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A Project Proposal on
Flash Flood Early Warning System

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Thank You!

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1. Background

The abundance of water resources and diversity in natural topography of Nepal are considered to be the boon of nature. These valued gifts of nature have always served Nepal for its all-around development and prosperity.

But, several times this very nature has turned into a violent and devastating disaster. Almost every year, we hear of a number of massive disasters affecting the life and habitat of different parts of the country. Among various catastrophic forms of nature, flood and landslides are the most prevalent ones in Nepal. According to UNDP report "Reducing Disaster Risk: A challenge for development", Nepal ranks 12th in the world in terms of the proportion of its population exposed to the threat of flood annually (23.74%). And the Terai region, the lowermost belt of Nepal running east to west with almost 50% of the total population is under the high risk of these disasters.

Among different nature of flood, flash flood is the most dangerous one. Most of the times, flash floods occur due to the outburst of the glaciers, lakes etc. Since, this kind of outbursts result in immediate rise in water levels and overflow of regular rivers, they immediately take the form of flood. Unlike regular flood, flash flood takes place within a short interval of time, leaving the victims very less time to react.

Flood occur in many parts of the country every year claiming the life and property that worth million of rupees. On 5 May 2012, flash flood occurred in the Kaski district of Nepal and it resulted in the death of at least 31 people. Dozens of people went missing. People lost their homes, businesses, crops, and livestock. To summarize, it caused a great loss of lives and property. It is believed to be due to the outburst of a landslide-dammed lake. Most of the damage and loss of life was near *Sardi Khola*.

Similarly, when Koshi River erupted in 2012, about 107,200 people's life was affected. As per a survey, (44,000 – 70,000) people were displaced by the flooding incident. It was tagged as the country's worst flooding in 50 years. Over 9,000 hectares of rice paddy, sugar cane, corn and jute had been destroyed. In Sunsari District, the VDC's of Sripur, Haripur, and West Kusah were totally destroyed. The VDCs of Laukahi and Narsingh were partially destroyed.

These are just representative incidents out of many flash flood incidents that occur in our nation in yearly basis. And due to the absence of any effective flash flood early warning systems, the damages have been worse than they ought to be. In the Koshi flood incident mentioned above, people escaped with just the clothes they were wearing. The death toll would have increased if the flood had occurred at night. If there had been some early warning system, the disaster would have certainly been minimized.

Our project is concerned with solving the similar problem. Our project is Flash Flood Early Warning System (FFEWS).

2. Objectives

The primary objectives of FFEWS can be listed as below:

1. Prevention of loss of lives caused by natural disasters like flood.
2. Reduction in loss of property and livestock caused by flood.
3. Providing early warning about the flood to the concerned ones.
4. Providing rescue and evacuation planning suggestions to the concerned authorities during the disaster.
5. Providing the details of disaster effect after the disaster.

The secondary objectives of FFEWS are:

1. Collection and storage of flood related data for the analysis and research purpose.
2. Encourage automated warning system implementations in highly risked areas of Nepal.
3. Help public, private and government sectors working in the related field in disaster management.

3. Scope of Work

FFEWS project, as its name suggests, is an early warning system for flash flood. The fully featured and detailed project of FFEWS would be very large and its accomplishment period would exceed the time-frame of one year. So, considering the time-frame, we have limited our project to include the basic features of following parts:

1. Information Database
2. Data Collection and Forecasts
3. Communication and Warning
4. Disaster Information
5. Response and Rescue planning

3.1 Information Database

This part will be the input system of the project. All the data, information, statistics related to the hazard will be stored in this system. Also, the entire geological database, hydro-meteorological information will be fed in this part of the project.

3.2 Data Collection and Forecasts

This will include the continuous real-time data collection from the hydrological sensors, storage of data, processing of data for anomaly detection and early forecasts based on the acquired information. This will also make use of the information database for the data processing and forecast purpose.

3.3 Communication and Warning

This part will consist of various mechanisms of information distribution during the disaster. It may include public siren alarm activation, web based information portal, SMS-based information dissemination or other suitable ways of warning to the probable victims and concerned authorities.

3.4 Disaster Information

This part will consist of predicting the risk and probable effects of the disaster. Based on the flood's severity, its possible route and demographic data of the location, the risk information will be predicted.

3.5 Response and Rescue Planning

This part of the system will deal with the response planning. It will suggest the evacuation route and priority for the provided area under the risk. It may also include evacuation mechanism for different affected areas.

4. Literature Review

4.1 Flash Flood Forecasting Subsystem Examples in Nepal

Some examples of similar types of existing systems in Nepal are:

1. Department of Hydrology and Meteorology (DHM)
2. Flood Alarm in Seti

4.1.1 Department of Hydrology and meteorology (DHM)

The Rapti River is often at risk during country annual monsoon season from July to October. When river water reaches warning level indicated by telemetry readings at observation sites set up in 2008 at various points along the river's edge and transmitted to a gauge reader's office who immediately communicates this data to key local disasters risk reduction and response teams from the government, army, police and Red Cross, who in turn raise alarm in local communities.

The DHM also known as IRIN comprises 280 rainfall centers, 100 climate centers, and 180 hydrology centers, and is the key agency leading the early warning system in Nepal, but it needs upgrading, particularly in the area of warning and providing real time data.

4.1.2 Flood Alarm in Seti

After the recent flash flood occurred in Seti River in Kaski, a flash flood early warning system is being installed in the Seti River. When installed and operated, the radar-based system is said to collect relevant data and transmit them to the local communities. The system sends first-hand information to the weather office in Pokhara and District Administration Office before it is relayed to local people.

4.2 Flash Flood Forecasting Subsystem Examples outside Nepal

Outside Nepal, there were number of similar systems implemented in various country. Some of them are listed below:

1. Manual local flash flood warning systems.
2. Automated local evaluation in real time (ALERT) systems.
3. Flash flood guidance (FFG) forecasting subsystems.

4.2.1 Manual local flash flood warning systems (Phillipines)

A flash flood warning scheme was set up in the municipalities of Dinalupihan and Hermosa in Bataan province in order to help mitigate the disastrous effect of flooding, largely from typhoons. The system is non-structural hydrological monitoring system which collects the information and flood warnings based on river stage and rate of rise.

The system is composed of a set of river stage gauges. The gauges are used as reference markers for the community to monitor during times of inclement weather. Dedicated radio communication equipment or cellular phones are used for data and information exchange during these times.

4.2.2 ALERT (Automated Local Evaluation in Real Time) Systems

ALERT system previously started in USA has now spread internationally. Some countries using ALERT are Argentina, China, Australia, Spain, Jamaica, and Indonesia. One of the most popular ALERT system is FORT COLLINS, Colorado Real Time Flood Inundation Mapping and Notification system.

This system integrates hydrological and hydraulic runoff modeling with emergency operations in a system that is user friendly and graphically oriented. Data is collected at 54 gauge sites from 38 rain gauges, 35 water level gauges, and fire weather stations. Hydrologic numerical models produce estimates of real time runoff based on the data received from the gauges and from radar. All information output is displayed in graphic format using Geographic Information System (GIS).

4.2.2.1 San Diego County

Changes in rainfall, stream flow levels, weather conditions (temperature, wind, humidity), and lake levels throughout San Diego County are transmitted by radio to mountain top repeaters, which in turn relay the transmission to a District flood warning office. At the DFWO, the radio signals are intercepted and also relayed by independent radio repeaters to the National Weather Service (NWS) in San Diego. When flooding conditions develop, the FCD evaluates the flooding potential presented by the ALERT data and advises the NWS and OES (Office of Emergency Service) on possible flooding in the country.

4.2.2.2 Local Flood Monitoring Network in Poland

Poland has local monitoring networks under construction that is integrated with regional networks (Staszowski County). The local networks are commonly based on automatic observing stations which conduct ongoing measurements, while the transmission of data is based on an infrastructure of GSM telephone providers or private radio networks.

4.2.3 Flash Flood Guidance (FFG) Forecasting Subsystems

An example of flash flood guidance forecasting subsystem is USA FFG methodology coupled with computer processing of radar rainfall estimates via the flash flood monitoring and prediction software.

1. **Central American Flash Flood Guidance (CAFFG) System**

   CAFFG is the first fully automated real time regional flash flood guidance system which has been in operation for seven countries in Central America since 2004.

2. **International Flood Network's Global Flood Alert System**

   The infrastructure Development Institute (IDI) of Japan has launched the International Flood Network, a program to educate the public on flood hazards.

   Utilizing rainfall data obtained by multiple global observation satellites, GFAS sends out advisory information such as amounts of rainfall in the world's river basins and reports indicating the probability of rainfall that are used to forecast whether floods will occur.

5. Methodology

5.1 Project Phases

The project will be accomplished in different phases. The phases are divided on the basis of the tasks to be accomplished.

5.1.1 Research Phase

In this phase, an extensive research will be carried out on the subject field. The concerned authorities, NGOs, INGOs and experts will be consulted. The necessary data and information will be collected for the project.

5.1.2 System Design Phase

Based on the information collected on the research phase, the project's system will be designed. The necessary modules, features and their working mechanisms will be decided. The skeleton of the system will be created and the modules will be divided among the team.

5.1.3 Project Development - Primary Phase

In this phase, the core modules will be developed. Basically, the back-end engine of the system will be developed in this phase. All the proposed components of the system will be developed according to the constructed design.

5.1.4 Project Development - Secondary Phase

In this phase, various secondary components of the system will be developed. The system's GUI, modular integration interfaces and various components' fine tunings will be developed in this phase.

5.1.5 Local Test and Debugging Phase

In this phase, the developed system will be tested on the local machine with virtual data and will be debugged for errors. The test will be carried on either the data from past records or virtually generated data.

5.1.6 Implementation Test Phase

In this phase, the system will be tested with real-data from the implemented system. The system will be implemented in the site and tested for the final debugging.

5.1.7 Documentation

In this phase, the final documentation of the project will be carried out. The documents like final report, user manuals, etc. will be prepared in this phase.

5.2 System Architecture

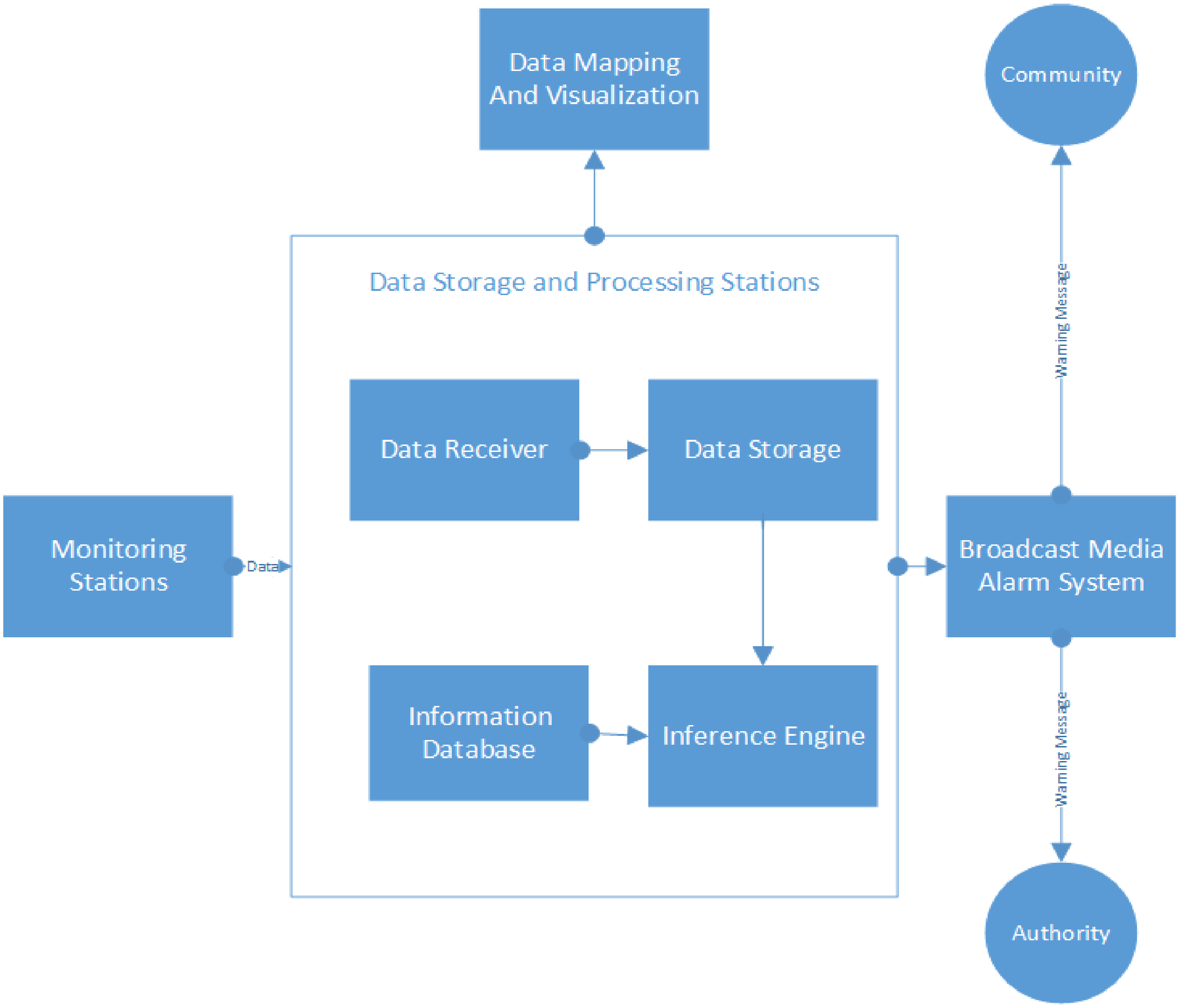


Fig 5.1:- System Architecture of FEWS

Basic architectural overview of the project is shown in the above diagram. The overall project can be divided into three major subsystems. They are

1. Monitoring stations
2. Data storage and processing system
3. Broadcast media

5.2.1 Monitoring stations

Monitoring stations consist of hydrological sensors and transmission networks. All the required sensors like rain gauge, water flow gauge, water level meter etc. are fit in the system at the measuring site. And the entire data collected from the sensors are passed in the transmitting network. The transmitting network transmits the data to the receiving station for data processing.

5.2.2 Data storage and processing station

This subsystem is the heart of the project. Majority of the tasks of the system takes place in this subsystem. It consists of a number of modules within the subsystem.

5.2.2.1 Data receiver

This module will collect the data at the receiving end transmitted from the monitoring stations. The data is collected through a wireless network.

5.2.2.2 Storage database

This module is responsible for the proper storage of the collected data in the well maintained database. It will facilitate the quick and easy access of the data for real-time processing.

5.2.2.3 Information database

This module is the part where the entire information about the flood science, hydrological science and statistics are fed. The data processing takes place based on these information.

5.2.2.4 Inference Engine

This module can be considered as the brain of the overall system. The main task of the prediction and calculation takes part in this part of the system. The data is processed with the help of information from the information database. All the information required as outcome of the system are generated in this module.

5.2.2.5 Decision support system

The information generated by the system is very critical. The wrong information could prove to be fatal. So before transmitting the information, it is passed to the decision support system.

5.2.3 Broadcast media

The broadcast media is responsible for transmitting the information to the vulnerable mass and the information generated by the system is broadcasted as warning through different media like SMS, news, public siren alarm etc.

6. Expected Output

6.1 Warning Message Transfer

Once the flash flood prediction has been made, a warning message would be transferred to every individual that are residing along the route of flood.

Another method of warning message transfer would be through warning stations, stationed at different location along the route. Another alternate method of radio broadcasting could be used, since radios are fairly cheap and available even in rural areas.

6.2 Flood Simulation

A visual display of how the flash flood would propagate through the land structure is one of the outputs of the system. Tributaries connected to main stream, land structure along the route of main stream, and water level increment would be used to visualize the flow.

Fig 6.1: Sample figure showing flood simulation

6.3 Graphs

A prediction of water level increment over time is one of the major output of the system. Considering the current rate of rainfall, the soil moisture, land structure throughout the route and probable other factors, a regression model would be fitted that would predict the time instant at which the flash flood would probably appear. Thus, it would help to increment the escape time frame for the local people by predicting beforehand the flash flood appearance time instant.

Thus, a graph of expected water level increment VS time would be plotted to visually display the time instant of appearance of flash flood.

6.4 Maps

Using the estimated water level increments and considering the demography at each probable affecting area, an intensity plot of the probable destruction and damage would be shown in a map.

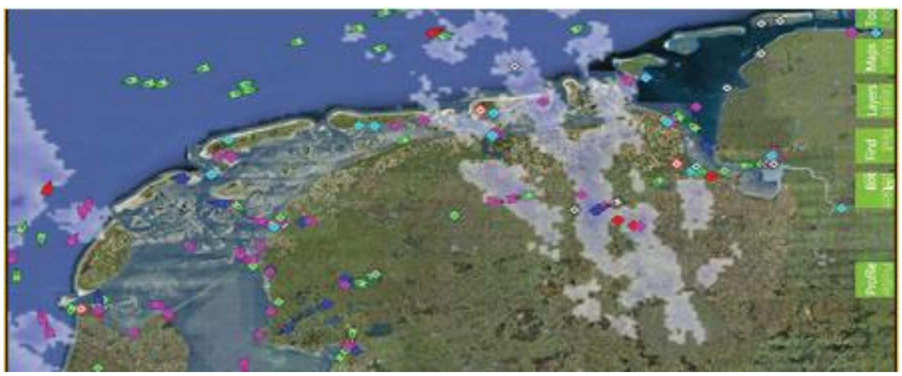
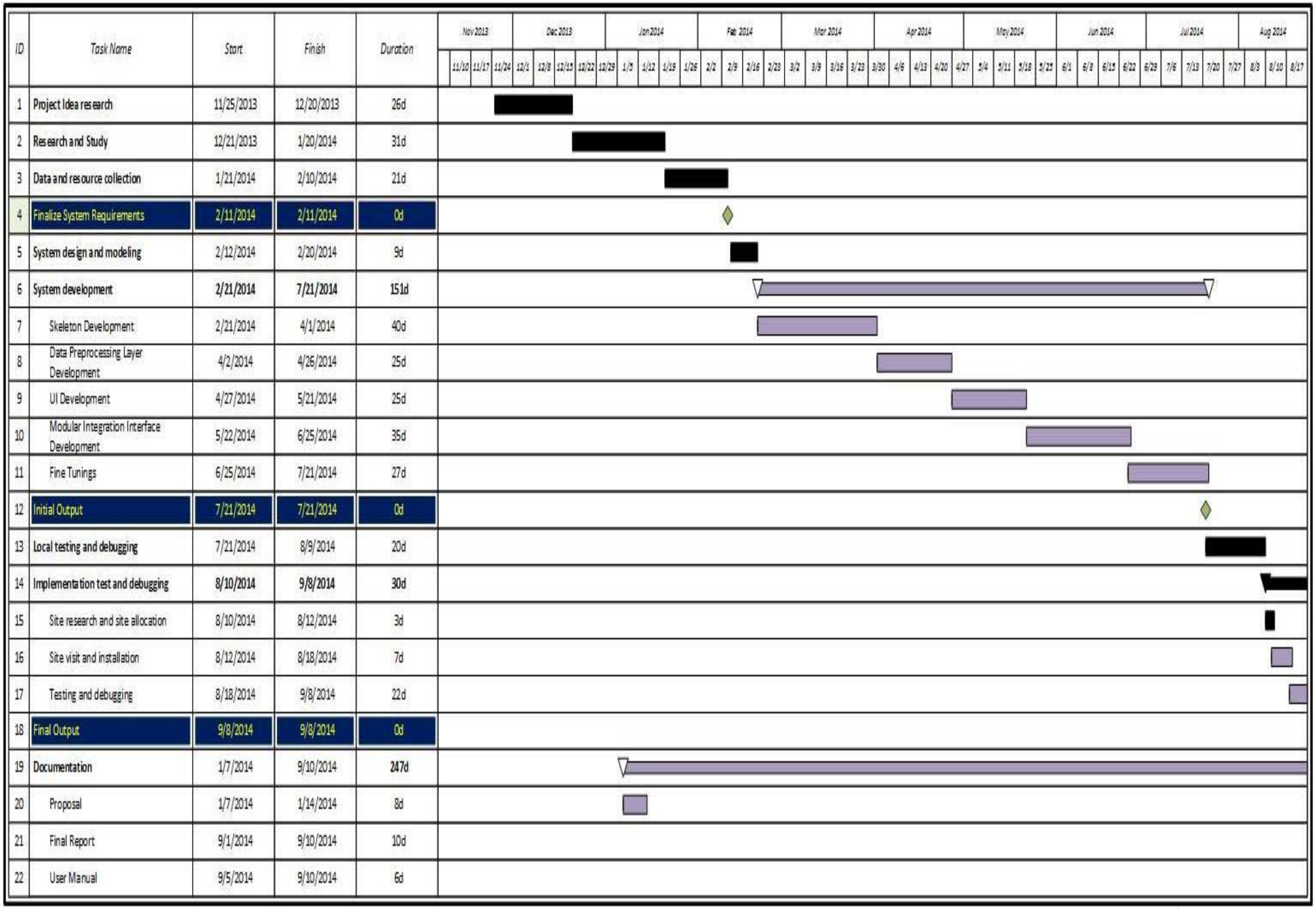


Fig 6.1 : Sample plot showing affected area

7. Timeline



ID	Task Name	Start	Finish	Duration
1	Project Idea research	11/25/2013	12/20/2013	26d
2	Research and Study	12/21/2013	1/20/2014	31d
3	Data and resource collection	1/21/2014	2/10/2014	21d
4	Finalize System Requirements	2/11/2014	2/11/2014	0d
5	System design and modeling	2/12/2014	2/20/2014	9d
6	System development	2/21/2014	7/21/2014	151d
7	Skeleton Development	2/21/2014	4/1/2014	40d
8	Data Preprocessing Layer Development	4/2/2014	4/26/2014	25d
9	UI Development	4/27/2014	5/21/2014	25d
10	Modular Integration Interface Development	5/22/2014	6/25/2014	35d
11	Fine Tunings	6/25/2014	7/21/2014	27d
12	Initial Output	7/21/2014	7/21/2014	0d
13	Local testing and debugging	7/21/2014	8/9/2014	20d
14	Implementation test and debugging	8/10/2014	9/8/2014	30d
15	Site research and site allocation	8/10/2014	8/12/2014	3d
16	Site visit and installation	8/12/2014	8/18/2014	7d
17	Testing and debugging	8/18/2014	9/8/2014	22d
18	Final Output	9/8/2014	9/8/2014	0d
19	Documentation	1/7/2014	9/10/2014	247d
20	Proposal	1/7/2014	1/14/2014	8d
21	Final Report	9/1/2014	9/10/2014	10d
22	User Manual	9/5/2014	9/10/2014	6d

Fig 7.1: Timeline

8. Manpower Hardware/Software Resource Requirements

A forecast center requires computers to effectively collect, process, monitor and display each observation data and to produce and disseminate outputs. Some hardware requirements can be listed as follows:

8.1 Hydro meteorological sensors

Different sensors like rain gauge, stream flow gauges would be required to collect real time data.

8.2 Communication requirements

For the efficient transfer of warning message, a fault tolerant communication protocol would be required. Some communication methods could be

1. SMS Gateway
2. Warning message transfer through mobiles.
3. Warning Sirens.

8.3 Training data requirements

For the training of the system and inducing results out of the system, huge datasets with sufficient amount of features are required. Features in the data include rainfall amounts, information on geological structure etc.

8.4 Manpower requirements

The study of geological structure and its effect on the streamline flow of water is a complex field of study, so experts on hydrology and geology are required for assistance.

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