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Interim Report

Forest Fire Detection and Alert System with LoRa

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Abstract

Forests are the crucial part of the ecosystem and the environment to which humans and other life forms are dependent for survival. It is also one of the major sources of economy for human beings. In the current time, forest fire is a great problem that is faced by not only humans but by many other creatures too. Forest fire is creating a lot of trouble in the environment and brings a lot of changes in the climate. In the recent forest fire in Australia alone, an estimation of 500 million animals have been killed. In the recent years, the frequency of forest fire is increasing. The forest fires can be controlled with immediate response after knowing the fire has just started. There is a need of suitable fire monitoring system in several remote forests. To overcome this problem, a system based on IoT infrastructure has been proposed by incorporating several sensors to detect and alert the forest fire. Choosing a suitable methodology, the project has been in development.

Table of Contents

Table of Figures

Table of Tables

1. Introduction

Forest fires are common in a lot of parts in the world and as simple the word ‘forest fire’ seems, the damage caused by this disaster is immeasurable. Generally occurring during summer due to heat and also by lightning, nowadays the number of wildfires is increasing due to humans for agriculture and wood industry. Being aware of forest fire in time is imperative to reduce the loss that is made to nature by the disaster. Continuous monitoring is necessary for the protection of the forest as well as inspecting the changes occurring in the climate.

1.1. Problem Statement

Nepal is highly prone to forest fire as it is situated in the temperate region of the world. Wildfires generally occur in Nepal during the dry season from November to June affecting both vegetation and wildlife. In 2016, a total of 5630 wildfire incidents have been reported burning an area of 222,046 hectares and has caused degradation of wildlife and forest in Nepal (Bhujel, et al., 2018). In the USA alone, there were 46,706 wildfires recorded from January 2019 to November 22, 2019 burning around 4.6 million acres of land (National Interagency Fire Center, 2019). Release of vast quantity of greenhouse gases and smoke pollutants degrade the ecosystem indirectly. The fires caused due to natural and human factors increase the carbon emission which directly influence climatic change. Such climatic change has resulted in increase in temperature thus changing monsoon pattern. Increasing in number of disasters like flood and landslide is the consequence of this factor (Matin, et al., 2017).

1.2. Current Scenario

At present, forest fire monitoring in Nepal is done by Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. MODIS performs data acquisition, processing and reporting fire location with 1x1 km resolution twice a day as it passes over. This system sends email to several forest divisions and sends an SMS alert to them. However, this monitoring system watches over a certain location only twice a day (International Centre for Integrated Mountain Development (ICIMOD), 2019). This creates nearly 12-hour gap between monitoring time. If a forest fire starts during this interval, there is less chance of detecting and stopping the fire before it spreads on a large scale.

1.3. Survey Result

A survey conducted among 10 different people who have knowledge on working of Internet of Things, most of them think forest monitoring system is not efficient in Nepal and require a monitoring system that can detect fire as soon as possible. The project will help in controlling forest fire.

1.4. Project as a Solution

As a solution to the problem caused by forest fire, a system that can detect forest fire remotely and alert the relevant authority as fast as possible, has been in development. This can assist in protection of vegetation and wildlife from forest fires with an immediate response afterwards. In this proposed solution, there will be two nodes consisting of sensor node and receiver node. Humidity and Temperature sensor, flame Sensor, smoke sensor and rain sensor integrated in Arduino as sensor node will be place in different locations of forest. Data collected by various sensors will be sent at gateway placed in forest department with wireless transmission medium, LoRa. The fire will be detected with the intelligent algorithms set in the receiver. The data received at the gateway will be used in analysing data to find fire patterns.

1.5. Aim and Objectives

The aim and objectives set for a project helps in realization of goals by providing a framework for the case, identifying the destination and providing guideline to get there.

Aim:

The main aim of this project is to develop a prototype system that is based on the infrastructure of IOT using the sensors that can detect the raging fire in the jungle and alert the officials immediately so that appropriate actions can be made to minimize the loss caused by forest fire. A cost-effective transmission medium is required to transmit the data from sensor node to the base station or gateway and store data in database.

Objectives:

- Gather the hardware required for setting up the device.
- Design the circuit nodes and then integrate all the sensors and electrical equipment with Arduino.
- Set up transmission medium, LoRa, in both sensor node and gateway/receiver node.
- Test the working of all the sensors and data transmission between the two nodes
- Developing interface to store all the received data and conduct data analysis for fire pattern.
- Perform Vulnerability Analysis and Penetration testing to secure the device.

2. Background

In the case of forest fire, the delay in controlling forest fire after there has been detection is caused due to the delay in relaying the information giving warning about the fire. This problem is due to lack of proper network for data communication. Therefore, a device system that can make communication over a large distance without internet is needed.

2.1. Summary of survey

The survey conducted among the people who can understand this project that is being developed. A total of 10 people responded the survey. From the survey 90% of them consider that Nepal has inefficient forest monitoring system as its reliance on NASA’s satellite.

Six out of ten people consider the impact of forest fire in Nepal is very high, 3 of think there is a high impact and 1 responded with moderate impact. All of them think forest fire needs to be detected and controlled as soon as possible. 80% of them are certain that this project will help in controlling forest fire. As for its practicability, 40% of them gave a rating of 5 out of 5 and 60% gave a rating 5 out of 5.

2.2. Similar Systems

This project has been proposed for development by keeping in reference of the several other previously developed devices that could detect the forest fire and provide alert about them. This section discusses about the several such devices from which concepts have been taken in order to develop the project. The development of those systems, working process as well as critical analysis of the systems are also discussed.

2.2.1. Similar System 1

An IoT Based Forest Fire Detection and Prevention System Using Raspberry Pi 3 (E, et al., 2019).

This is a Raspberry Pi based system which works as the processing unit in this system. It is an integrated system where Raspberry Pi 3 Model B, GSM modem, GPS module, PIR sensor, a normal web camera, Flame sensor and buzzer work in co-ordination to information about fire. When the system is working, the sensors and equipment record the data continuously. Raspberry Pi processes the data and decides if the fire has occurred based on the algorithms set in the Pi.

During the time of fire, when raspberry pi receives high value, message through SMS alert is sent to the forest department. The SMS includes a warning message and google map link of the fire location. At the time, an image is captured and is sent to the fire station through mail via WiFi. At the same time the system activates the buzzer to notify the forest department as soon as possible. The received information is updated in their webpage after that (E, et al., 2019).

The good feature of this system is that it gives the exact location of the fire occurring place through the use of GPS. The sensors used in the system gives almost accurate detection during forest fire. There is less chance of false alarm and works efficiently. However, the ineffective part is problems during data transmission through WiFi. WiFi does not have a wide range and information is hard to receive in the forest department. So, missing of information would be common in the system.

For the final year project, the use of sensors is implemented for the accurate detection of fire. The temperature and humidity sensor and flame sensor are used in the FYP. The idea of notifying the forest department about the information of fire location is also implemented. If fire location is implemented, it would be easy to locate where fire is occurring.

2.2.2. Similar System 2

An Autonomous IoT Infrastructure for Forest Fire Detection and Alerting System (Niranjana & HemaLatha, 2018)

The system is designed in two parts: IoT sensor node and web application part that is kept in central location. The sensor part is configured with Arduino and raspberry Pi as microcontroller and is integrated with temperature sensor, flame sensor, Smoke Sensor, Rain sensor and GSM Modem with WiFi shield. The microcontrollers are configured to receive and process the data. The GSM modem uses a separate battery and the remaining parts use another battery.

To detect the forest fire, all the sensors work accordingly. The data received by all the sensors is processed and if there is increase in threshold of temperature, or amount of gas or flame, then a push SMS is sent to the forest department through emm modem. All the values from the sensor are stored in a database server for future purpose (Niranjana & HemaLatha, 2018).

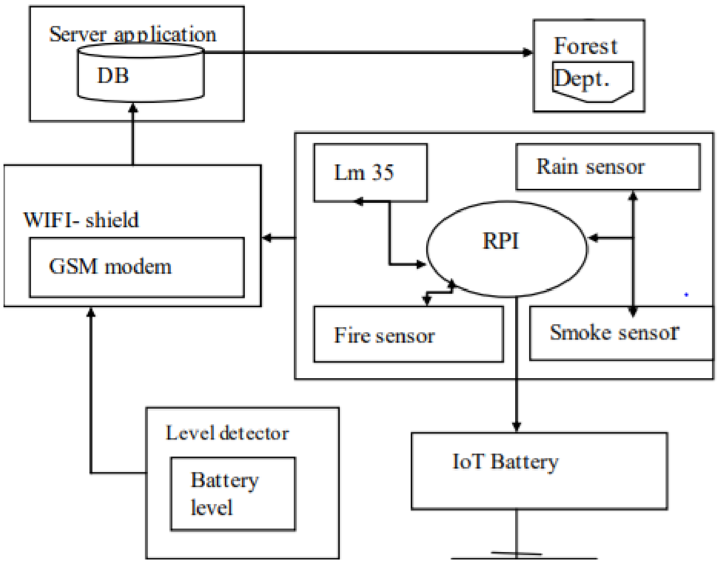

Figure 1: System architecture (Niranjana & HemaLatha, 2018)

The pros of this system are that there is use of multiple sensors and helps in accurately detecting forest fire. With the multiple sensors, every aspect that can help detect forest fire can be covered. The chance of missing fire is really slimmed.

In the final year project, the idea of using smoke sensor and rain sensor is received from this system. These sensors help in detecting the fires with extra information of smoke received. The idea of storing the data received in a database for future use is also implemented in the developing system.

However, this system can generate a lot of false alarms because it sends an SMS for every high data received in every sensor. If there is increase in gas amount only, it will still send SMS alert to forest department. There may not be fire at all. This will create a nuisance for forest management.

2.2.3. Similar System 3

Forest Fire Detection using LoRa Wireless Mesh Topology (Salam, et al., 2018)

The overall architecture of this system is divided into two parts; sensor node and gateway or receiver node. The sensor uses Arduino Uno as the microcontroller and integrates Lora shield 915 MHz, DHT11 Temperature and Humidity sensor and M2Q gas sensor. The receiver end consists of Raspberry pi and Lora module. The LoRa module is used to transmit data from sensor node to gateway node. The sensor nodes are placed in various locations making a mesh topology. This configuration allows the data to be sent to over 500 metres where gateway is situated.

Figure 2: Lora network architecture (Salam, et al., 2018)

When the system is working, the data from sensors is sent periodically to the gateway. The data is transferred from the gateway to a cloud where a software detects the forest fire. In order to detect fire, threshold of temperature, humidity and smoke have been set. Threshold for temperature is 40 degree Celsius, humidity 50% and smoke particle threshold of 2368 ppm. The system receives alarm when the predetermined values are received (Salam, et al., 2018).

The main advantage of this system design is scalability. Using multiple sensors and a gateway allows the forest monitoring in a very large area. The use of LoRa gives an advantage where internet does not work. The coverage of LoRa is very large up to several kilometres. So, this transmission medium is suitable in locations such as forest.

Since there is a use of mesh network there is high chance of interference in the Lora transmission. This may cause the data to reach the gateway slower than required.

From this system design, the idea of making two nodes, the sensor node and gateway node, is implemented in the FYP. However, data connection in internet will not be implemented. Long range data transmission is easier with this setup. The use of LoRa as a wireless transmission medium gives great scalability and data can be sent through a very large distance. Therefore, the transmission medium in the project is selected as LoRa. Arduino is kept as microcontroller. It can support multiple sensors, parts and due to its low cost, the overall cost of the project decreases.

2.3. Review of tools

The final year project is a system of integration of both hardware as well as software. This is an IoT system. The effective combination of hardware and software keeps the system running. The hardware equipment in this project are Arduino Uno, Flame Sensor, Temperature and Humidity Sensor, Smoke Sensor, Rain Sensor, LoRa as transmission medium, Breadboard, Resistor as well as wires to connect the equipment with microcontroller, Arduino.

The software that will be used in the project are Arduino application and C/C++ for Arduino programming.

2.3.1. Hardware

i. **Arduino Uno R3**

Arduino Uno is a microcontroller based on the ATmega328P. this microcontroller consists of 14 digital input/output pins and 6 analog inputs. It also consists of a USB connection, power jack, ICSP header and a reset button. The controller has a flash memory of 32 KB (Arduino, 2020).

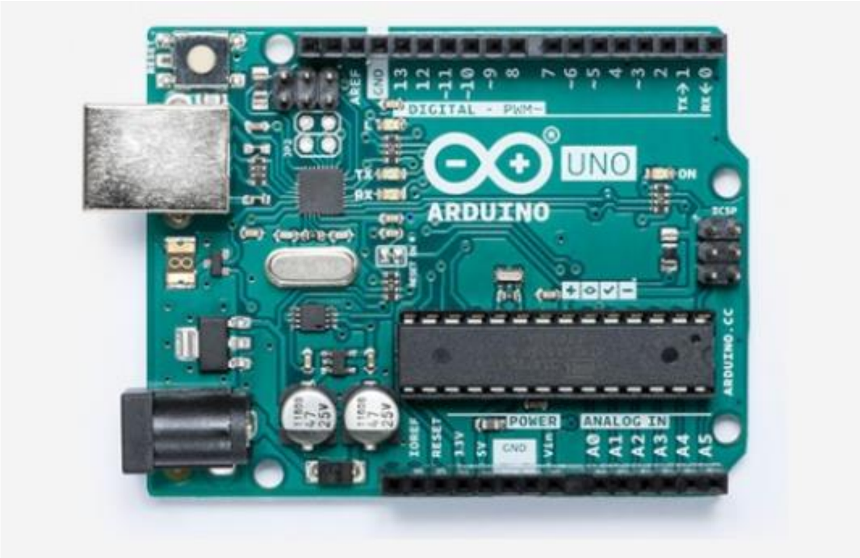

Figure 3: Arduino Uno R3 (Arduino, 2020)

The use of Arduino Uno reduces the cost of the project as it is cheaper than other microprocessors and microcontrollers, all the equipment can be connected easily, and it is easy to set up.

ii. LoRa

LoRa, short form of Long Range, is a spread spectrum modulation technique derived from the chrip spread spectrum technology. It is a long-range low power wireless platform that can work in transmission over a long distance. It is like a trade between bandwidth and transmission range. With a very high transmission range the bandwidth is very low (SEMTECH, 2020). LoRa SX 1278 is used in the project and works on radio frequency of 433 MHz. two LoRa modules are required for transmitting and receiving data.

In a forest there is no network of any means and always puts a hinder in data transmission. Here, LoRa plays the role of transmitting data from sensor node to the gateway and it does not need any network. Data is transmitted through radio frequency. The very long range of LoRa makes it suitable for forests.

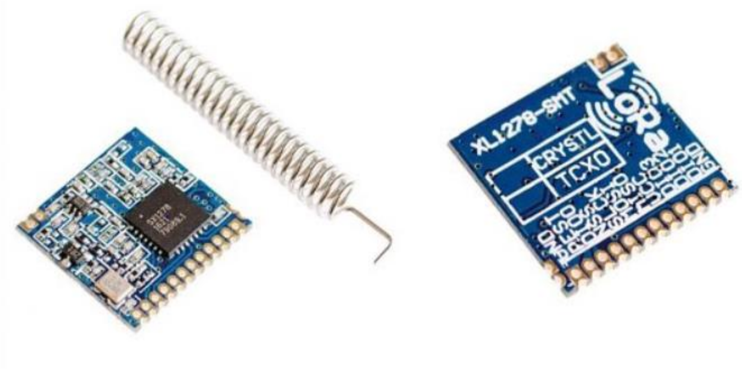

Figure 4: LoRa module (AspenCore, Inc, 2020)

iii. Temperature and Humidity Sensor

DHT 11 is a sensor that can record both temperature and humidity with a single equipment. When there is a spike in temperature and drop in humidity, there is more likely to get forest fire.

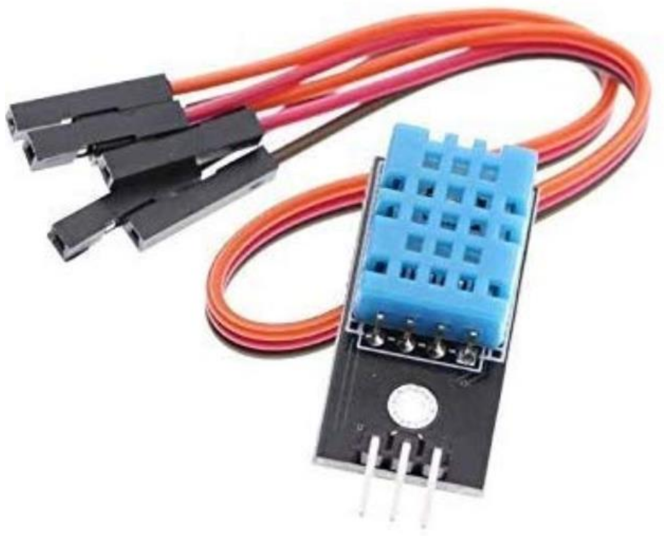

Figure 5: Temperature and Humidity Sensor (Amazon, 2020)

iv. Flame Sensor

It detects flames of infrared wavelength between 760nm to 1100nm and the signal threshold can be adjusted with potentiometer. It helps detecting forest fire by detecting the waves produced by the flames.

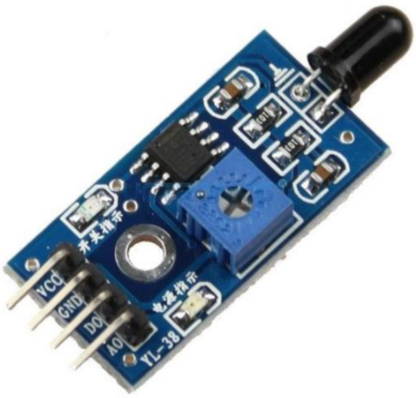

Figure 6: Flame Sensor (IndiaMART , 2019)

v. Smoke Sensor

The smoke sensor module MQ-9 detects the gases carbon monoxide and methane that are produced during forest fire.

Figure 7: MQ-9 Gas Sensor (IndiaMART , 2019)

vi. Breadboard

It is a solderless device that is used for prototype electronics and test circuit designs. This will be used in the project to integrate various sensors and transmission medium. A breadboard increases the scalability of the microcontroller since all the connections to the microcontroller can be made through breadboard.

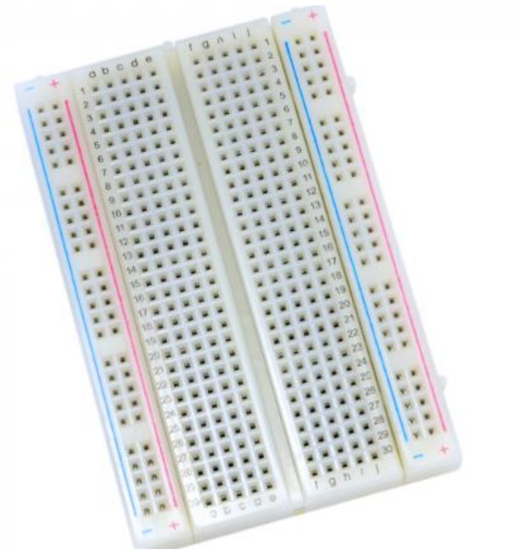

Figure 8: Breadboard (core ELECTRONICS, 2020)

vii. Rain Sensor

This sensor helps to detects whether there is rainfall or not with the plate. It gives analog signal as output.

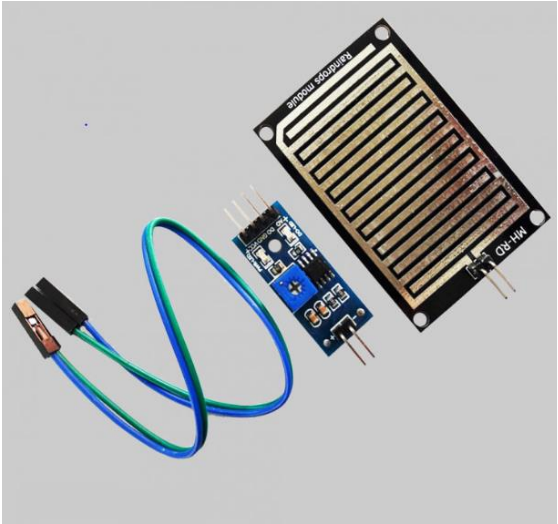

Figure 9: Raindrop Sensor Module (RedDoko.com , 2020)

2.3.2. Software

i. Arduino IDE

Arduino application, also known as Arduino IDE is an open source software that facilitates in writing code and uploading it in the board. The sensors and transmission medium are integrated in Arduino microcontroller. This code written here will make the sensors work and data can be received with it.

ii. C/C++

It is the programming language that is used to write code in Arduino IDE. The code is written in structural format. This is also the default programming language of Arduino.

3. Development

Projects are target-oriented jobs where the objectives of the deliverables, the total cost of the project, resources available for the project as well as the deadlines are agreed between the owner and the project development team (Vukovic, 2005). Every project is started to provide solutions and products to fulfil the requirement and gain knowledge as well as profit. The main objectives of every project are set in the beginning of the project and making sure that the project achieves its objective is done through project management.

Everything that is needed for the completion of a project is defined by project management. Development of project plan including project aim and objectives, allocation of budget and resources required, and time maintenance is done through project management (Vukovic, 2005). So, there is a need of definitive methodology for every project. The project methodologies vary according to the requirement of the projects. A methodology provides guidelines and procedures for the organized development as well as maintenance and design of the project. Project methodology also ensures the optimum utilization of resources while fulfilling the requirements (Barjtya, et al., 2017).

3.1. Project Methodologies

The final year project needs a methodology for the management of tasks as well as allocating time to complete various steps during the development of project. To develop this project three methodologies are taken into consideration. They are Waterfall methodology, Scrum methodology and Kanban Methodology.

3.1.1. Waterfall Methodology

Waterfall method is a basic project development methodology which works in a linear and sequential process and is also known as iterative model. In this method, each step must be completed properly before going into another step. Like a waterfall, after going into another phase, jumping into previous step is not possible. The only option is to keep on moving forward (Kannan, et al., 2014).

There are mainly five phases in this project methodology:

1. Requirement Analysis and Specification
2. System Design
3. Implementation and Unit Testing
4. Integration and System Testing
5. Operation and Maintenance (Eason, 2016)

After completing each step, a review is done whether it is in compliance with requirement analysis that is defined in the first phase. This method is best suited when the requirements are all well defined and there is no need to change any of them during development. Also, when there is clear picture of final product, this is suitable

Advantages

- The main advantage of this methodology is that the structure for project organization and control is provided clearly.
- The errors and the design details are well-recorded before the development and saves time.
- Estimation of time and cost can be efficiently done with the exact following of this methodology.
- The defects and faults can be recognized before entering another phase (Kannan, et al., 2014).

Disadvantages:

- All the requirements must be clearly stated in the beginning which is really difficult since there are always changes in requirements during development.
- No changes are allowed because of linear structure.
- There is no management of risks and security issues.
- It is not suitable for large projects since the real products are not completed sequentially.

3.1.2. Scrum Methodology

It is a development and design methodology that follows the principle of Agile methodology. The project under this methodology is done in a group to perform tasks quickly and work on the development of project. Both management as well as development is included in Scrum. After gathering the requirement specifications, the whole process is divided into several iterations and each task is completed through four steps: Planning, Staging, Development and Release. Each iteration of the process is known as Sprint and each Sprint can be 2 to 4 weeks (Neelima & Saile, 2013).

In this methodology, the work is conducted in the collaboration of scrum master and scrum team with product owner in continuous repetition of the evolving software. In a scrum process, scrum master's main task is to eliminate the obstacles**.** Scrum team comprises of developers, testers and other experts of various fields to create an end product that meets the requirement of customer.

Advantages:

- The scrum sprints divide the work into several smaller parts and is completed with the daily stand-up meetings.
- Rapid iteration and development in the project is possible.

Disadvantages:

- The project team is self-managing thus there is higher chance of failure unless team members are motivated and disciplined.

Among all the methodologies that are considered for project, Kanban method is selected for project development.

3.1.3. Kanban Methodology

Kanban is a framework which follows agile principle of project management. The work items in Kanban methodology are represented visually that allows the member of projects to see work state at any time. This process was developed by Toyota in 1940s to meet the customer demand. The main theme of Kanban is to produce only what is needed. The supply of the product at the right time, in right quantity, and right place is made sure. That's why the working philosophy is also known as Just kin Time (JIT) (Adnan, et al., 2013).

Kanban helps in achieving improvement by recognizing the work limit in the process inventory and thus decreases the overload in the work development. There is no specific role in this method and importance is given in improvement of the throughput (S & K , 2018). The main feature of this method is that it visualizes the workflow. There is use of Kanban Board and Kanban card to visualize the work. The cards are used for withdrawal, store and managing process with signs that creates smooth process in the production. The team members fully able to track the workflow in the process of development. The Kanban cards are kept in Kanban board. The Kanban board consists of three things: To Do, In Progress and Done. Whenever one process is completed, another task from the backlog is pulled to the right-hand side. The consumption and demand for more products is also signalled by the cards (Wakode, et al., 2015). This framework allows an efficient feedback loop too. The feedback from customers can be crucial for project completion.

Following agile method of development, changes can be made during the development of phase too. So, whenever a new feature is needed, it can be added in the backlog and prioritization of the work can be made. The tasks can be reprioritized, without disrupting the team (Kirovska, 2015). Tasks can be separated for every member of the team and bottlenecks in the work can be reduced given that only one work is completed at a time (S & K , 2018).

Though there are no specific roles in Kanban, formal roles are important to clients. But the significance of these roles is far lesser then that of other methodologies. The two primary roles that can be implemented are:

- Service Delivery Manager (SDM)
- Service Request Manager (SRM) (Kanbanize, 2020)

Service Delivery Manager (SDM)

The SDM is an emerging role in Kanban where it is not a distinctive title but an added responsibility to the existing team members. The primary function of SDM is to make sure that there is proper workflow of the items and to facilitate in continuous improvement and changes in the activities. Making sure that the work is going on continuously by checking Kanban board. The SDM also makes policies for the team members. In order to improve the activities, SDM collects the data from Kanban board and discusses with the team and makes sure the error does not get repeated (Kanbanize, 2020).

Service Request Manager (SRM)

The SRM is also an added responsibility to an existing team member. SRM is responsible for recognizing the client’s requirements and expectations. The SRM can be considered as ‘middleman’ who has an in-depth knowledge of the team or company’s value stream but don’t necessarily create direct value to the customer. The main responsibility of SRM is to provide facility in prioritizing the works from backlog and ordering the work items (Kanbanize, 2020).

3.2. Analysis of Project Methodology

Choosing an appropriate methodology for project development is absolutely necessary because it defines the process involved during the development and provides guideline to the project. Using Kanban framework, it helps to visualize the work and manage the tasks accordingly. In this final year project, Kanban is very suitable for project development. The changes and extra requirements that come during the process can be added easily and the work can be prioritized accordingly. The efficiency of the project can be improved by properly following the framework. Since a proper feedback ca be obtained, it can help in realizing the necessities and features can be added later.

3.3. Work Breakdown Structure (WBS)

Work breakdown structure helps in achieving the goals through a deliverable oriented work division. All the smaller tasks can be identified, scheduled, and budget can be allocated.

Planning of the project with Kanban Method.

The main roles that are present in the project are defined below.

People		**Role**
SDM	Service Delivery Manager	Managing work flow and bringing improvement in activities
SRM	Service Request Manager	Understand Client's requirements
TM	Team Members	Performs the tasks
CL	Client	Make work request to project team

Table 1: Roles in Kanban Framework

Forest Fire Detection and Alert System with LoRa					
No.	**Activity**	**Start Date**	**End Date**	**Duration (Days)**	**People**
1	**Requirement Analysis**	**2019/08/23**	**2019/09/11**	**20**	
1.1	Receiving requirement from client	2019/08/23	2019/08/26	4	CL, SRM, SDM
1.2	Checking technical feasibility	2019/08/26	2019/09/3	9	SDM, SRM
1.3	Financial Analysis	2019/09/4	2019/09/11	8	SDM, SRM
2	**Project Research**	**2019/09/12**	**2019/10/8**	**27**	
2.1	Problem research	2019/09/12	2019/09/15	4	SRM, SDM, TM
2.2	Hardware requirements	2019/09/16	2019/09/20	5	SRM, SDM, TM
2.2.1	Selecting suitable transmission medium	2019/09/18	2019/09/20	3	SRM, SDM, TM
2.3	Software Requirements	2019/09/21	2019/09/27	7	SRM, SDM, TM
2.4	Methodology Selection	2019/09/28	2019/10/03	6	SRM, SDM, TM
2.5	Project Threat, Contingency Planning	2019/10/04	2019/10/08	5	TM

3.	**Proposal and Approval**	**2019/10/09**	**2019/10/21**	**13**	
3.1	Development of proposal	2019/10/09	2019/10/17	9	TM
3.2	Approval of project	2019/10/17	2019/10/21	5	SRM, CL
4	**Gathering Hardware**	**2019/10/22**	**2019/11/15**	**25**	
4.1	Ordering and receiving of sensors and microcontroller	2019/10/22	2019/10/29	8	TM
4.2	LoRa ordering and receive	2019/10/25	2019/11/15	22	TM
5	**Circuit Designing**	**2019/11/17**	**2019/11/30**	**14**	
5.1	Designing Sender Node	2019/11/17	2019/11/22	6	TM
5.2	Design of Gateway Node	2019/11/22	2019/11/30	9	TM
6	**Survey and Development of Sensor Node**	**2019/12/1**	**2020/01/13**	**44**	
6.1	Conducting Survey	2019/12/01	2019/12/08	8	
6.2	Update Arduino firmware	2019/12/01	2019/12/02	2	TM
6.3	Configure Serial Port	2019/12/03	2019/12/04	2	TM
6.4	Assemble Temperature and Humidity Sensor	2019/12/05	2019/12/07	3	TM
6.5	Programming and Testing Humidity Sensor	2019/12/08	2019/12/15	8	TM
6.6	Flame Sensor Assemble	2019/12/16	2019/12/18	3	TM

6.7	Programming and testing flame sensor	2019/12/19	2019/12/25	7	TM
6.8	Assembling Smoke Sensor	2019/12/26	2019/12/30	5	TM
6.9	Programming and testing smoke sensor	2020/01/02	2020/01/06	5	TM
6.10	Assembling rain Sensor	2019/01/07	2019/01/08	2	TM
6.11	Programming and testing rain sensor	2019/01/09	2019/01/13	5	TM
7	**Development of Receiver Gateway Node**	**2020/01/14**	**2020/01/22**	**9**	
7.1	Updating Arduino and configuring serial port	2020/01/14	2020/01/15	2	TM
7.2	Assembling and Testing Buzzer	2020/01/16	2020/01/22	7	TM
8	**Transmission**	**2020/01/23**	**2020/02/20**	**29**	
8.1	Assembling LoRa in Sensor node	2020/01/23	2020/01/28	6	TM
8.2	Programming and testing LoRa module	2020/01/29	2020/02/04	7	TM
8.3	Assembling LoRa in receiver/gateway node	2020/02/05	2020/02/10	6	TM

8.4	Programming and Testing LoRa module	2020/02/11	2020/02/16	6	TM
8.5	Testing data transmission	2020/02/16	2020/02/20	5	TM
9	**Testing and Evaluation**	**2020/02/21**	**2020/03/05**	**14**	
9.1	Testing of overall data collected by sensor	2020/02/21	2020/02/28	8	TM
9.2	Testing of fire alarm under suitable conditions	2020/02/29	2020/02/05	6	TM
10	**Data Analysis**	**2020/03/05**	**2020/03/30**	**26**	
10.1	Research to conduct data analysis	2020/03/05	2020/03/10	6	TM
10.2	Collection of all data received at Gateway	2020/03/11	2020/03/15	5	TM
10.3	Data Analysis	2020/03/16	2020/03/30	15	TM
11	**VAPT**	**2020/04/01**	**2020/04/20**	**20**	**TM**
12	**Documentation**	**2019/11/22**	**2020/05/20**	**181**	
12.1	Interim Report	2019/11/22	2020/01/06	46	TM
12.2	Final Report	2020/01/20	2020/05/20	122	TM

Table 2: Work Breakdown Structure

3.4. Gantt Chart

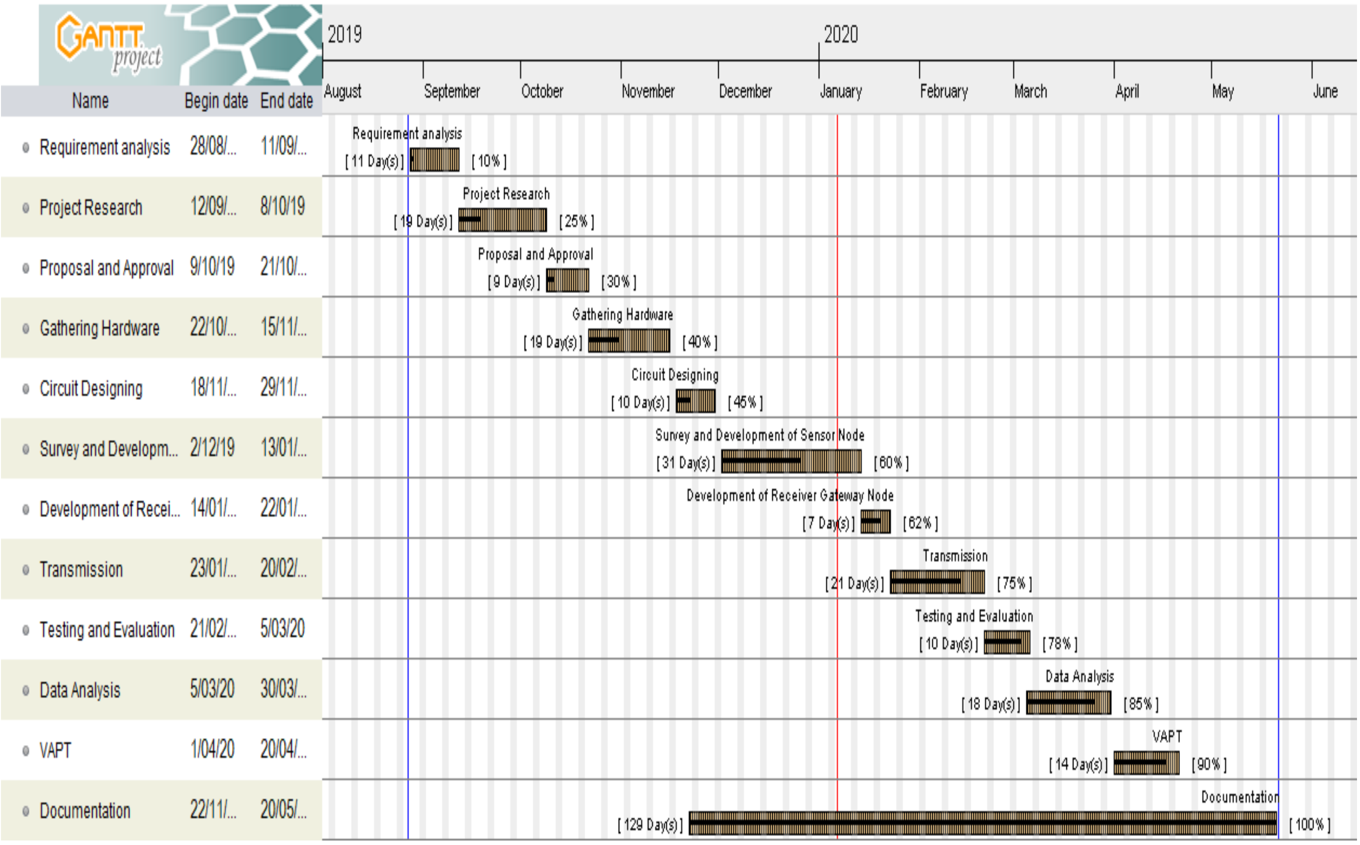

Figure 10: Gantt Chart

4. Progress

At the time nearer to the submission of the interim report of the Final Year Project, the progress on the project is continuing and around 40% of the work has been completed. The work is being completed by following Kanban framework. The tasks are scheduled in the work breakdown structure (WBS) and is executed accordingly. Any task can be prioritized and can be completed at any time. The work has been scheduled to make continuous development and ease the team members.

4.1 Requirement Analysis

It is the first phase of the project development where the requirements for the project is analysed. At first, the Service Request Manager (SRM) is approached by the client and asks for the development of the project. The client requests a device that can detect fire and alert it remotely. The SRM discusses with the SDM and technicality achievability of the project is explored to make sure if it is possible to complete with the current resources. An estimation of the cost on the project is also made if the cost required is suitable for the type of product that is produced at the end of project.

4.2 Project Research

In the second phase of project, a research on the hardware required for the project is conducted. At first the problem domain is analysed and solution to the problem is worked out. The effects of fire on environment and economy is researched. SRM, SDM and all the TM work on it and find that integrated sensors can help detect fire as soon as possible. Smoke sensor, Flame sensor, Temperature and Humidity Sensor as well as rain sensors are selected.

To integrate it in a micro processing system, Arduino Uno is selected since it is cheaper than other processors and can handle multiple sensors at the same time. After finding the necessary components, a suitable transmission medium is required to send information from a distant location; therefore, LoRa is selected because of its low power consumption and a very long range of transmission. Arduino IDE is selected to program the sensors and transmission medium and C/C++ as programming language for coding.

A suitable project management methodology is required to complete the project. So, Kanban method is selected. The risks occurring during the project are analysed and contingency planning is done to deal with the risks.

4.3 Proposal and Approval

Determining all the components required for the project, the TM develop a strong proposal to submit it to the client. The SRM presents the proposal to the client and after accepting it, the development in project starts.

4.4 Gathering Hardware

After the acceptance of proposal, the hardware required for the project is ordered. This includes sensors, microcontroller (Arduino), Jumper Wires, Resisters and transistors. Because of the unavailability of LoRa module in the Nepali market, it is ordered from India.

4.5 Circuit Designing and Survey

After all the hardware components have been ordered and received, a circuit is designed of both sensor node and receiver node. The circuit design helps in wiring properly while developing it in real conditions. The built circuit can also function fully.

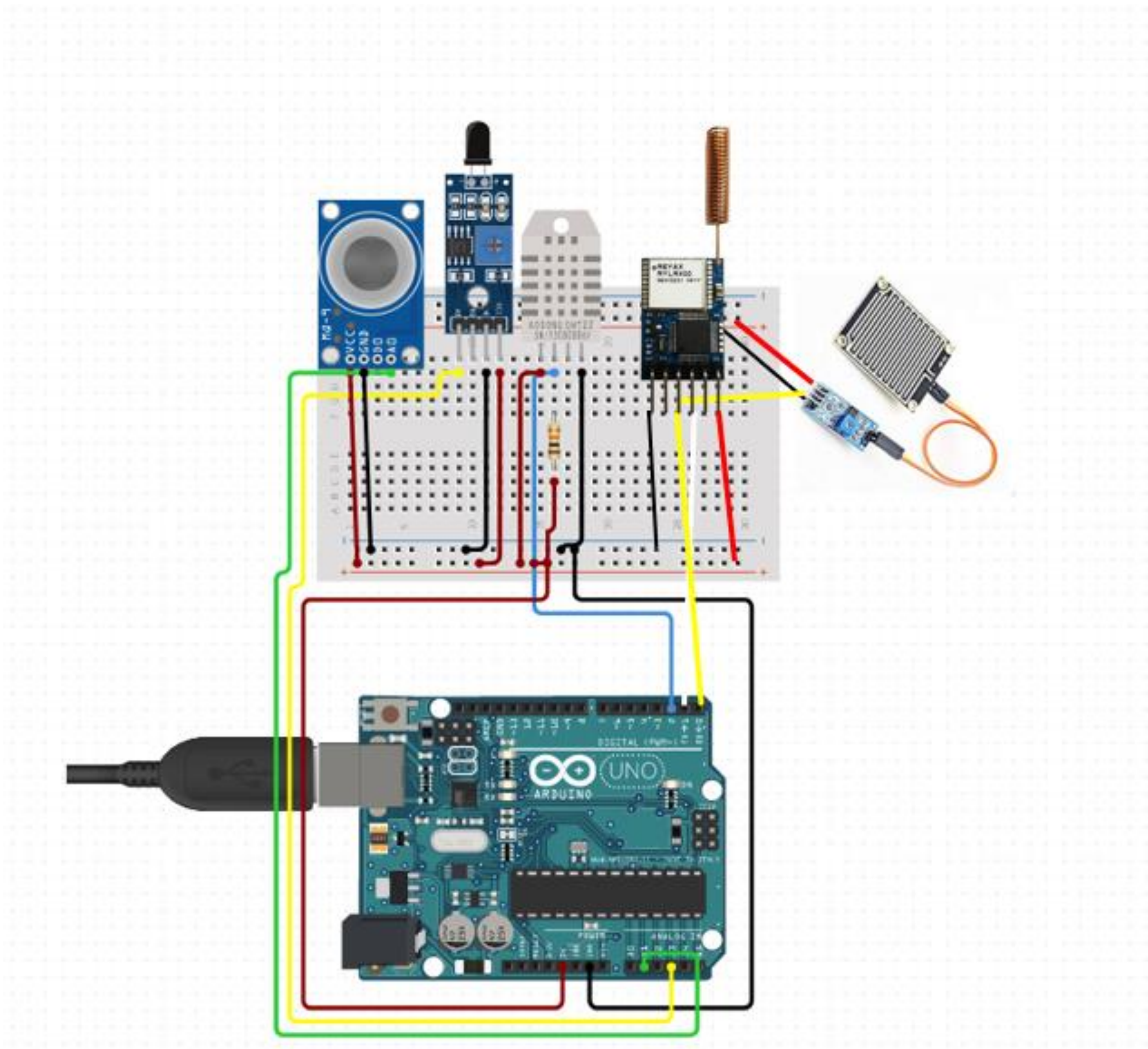

Figure 11: Sensor node circuit

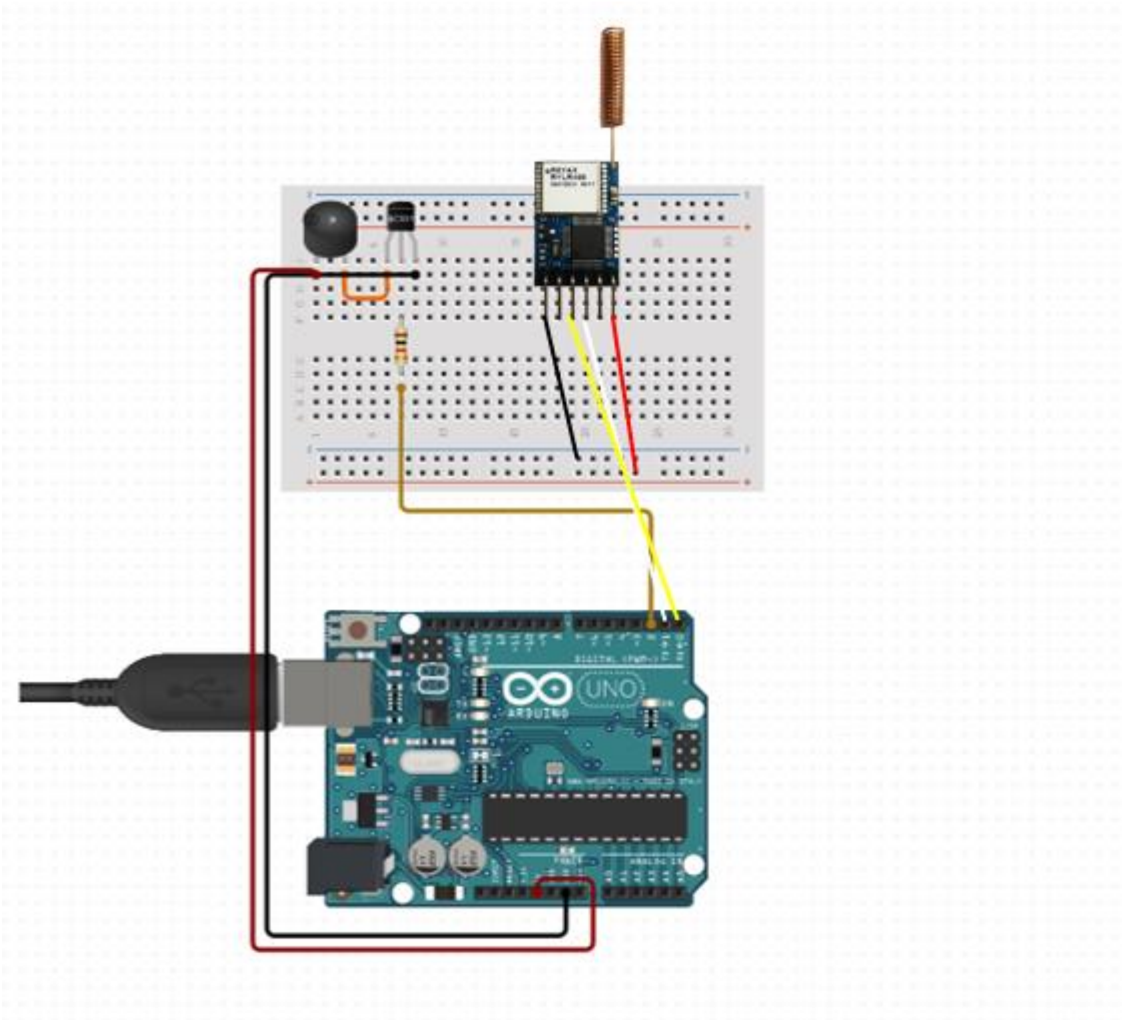

Figure 12: Gateway Node circuit

4.6 Survey and Development of Sensor Node

A survey is conducted after completing the design of the nodes by the SDM. The survey is carried out by among the colleagues of Islington college who have a knowledge on how Internet of Things work. The survey consists of questionnaires that includes project's practicability and feasibility. From the survey, some suggestions are also taken and planned to implement in the developing project.

After conducting the survey, the part of node construction comes into action. At first, the firmware of microcontroller, Arduino is updated and then the serial port that connects to the computer is configured through Arduino application. The serial port is configured to be COM10. After the setup of microcontroller, Temperature and Humidity Sensor, DHT 11, is assembled with wires, register and breadboard keeping the node circuit design in reference and programming is done to make it work.

sketch_jan06b §

```
#include <dht.h>

dht DHT;

#define DHT11_PIN 7

void setup(){
  Serial.begin(9600);
}

void loop()
{
  int chk = DHT.read11(DHT11_PIN);
  Serial.print("Temperature = ");
  Serial.println(DHT.temperature);
  Serial.print("Humidity = ");
  Serial.println(DHT.humidity);
  delay(1000);
}
```

Figure 13: Programming Temperature and Humidity Sensor

```
COM10

11:37:32.481 -> Temperature = 20.00
11:37:32.516 -> Humidity = 80.00
11:37:33.521 -> Temperature = 20.00
11:37:33.556 -> Humidity = 81.00
11:37:34.558 -> Temperature = 20.00
11:37:34.558 -> Humidity = 81.00
11:37:35.558 -> Temperature = 20.00
11:37:35.592 -> Humidity = 81.00
11:37:36.588 -> Temperature = 20.00
11:37:36.623 -> Humidity = 81.00
11:37:37.629 -> Temperature = 20.00
11:37:37.629 -> Humidity = 81.00
11:37:38.635 -> Temperature = 20.00
11:37:38.670 -> Humidity = 81.00
11:37:39.674 -> Temperature = 20.00
11:37:39.674 -> Humidity = 81.00
11:37:40.679 -> Temperature = 20.00
11:37:40.713 -> Humidity = 80.00
```

Figure 14: DHT 11 Output

After successful assembling, coding and working of DHT 11, the task of Flame Sensor started. The flame sensor is also configured according to the circuit design or sensor node and programming is done to make the flame sensor work. Coding is done in Arduino application. The sensor works be detecting higher wavelength infrared light. Whenever the sensor detects fire, the DO-LED lights up.

sketch_jan06b §

```
// lowest and highest sensor readings:
const int sensorMin = 0;     // sensor minimum
const int sensorMax = 1024;  // sensor maximum

void setup() {

  Serial.begin(9600);
}
void loop() {
  // read the sensor on analog A0:
  int sensorReading = analogRead(A0);

  int range = map(sensorReading, sensorMin, sensorMax, 0, 3);

  // range value:
  switch (range) {
  case 0:    // A fire closer than 1.5 feet away.
    Serial.println("** Close Fire **");
    break;
  case 1:    // A fire between 1-3 feet away.
    Serial.println("** Distant Fire **");
    break;
  case 2:    // No fire detected.
    Serial.println("No Fire");
    break;
  }
  delay(1);  // delay between reads
}
```

Figure 15: Programming Flame Sensor

The progress in the Final Year Project is up to this point in sensor node development. The remaining works is explained in Further Work Section.

5. Further Work

The progress on the project till this date January 2, 2020 should have been up to assembling and programming the smoke sensor. But since LoRa module is not available in Nepal and had to be ordered from India, there were certain delays in the development of project. So, to be synchronized to the work schedule, I have decided to perform the remaining tasks without the use of LoRa module and complete the remaining work within the allocated time by giving more time on the project where development of sensor and gateway node will be completed earlier.

5.1. Further Development on Sensor Node

The remaining sensors, Smoke sensor and Rain sensor will be assembled by taking the circuit design as reference and programming will be done with the best favourable conditions. After this process, the work on Sensor Node will be almost complete; with exclusion of LoRa transmission medium which will be assembled and configured later after configurating the receiver node.

5.2 Development of Receiver/Gateway Node

After working on sensor node, work will start on the development of gateway node. The gateway node is not as complex as sensor node. The gateway node will consist of a buzzer and LoRa transmission medium. The equipment will be assembled and configured according to the circuit design of Gateway node.

5.3 Transmission

After receiving the transmission medium, LoRa SX 1278, which will be received by third week of January, work on transmission medium will start. The data received from the sensor node will be sent through LoRa chips. LoRa will be assembled in Sensor Node at and then programmed to make it work well and then assembled and programmed in the receiver node. After proper programming is done in both sender and receiver, a test is performed to check the data transfer between sender and receiver.

5.4 Testing and Evaluation

After completing all the construction processes, a test is performed to determine the overall quality of the constructed system. The accuracy of the data collected by the receivers is checked so that there are less chances of false alarm during its use. A thorough testing will be done to check the working of buzzer during the time of fire.

5.5 Data Analysis

Data generated by sensors need to be utilized. So, data analysis will be done to maximize the utilization of data. First of all, the data received at the gateway needs to be collected. After careful research and planning, data will be collected at a computer. The data that has been collected will be analysed statistically as the data received are mostly statistical data. Python will most likely be used for data analysis incorporating with the data analysis library Pandas. If the selected tool does not work, the analysis will be performed in traditional style with Ms. Excel or with SQL.

5.6 Vulnerability Analysis and Penetration Testing (VAPT)

The device that has been developed needs to be provided with some sort of security measures. The vulnerable and rough device cannot be launched as it may become a source of threat in the near future. So, VAPT will be done to find out the weakness in the system and work on it to make ready for use. Everything will be conducted in process: beginning with information gathering to generation of report.

5.7 Documentation

This will be the final phase in project development. After a discussion with SRM. SDM and the Team Members, documentation will be created. The documentation consists of Interim report and the Final report. The final report will comprise of every minute details that has been performed since the beginning of the project to the end.

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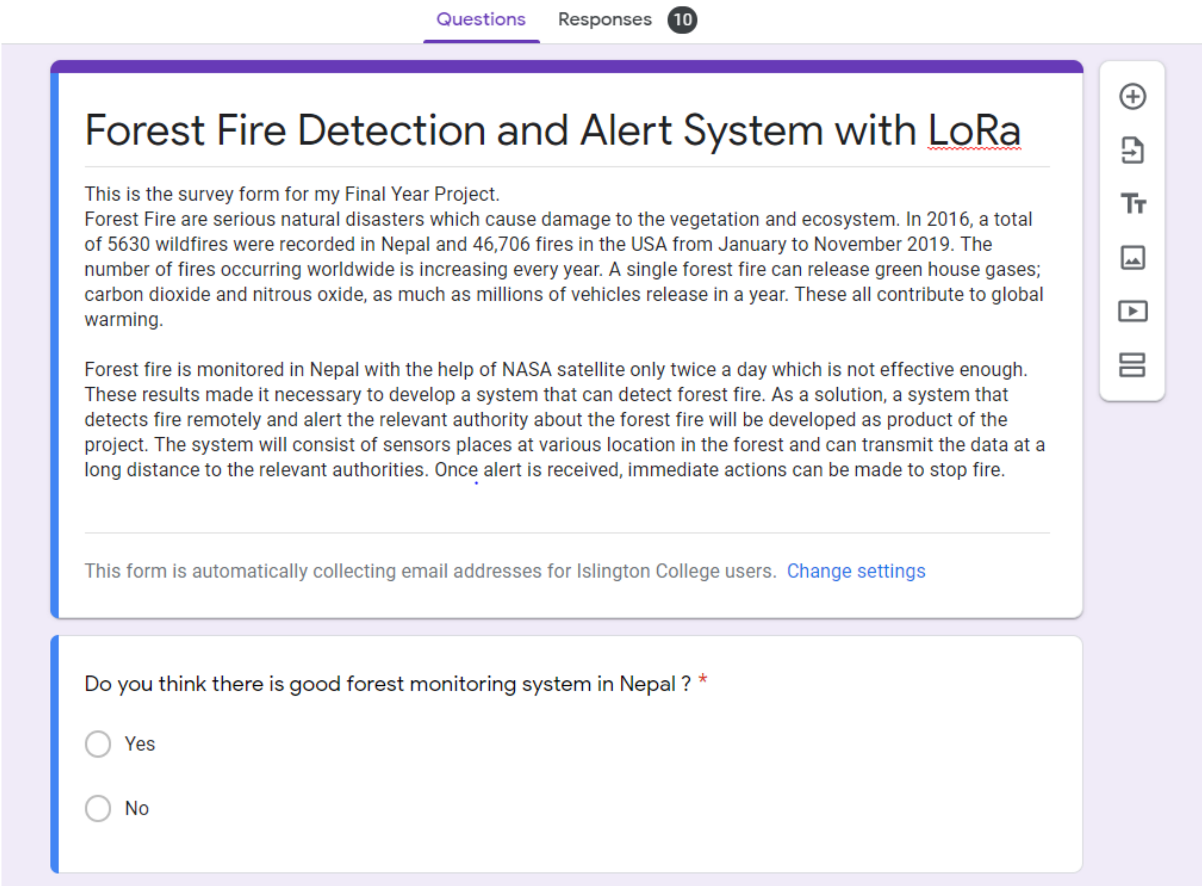
7. Appendix



Questions Responses 10

Forest Fire Detection and Alert System with LoRa

This is the survey form for my Final Year Project.
Forest Fire are serious natural disasters which cause damage to the vegetation and ecosystem. In 2016, a total of 5630 wildfires were recorded in Nepal and 46,706 fires in the USA from January to November 2019. The number of fires occurring worldwide is increasing every year. A single forest fire can release green house gases; carbon dioxide and nitrous oxide, as much as millions of vehicles release in a year. These all contribute to global warming.

Forest fire is monitored in Nepal with the help of NASA satellite only twice a day which is not effective enough. These results made it necessary to develop a system that can detect forest fire. As a solution, a system that detects fire remotely and alert the relevant authority about the forest fire will be developed as product of the project. The system will consist of sensors places at various location in the forest and can transmit the data at a long distance to the relevant authorities. Once alert is received, immediate actions can be made to stop fire.

This form is automatically collecting email addresses for Islington College users. Change settings

Do you think there is good forest monitoring system in Nepal ? *

Yes

No

Figure 16: Survey Question - 1

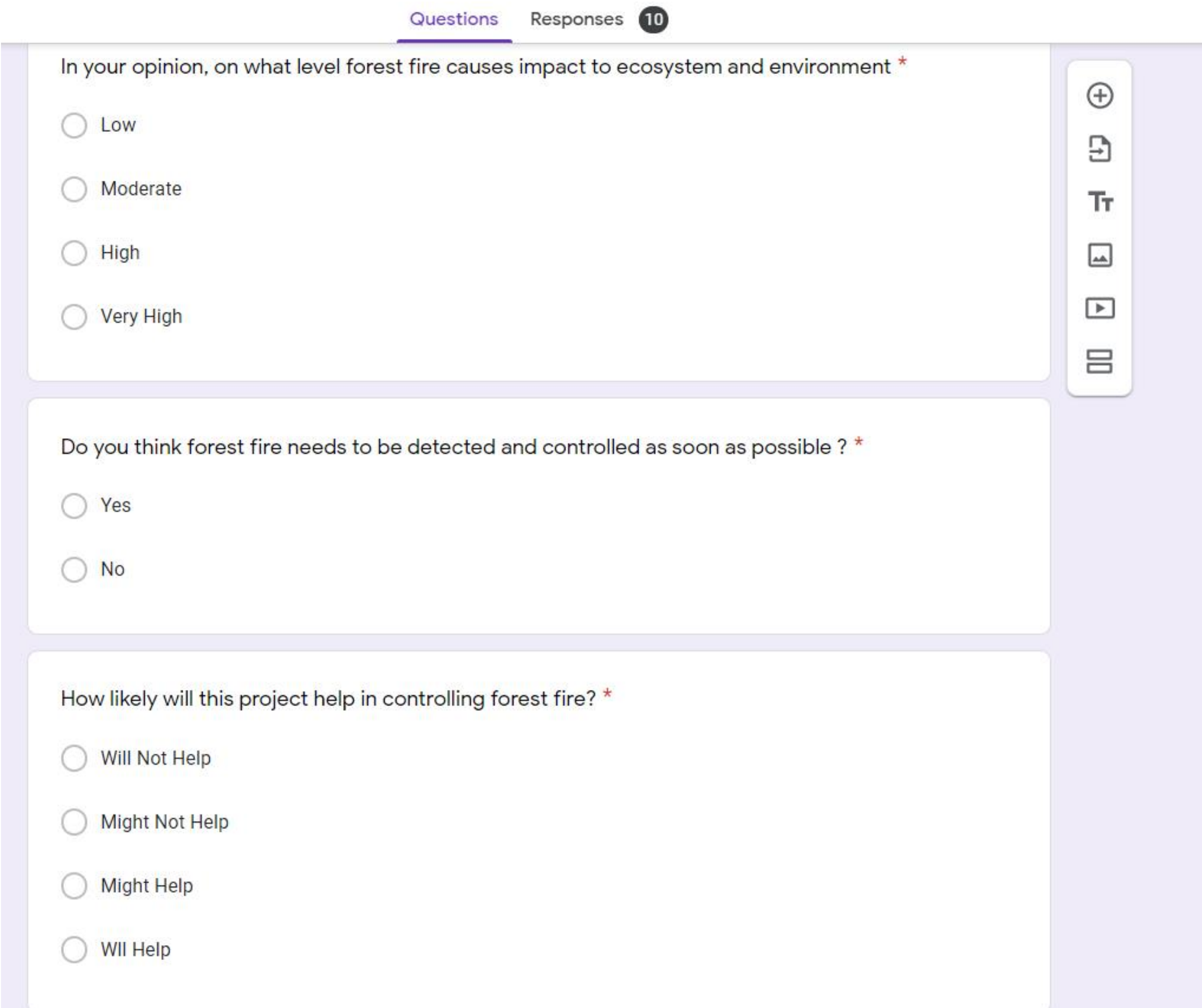


Figure 17: Survey Question - 2

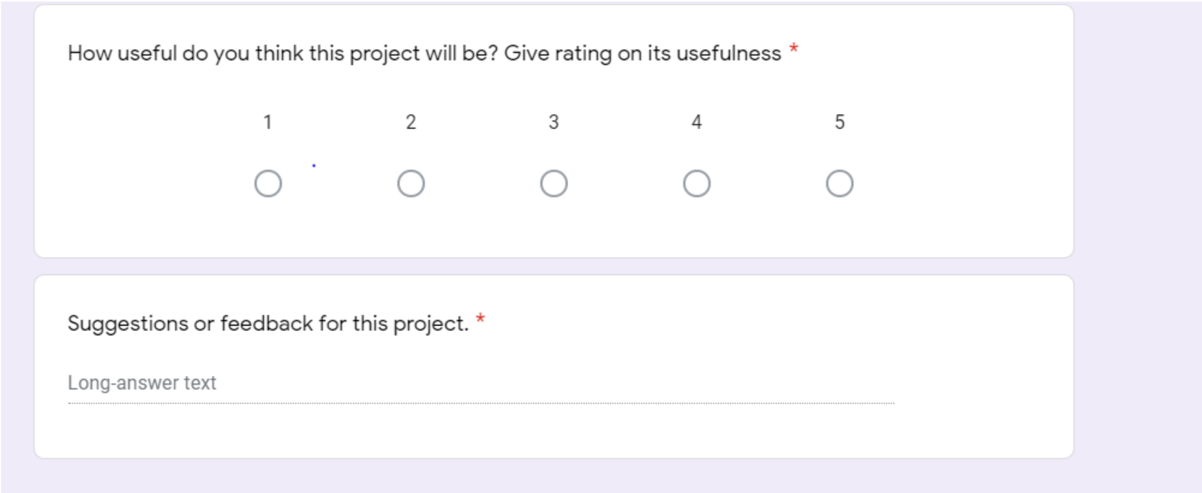


Figure 18: Survey Question - 3

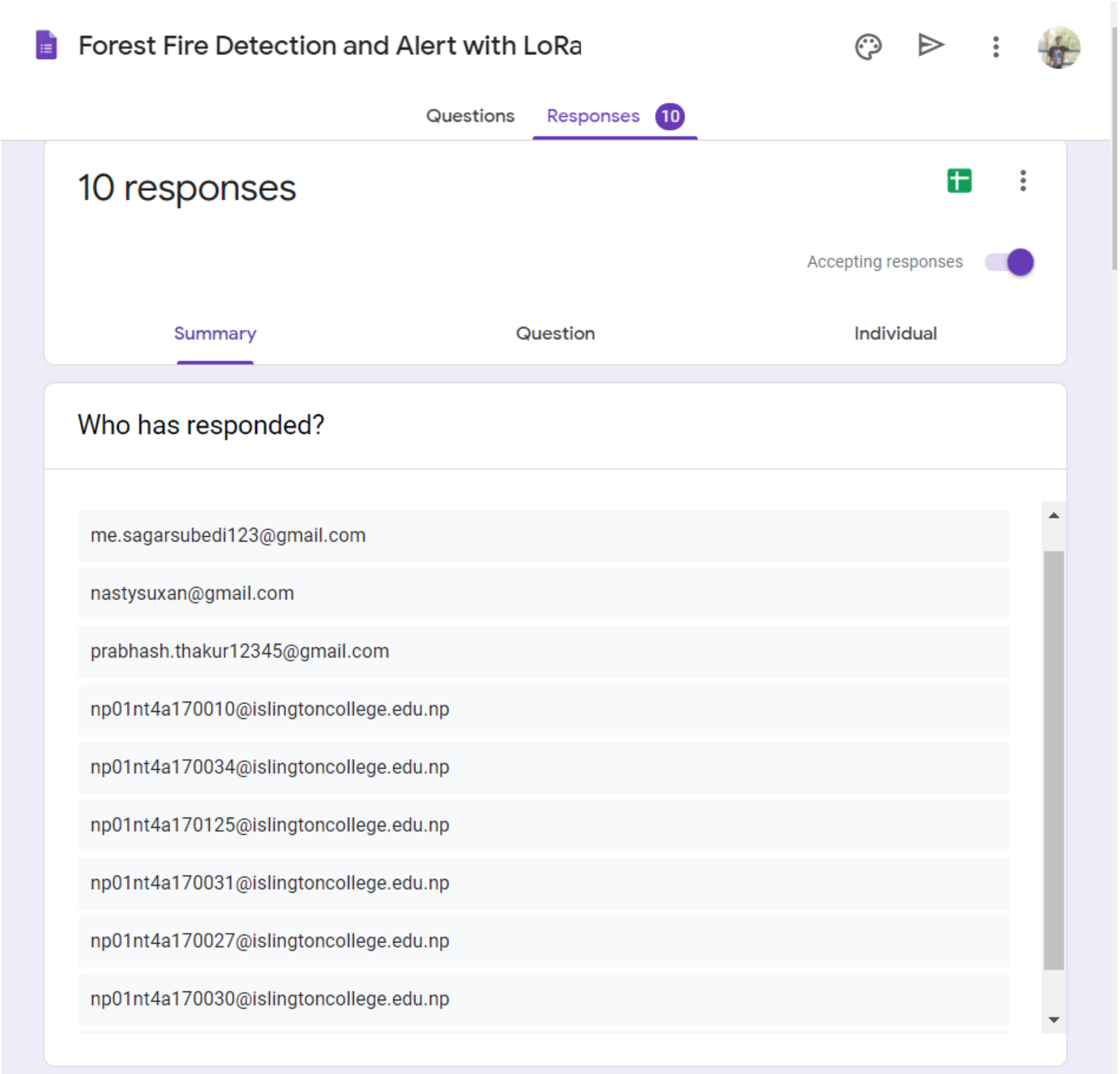


Figure 19: Responses

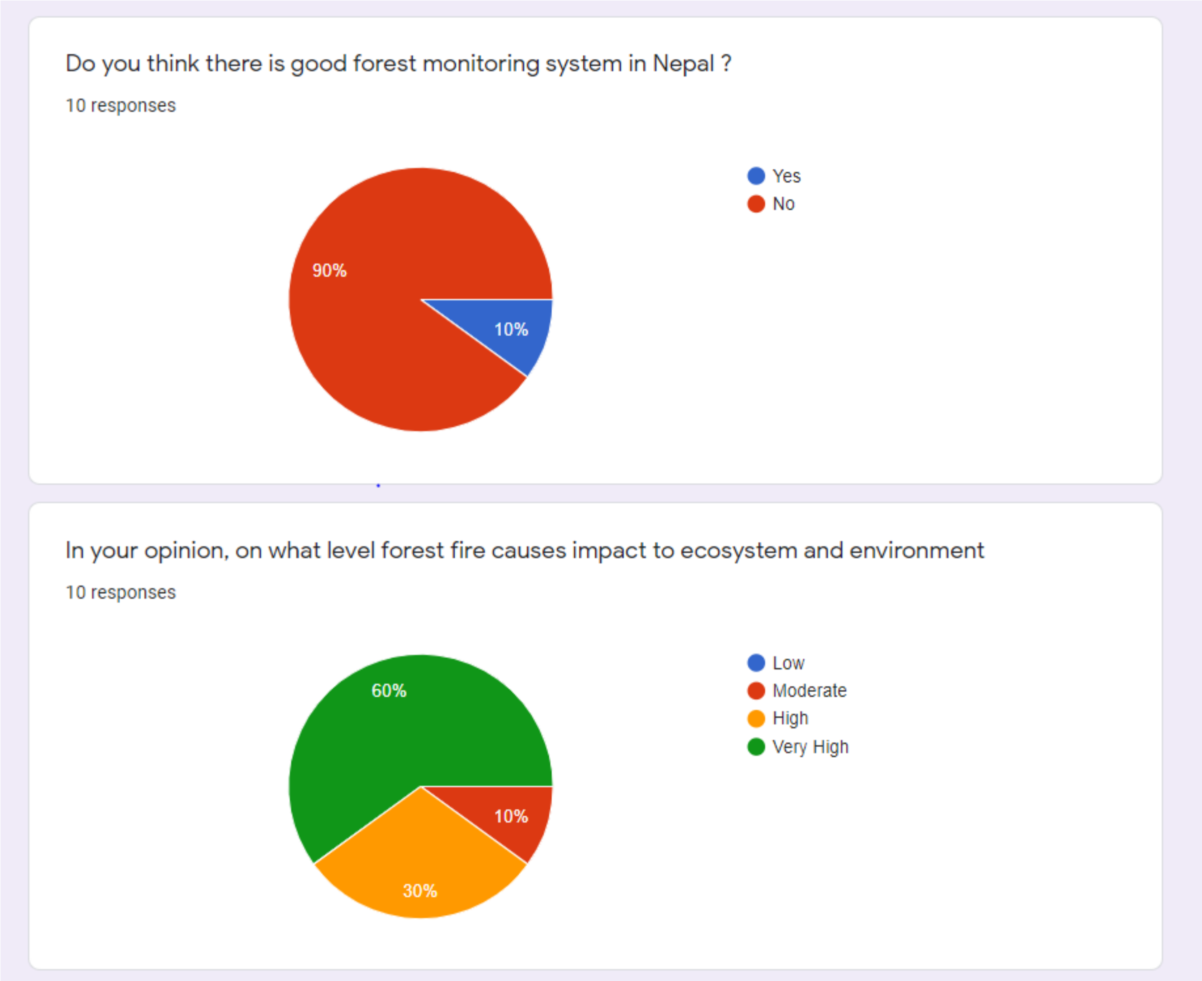


Figure 20: Response result - 1

Figure 21: Response Result - 2

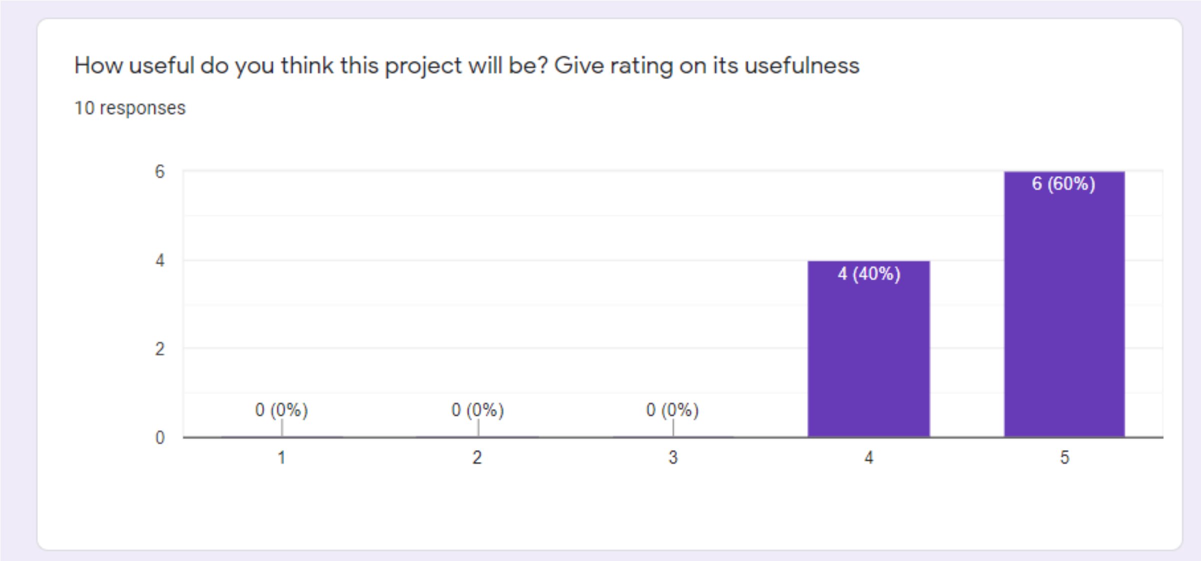


Figure 22: Response Result - 3

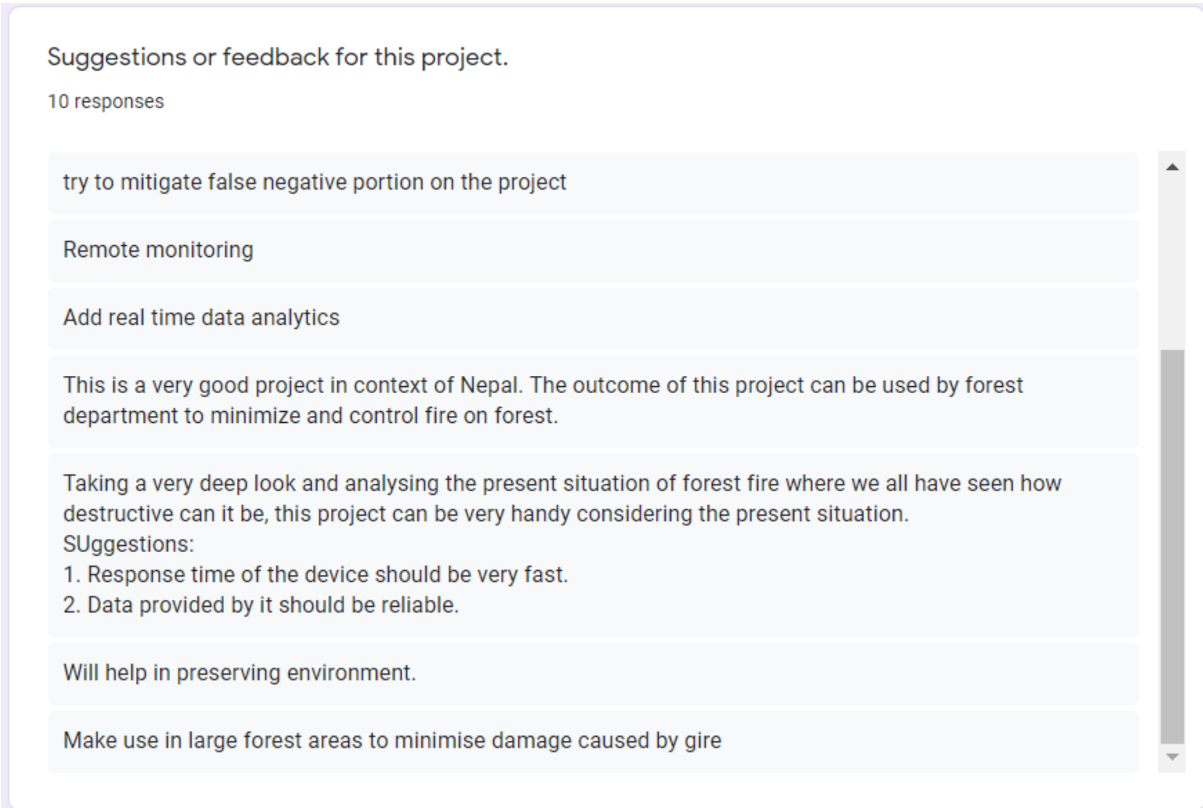


Figure 23: Survey Feedback