast water quality parameter by using historical water quality data through Machine Learning algorithm.

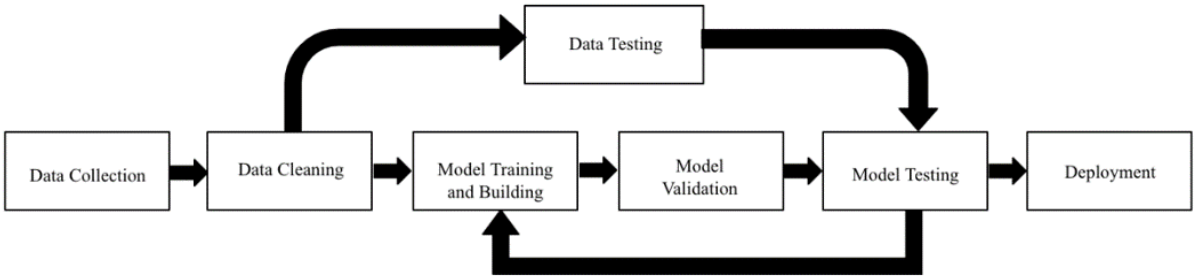

Figure 5 Machine Learning Model Progress

In order to predict the water quality parameters, we must follow prediction phase tasks it is shown in figure 5 that are an exploration of the data, feature extraction of datasets, training model by using a different algorithm, predict water quality parameters, validating the model and testing model.

Algorithm: - according to this forecasting water quality parameter component is used historical data for the prediction. ARIMA is a famous and extensively used statistical technique for reading and forecasting time series information. It is a clear and effective approach for time series forecast [16], the ARIMA model is selected for considering time series data of water quality parameter based on seasonal variation and location wise. It will be a huge dataset that will handle. ARIMA Model is chosen considering that the water quality parameter is a time series dataset, also because of the need to address a big dataset. Since accuracy is much important, the ARIMA model is fine appropriate because it offers greater accuracy than the alternative version.

3.1.2 Development Process

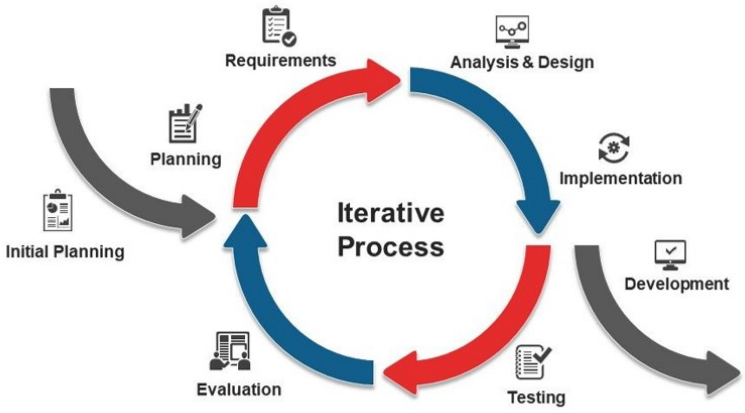

Figure 6 Iterating Process

Figure 6 illustrates the steps of the iterating process. In order to develop the application, we should follow this way to achieve the requirements.

Feasibility Study

It is an initial phase of every project. As we discuss the factor and problems about drinking water with people who are in dry zone areas as well as the Department of water supply and drainage in Sri Lanka. According to their statement, we are planning to do an alternative solution as this proposed system "Smart Intelligence tool to predict safe consumption of water" which has AI, ML and IoT technologies, that are trending technologies for solve their problems effectively through this research. Since it is an android application following technologies and tools are going to used to develop the proposed system.

- Pycharm
- AWS (Amazon web services)
- Android studio
- Android phone
- GPS

Requirement Gathering

By reading numerous research papers regarding the water quality prediction domain, to come up with what type of system we are going to do and what are products available in the market. Once gathered the requirement, to come up with an overall solution for the stated problem.

Implementation

Developing a mobile application that is used to view the result of forecasting water quality parameters based on seasonal variation at located location. A well-designed smart mobile application can appeal to person and they may share it with their community. But enforcing a mobile software with no issues could be very tough. In order to put into effect a successful mobile application, one has to paintings through the following steps.

- Identifying user requirements for mobile application
- Strategize
- Set the scope

- Asses essential resources
- Implementation planning

Model development

- Data collection: - For this component, gathering qualitative and quantitative data of water which has historical data of water quality parameters of specific place water sources which is used to calculate the water quality index. This has maintained in the Department of National Water Supply and Drainage Society.
- Data cleaning: - Incomplete and inconsistent data will be affected the result of the machine learning prediction therefore we should be developed the machine learning model will good quality data then only we can expect quality output.
- Data cleaning is a mechanism of identifying and removing inaccurate water quality parameters, corrupted and noisy data from the original dataset.
- Model Training and Building: - In this process, machine learning model will be developed by using cleaned past year water quality datasets with the ARIMA algorithm. For training the model which we are divided the dataset into 2 components. 80% for training data and 20% for testing data.
- Model Validation: - It is the mechanism of checking the correctness of the machine learning model output against the real data. Model validation can be done by measuring the accuracy of the results by using train datasets and test datasets. The advantages of model validations are early identification of bugs, cost deduction and Improving the quality of the model.
- Model Testing: - It can be done by testing the data used to train the model, testing the features of the model and finally testing machine learning algorithms of the model.
    - Testing the data which used to train the model – In this process checks whether datasets contains adversary dataset or not. If it has an adversary dataset it will be make Data Poisoning therefore result will be varied. To get correct and accurate output adversary dataset should be removed from the original dataset in this process.

- Testing the features of the model – In this process, if machine learning model contains redundant/irrelevant features it will make prediction bugs therefore those features will be removed to get better prediction results.
- Testing machine learning algorithms – In this process which machine learning algorithm will be provided best performance and accuracy with new data sets at regular intervals will be selected for the model.

- Deployment: - In this process, machine learning model can be deployed in Platform as a Service (PaaS) or Infrastructure as a Service (IaaS). The PaaS is good for lower traffic and if traffic increases good for moving to IaaS. There are many reliable and scalable cloud providers are available in the market such as AWS.

Testing

In this phase, testing the application and fix the bugs. Through testing, applications become more quality and the best deliverable product. Software testing out could be very critical in the development life cycle to identify defects and errors that have been made during the development stages. And, it is very essential to make sure the quality of the product. it is required for a powerful performance of product or software application. it is required every phase that we are following in SDLC which has below testing categories such as unit testing, integration testing, system testing, and user acceptance testing.

Maintenance

The maintenance phase is the last phase of this SDLC model. Here, maintain the software updates, repairs and fixes of the application.

3.2 Technology Selection

3.2.1 Software component

Mobile development	: Android
Machine learning and Artificial Neural Network	: Keras, Python
Continuous Integration and Continuous Delivery	: Jenkins
Version controlling	: Git

3.2.2 Project Management

Trello

Slack

3.3 Gannt Chart

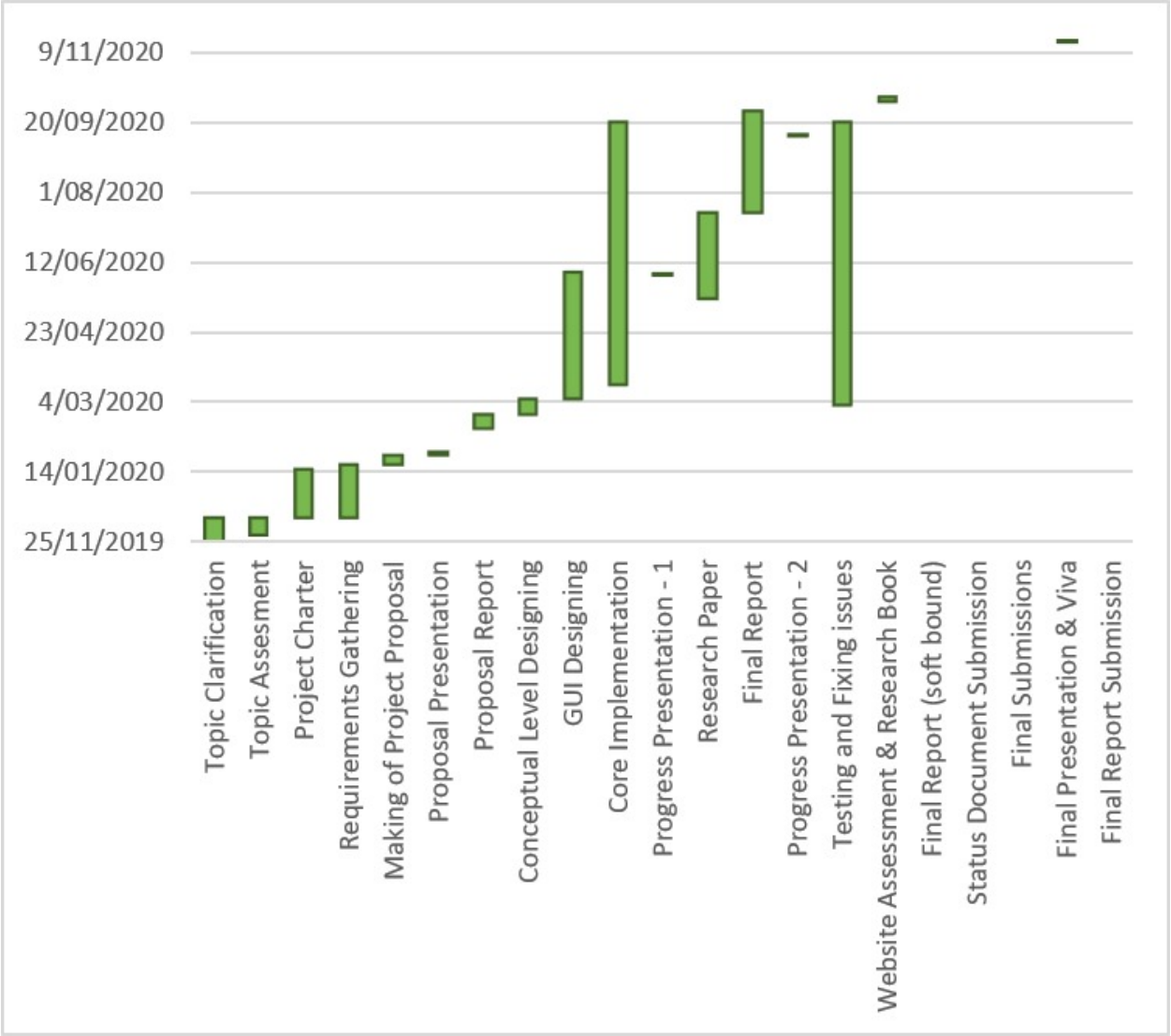

Figure 7 Gannt Chart

3.4 Work Breakdown structure

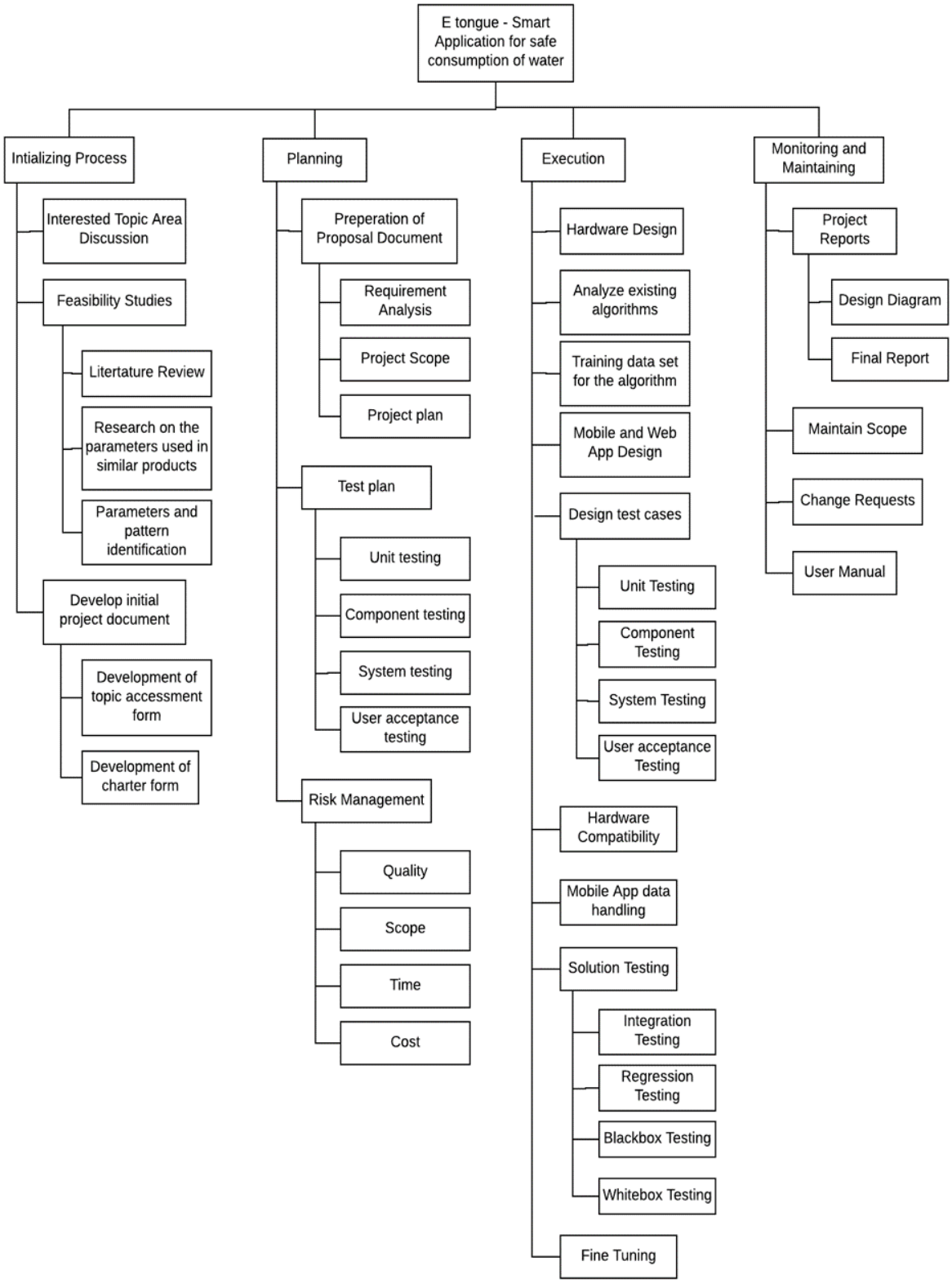

Figure 8 Work Breakdown structure

4. DESCRIPTION OF PERSONAL FACILITIES

Table 2 Description of personal facilities

Member	Component	Tasks
Thenuja S	• Forecasting water quality parameter	• Feasibility study to perceive the requirement of the aspect. • Identify the dataset which will be used in machine learning model. • Perform a thorough study of water-borne diseases and identify the major diseases that can be identified using the solution. • Identify the most suitable algorithm in order to produce accurate results. • Test the developed machine learning model with a dataset that has known results in order to obtain the accuracy.
	• Visualize the quality of water sources nearby locations based on seasonal variations.	• Gathering seasonal variation data. • Preparing a machine learning model with accuracy. • Implementing visualizing technique to show the outputs. • Develop a mobile application in order to visualize a heatmap.

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