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

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 acknowledgement 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 acknowledgement is made in the text.

Name	**Registration Number**	**Signature**
P.M.S.S.B. Gunarathna	IT16168800	

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

Smart solutions for water quality detecting are picking up significance with headway in communication innovation.21.4% of population is Sri Lanka satisfy their domestic water supply needs from groundwater assets. These water resources are spent without checking the safety of the water and they can be face to major outbreaks in future. Unawareness of the safety and quality of the water that consumes can leads to major health problems. Chronical kidney diseases and water borne diseases has been a major health concern in Sri Lanka that causes due to consumption of water that does not meet the water quality standards. There is less amount of solutions to identify the quality and the risk of exposure to CKDu or water borne diseases. The current solution for the issue is to propose a real time and user-friendly method to detect the quality of water and predict the risk of exposure to CKDu and water borne diseases. "E-tongue" the proposed smart device will be implemented to detect the quality of the water in real time using cloud platform and predict the risk of CKDu and water borne diseases using machine learning approach. The end results will be visualize using a cross-platform approach which consists with an android mobile application and web dashboard. The ultimate goal of the solution is to beware the people who are consuming the groundwater about its safeness, quality and risk of health concerns.

Keywords: water quality, machine learning, real time, CKDu, water borne diseases, cloud

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LIST OF ABBRIVATIONS

Abbreviation	Description
IEEE	Institute of Electrical and Electronic Engineers
IoT	Internet of Things
CKDu	Chronical Kidney Disease of unknown origin
GSM	Global System for Mobile Communications
NWSDB	National Water Supply and Drainage Board
TDS	Total Dissolved Solids
WQI	Water Quality Index
WQP	Water Quality Parameters
WSN	Wireless Sensor Network
SMS	Short Message Service
PH	Potential of Hydrogen
COD	Chemical Oxygen Demand
RSC	Residual Sodium Carbonate index
SAR	Sodium Absorption Ratio
ML	Machine Learning
AWS	Amazon Web Services

1. INTRODUCTION

Ground water is one of the major water resources that is extensively used in Sri Lanka for domestic, industrial, commercial and other purposes. Among 21.44 million population of Sri Lanka 5.3 million people, in percentage of 21.4 meet their rural domestic water supply needs from tube wells and dug wells by accessing ground water [9]. Uncontrolled use of ground water and natural poor quality or contamination can lead to major health concerns such as kidney failures, cardio vascular disease, dental fluorosis and CKDu. Unawareness of quality of the consuming ground water is one of the major causes for these scenarios. Chronic Kidney Disease of unknown aetiology (CKDu) is one of the greatest problems in north central province (NCP) which recorded highest mortality and morbidity rates and recognized reasons were unknown. Although there are solutions to determine the quality of ground water sample, those solutions need a period of time to deliver the results. Therefore, a solution that will help to overcome the challenge of determining water quality real time is demanded.

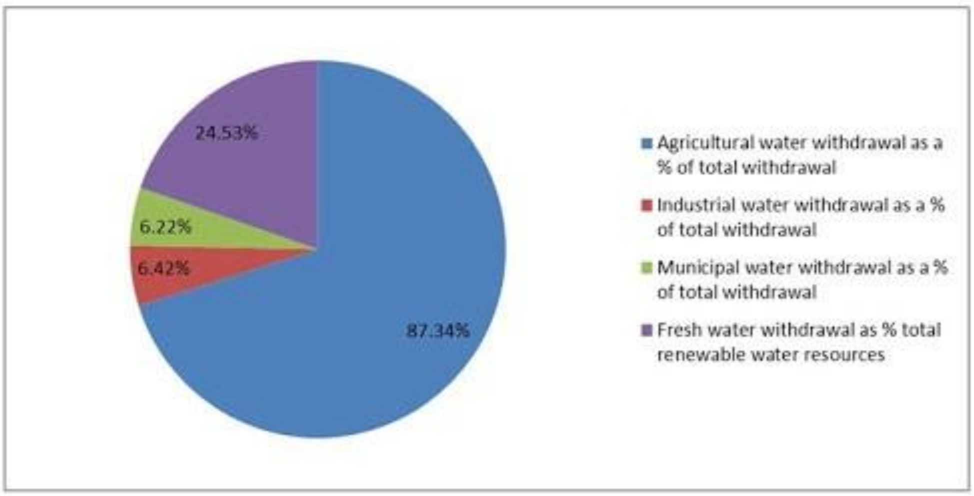

FIGURE 1.1: USAGE OF WATER

Research group has proposed a real time intelligence device which will be able to determine the quality of a consuming ground water sample. The real time behavior of the device will be gained using cloud services and the result can be accessed by a mobile application and a web application. Proposed system will be able to predict future risk of water borne diseases mainly concerning CKDu for a given area by assessing the water quality parameters such as PH, electrical conductivity, turbidity and TDS and it will be refined using the result of predicting future quality of a water sample which will be a functionality of the proposed solution. The proposed solution will be able to resolve a major problem that people face due to quality of consuming ground water.

1.1. Background and literature survey

Prof. Fredrik Winquist from the department of applied physics, Linkoping University, Sweden is the inventor of the voltammetry based electronic tongue concept voltammetry based electronic tongue concept [1]. By embracing the concept of E-tongue significant amount of research project have conducted such as analytical gustatory tool [2], wine discrimination [3], classification of tea samples [4] with usage of complex mathematical models.

The study performed by C.R. Panabokke and A.P.G.R.L. Perera on Ground water resources of Sri Lanka [9] there are six types of ground aquifers has been identified in Sri Lanka. And 80% of rural domestic water supply needs are met from groundwater. About 93 water supply schemes of nearly 30 percent of total water supplies distributed all over the country are operated base on supplies from shallow and deep groundwater.

According to research study conducted by Nikhil Kedia on Water quality monitoring for rural areas- a sensor cloud based economical project [7], 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. However, this solution can be improved to real time system.

According to the research carried by W.C.S. Wanasinghe and colleagues on Drinking water quality on chronic kidney disease if unknown aetiology [5], 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.

As is mentioned in the study that carried on Giradurukotte, Sri Lanka by M.K.N. Kumari and colleagues with the topic of Disease of unknown aetiology (CKDu) prevalent and non-prevalent areas in Giradurukotte, Sri Lanka [6] thirty-two water samples were selected representing CKDu prevalent and non-prevalent communities and experimented the water quality parameter such as PH, Electrical conductivity, TDS. Based on measured water quality parameters twenty five percent of ground water bodies were identified as doubtful, whereas all the natural surface water bodies were identified as suitable for drinking purposes.

In the research carried by Kuan Y. Change and colleagues on Association between water quality chronic kidney disease prevalence in Taiwan [8] they have checked association between 61 water attributes. Only 4 attributes of had positive result on significant association which are magnitude of Zn, ammonia, COD, magnitude of dissolved oxygen.

2. RESEARCH GAP

To determine the quality of water that people consume, multiple research projects were carried on. In each solution that provided by those research project has several limitations which prevent solution from gain total functionality that use to determine the quality of water. The research projects that carried in Sri Lanka has mainly focused on delivering result after delay of a time period rather than delivering it on real time. And most of the mobile application solutions needs to feed the data of the water sample manually to the mobile app in order to display the results. The cross-platform approaches are not implemented on most of the solutions that are related to water quality detection.

As a major health issue that happens in Sri Lanka, significant amount of research projects was take place to determine whether there is a connectivity between water quality parameters and CKDu. Even though there are proven results that shows the connectivity, no major implementation has done to determine the risk of water borne diseases and CKDu of a water sample.

TABLE 2.1:COMPARISON OF EXISTING SYSTEMS

Features	Existing Research/products				
	TDS	Irrigation water quality calculator	Zen-Test	Water quality monitoring for rural areas	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					✓

TDS [10] is an electronic device that can gather basic water quality parameter in real time and provide a result that shows the purity of the water. But in order to use the device user needs to have a thorough understanding about the device. The device is not connected to any cloud platform or it does not analyze any past data of water samples. Using the device user cannot identify the future water quality or risk of water borne diseases.

Irrigation water quality calculator [11] is an android mobile application which user has to upload the details of a water sample such as location, Ca^{+}, Mg^{+2}, carbonates and bicarbonates and it will give user the quality index such as RSC and SAR.

Zen Test smart water quality tester [12] is an android app that is designed for Zen test enabled smart multi parameter water testers which will connect via Bluetooth to the app. Using this app users can measure PH, conductivity, TDS, salinity and resistivity and show the results whether those values are under safe values.

Water quality monitoring for rural area is a research that focuses on ways to improve the water quality and awareness about the same through a sensor-actuator system which later shifts to Sensor-Cloud model. The project proposes different sensor systems. Apart from the embedded design and information dissipation, the project paper also discusses the technical challenges and economic viability model of the system involving Mobile Network Operator and Government.[7]

Above mentioned factors have created a research gap which lead research group to come up with the proposed solution of intelligence application by using machine learning, neural networks and cloud services.

3. RESEARCH PROBLEM

Detecting quality or ability to consume the water plays a major role in preventing health problems from water borne diseases. The majority who are suffering from water borne diseases and specially CKDu residing in dry zone areas of the Sri Lanka, where majority of people use ground water for consumption. But consumers of ground water resources do not have an efficient way to identify if there is a risk of water borne disease or CKDu in water resource which they use for consumption or domestic purposes.

Therefore, the proposed solution of the research project will detect the quality of the water real time and display the data in either web application or mobile application which user can access easily. The system also predicts if there is a possible risk of water borne disease or risk of CKDu. In order to perform the function accurately suitable mathematical model will be trained. Using the solution users will be able to take precautions in order to prevent the health concerns or prevent from using particular water resource.

4. OBJECTIVES

4.1. Main objectives

The main objective of this function is to predict the risk of exposure to CKDu and water borne diseases by consuming the given water sample resource for a longer time period. In order to implement the research project solution a real time system, implementing cloud services in another main objective of the component. Make people beware of the safety state of the water resources which they are consuming would be the end result goal of the proposed solution.

4.2. Specific objectives

- Perform a feasibility study to identify the requirement of the component.
- 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.

5. METHODOLOGY

The methodology of the component consists with two main functionalities. Transfer data and visualization will be one major functionality and predict the risk of the exposure to CKDu and other water borne diseases is the other main functionality.

5.1. Procedure

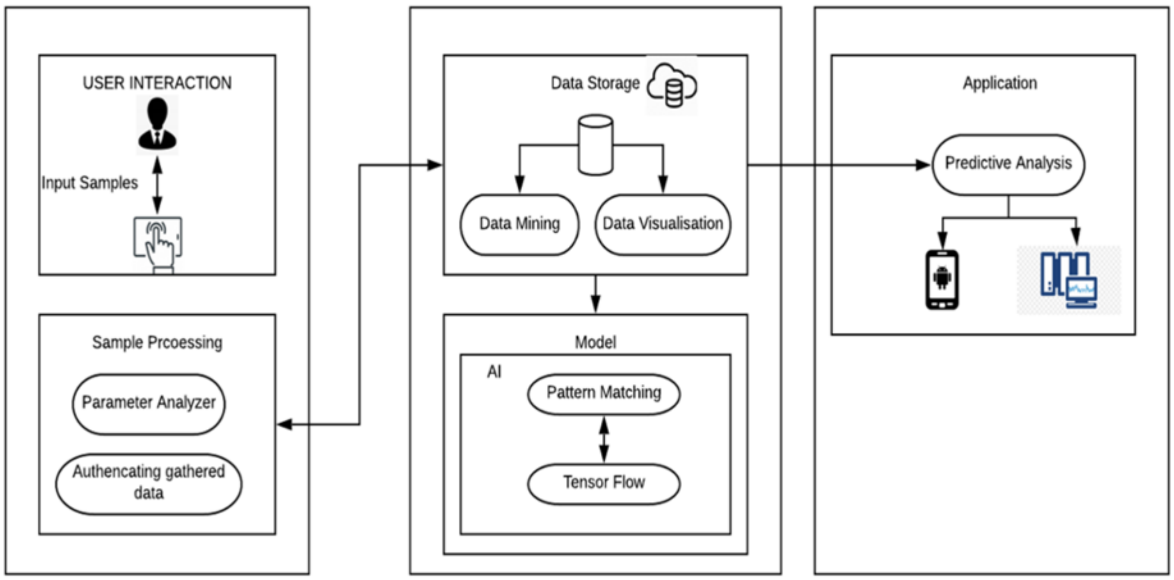

FIGURE 5.1: SYSTEM OVERVIEW DIAGRAM

5.1.1. Transfer data and visualization

This component functionality describes about the data transferring, analytics and visualization of the proposed system. Initially the raw data that will be collected from sensors will be transferred to the cloud platform. The output generated from the IoT device are consists the combination of structured, semi-structured and unstructured data. These data will be preprocessed and transformed to a proper defined structure. Then the data will be combined with the time series for the usage of streaming data.

Once raw data is preprocessed the data needs to be feed for several functionalities. A data streaming pipeline needs to be implemented to ingest the data to the mathematical models for real time predictions. These streaming pipelines will be also used to stream data to dashboard and obtain results from mathematical models.

Since the major functions are deployed on the cloud platform, server-less functions will be developed to trigger the relevant functionality. Finally obtained results will be transferred to mobile application and web dashboard for visualization. An android mobile application and web dashboard will be developed for visualize the results real time. Figure 5.2 shows the basic flow of the function.

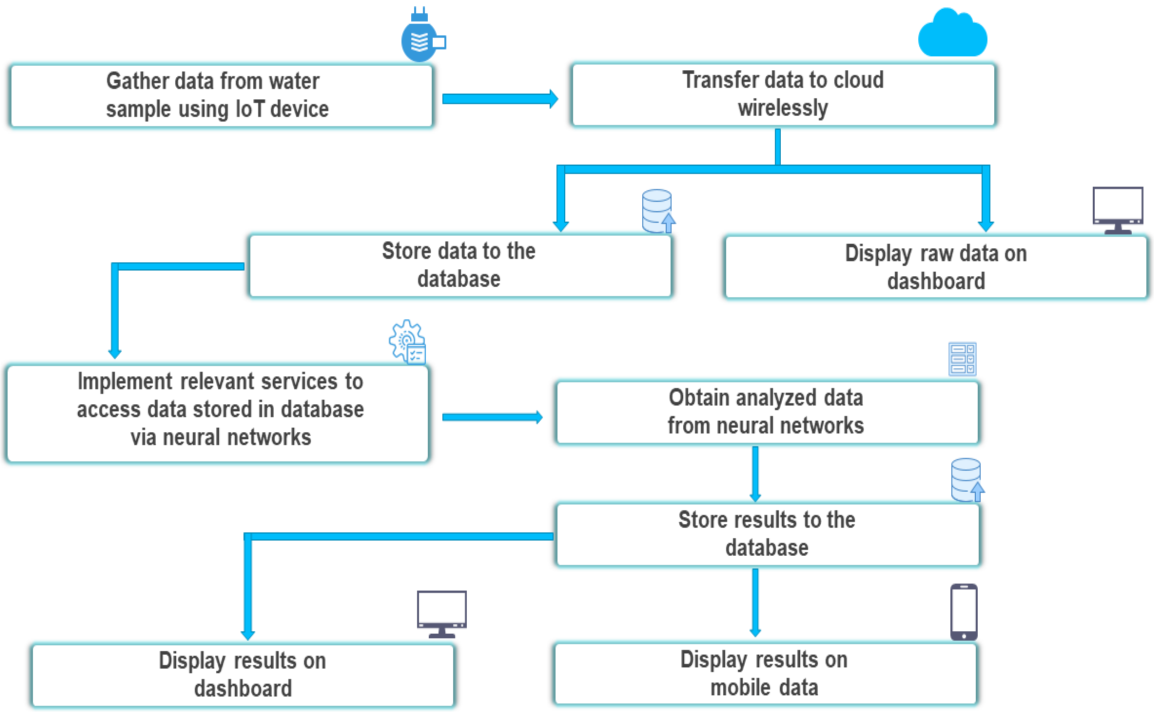

FIGURE 5.2: FLOW DIAGRAM OF TRANSFER DATA AND VISUALIZATION

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

Predicting whether user will be exposed to the CKDu and other water borne diseases by consuming the water resource that water sample is collected is the main functionality of the component.

There is significant amount of diseases that caused by pathogenic micro-organisms that are transmitted in water which are known as water borne diseases. Therefore, a thorough study needs to be performed in order to find and decide which water borne disease can be identified using the proposed solution.

The results will be obtained using a machine learning approach and the data set which will be used to train the machine learning model will be obtained from Department of Irrigation of Sri Lanka, Water Resources Board and hospitals. Once the dataset is collected machine learning model needs to be created. ML model will be trained using collected dataset and different algorithms in order to determine the most suitable algorithm for the solution. Two different models can be trained for CKDu and water borne diseases. Using trained ML model, the risk of exposure to CKDu and water borne diseases will be predicted. Figure5.3 shows the basic flow of the function.

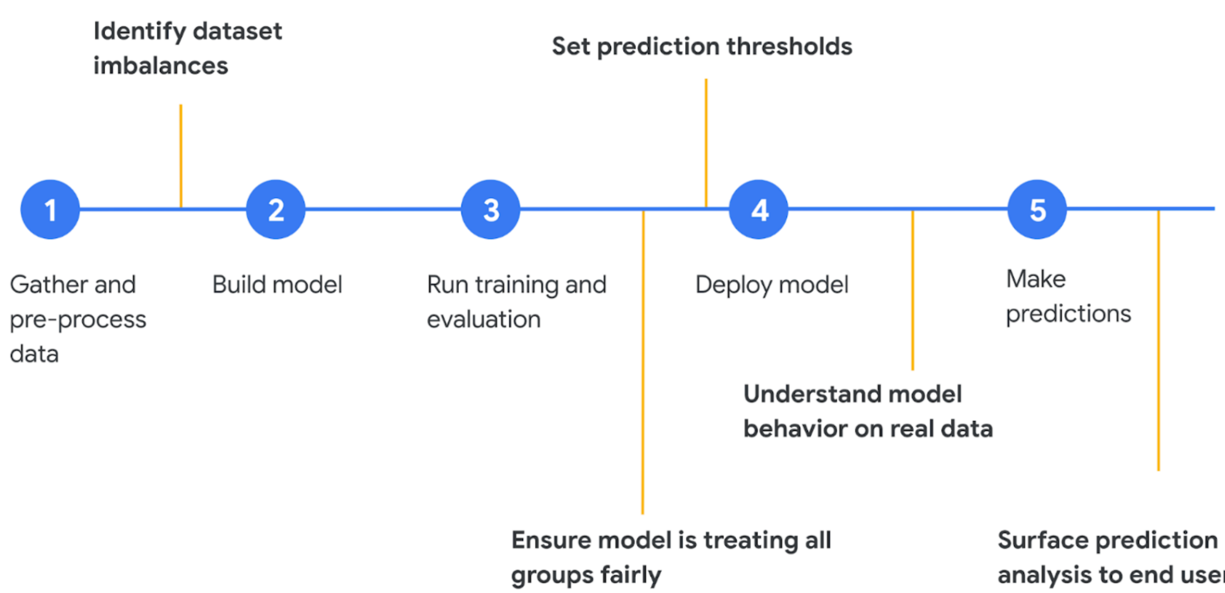

FIGURE 5.3: BASIC FKOW OF PREDICTION

5.2. Technology selection

5.2.1. Software component

Mobile development	: Android
Web Development	: React JS
Machine learning and Artificial Neural Network	: TensorFlow, Python
Version controlling	: Git

5.2.2. Project management

Trello

Slack

5.3. Gantt Chart

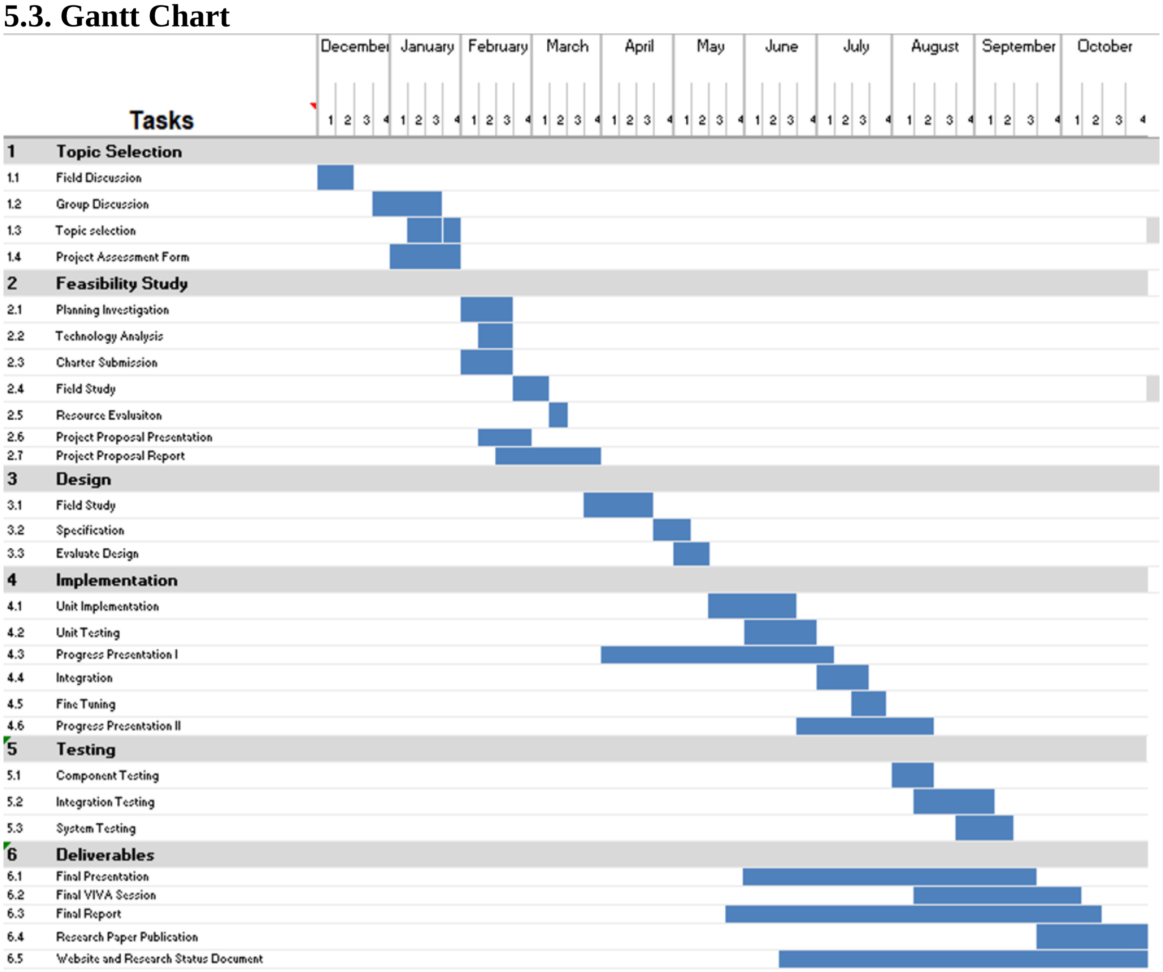

FIGURE 5.4: GANTT CHART

5.4. Work Breakdown Structure

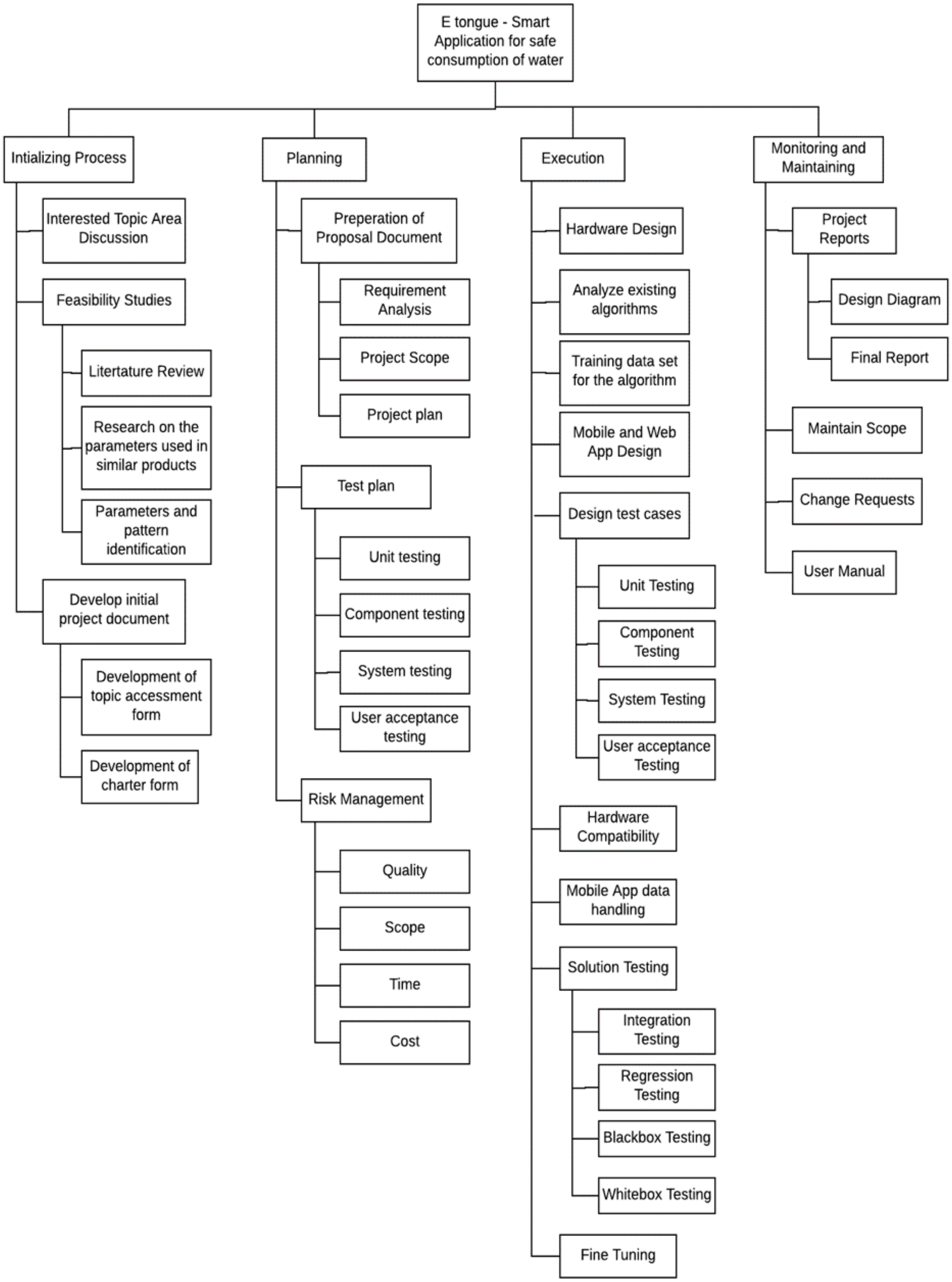

FIGURE 5.5: WORK BREAKDOWN STRUCTURE

6. DESCRIPTION OF PERSONAL AND FACILITIES

Member	**Component**	**Tasks**
Gunarathna PMSSB	• Predict the risk of exposure to CKDu and water borne diseases by consuming the given water sample resource for a longer time period.	• Perform a feasibility study to identify the requirement of the component. • 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 data and visualization	• 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.

7. BUDGET AND BUDGET JUSTIFICATION

TABLE 7.1 BUDGET CALCULATION

Description	**Amount (Rs)**
AWS IoT core	15.00
ML model deployment	2300.00
Cloud Storage	30.00
Total	2345.00

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