Abstract—The study and objective of this paper is to develop an early flood detection and warning systems as a public alerting system for possible imminent flood. The work is based on a previously conceptualized idea by the authors. The system focuses on monitoring the water level remotely using wired sensor network. Data is collected from the sensors using data acquisition device and channel to the control panels which then relay information to the public through Global System for Mobile Communication (GSM) using Short Message Service (SMS). It ensures that the end users receive appropriate warnings within suitable time interval to take effective action to save lives and minimize losses of property.

The research work had been conducted in collaboration with Malaysia’s Meteorological Department and Pahang Department of Irrigation and Drainage (JSP). Tests had been conducted and results are presented to verify the viability of our work.

Keywords—Alert warning system, flood disaster, GSM network, Short Messaging Service.

I. INTRODUCTION

In this paper, a specific location in Malaysia was chosen to conduct our investigation. Sungai Lembing, located in the state of Pahang has been experiencing major flood caused by monsoonal season in every December to January. Flood is a natural disaster that happens almost every year in Malaysia that causes damages and lost of property or lives. The most recent widespread flooding caused by monsoonal rain are the floods of December 2006 and January 2007 at Sungai Lembing. These massive floods displaced more than 110,000 people and leaving at least 18 people dead. In fact, the estimated total loss in this disaster is RM 1.5 billion. It is considered as the most costly flood damages in Malaysian history [1].

The problem arises when there is a lack of system in conveying warning to the communities before the flood. The existing method to convey information is rather ineffective as pointed out in many studies conducted [2,3,4,5]. The reason being that communication medium would simply breakdown in flooding situation.

One particular solution is making use of cellular network. However, information on flooding were not relay to all individual affected as pointed out by Pahang Department of Irrigation and Drainage (JSP). According to [6], Short Message Service (SMS) is delivered only to certain authorities such as JSP top management’s mobile devices. Therefore, this project will highlight the importance of SMS delivered to all of the victims in the affected area, to relay vital first hand information. Information such as changes in water level would allow victims to take precautionary action to evacuate to safer grounds.

II. RELATED WORK

A similar system was assessed prior to develop the proposed solution. In this section, we will highlight the modus operandi of the existing system, its strength, and weaknesses as well as how it is adopted to enhance our work.

Fig. 1 Flood monitoring and forecasting using SCADA for the State of Pahang

Fig.1 shows the flood monitoring system’s interface and forecasting using SCADA. This system have been designed, installed, and maintained by JSP to monitor water level changes at areas prone to flood.

The system is equipped with more that 300 remote sensors.
located nationwide which are integrated into InfoBanjir system. InfoBanjir or The National Flood Monitoring System is accessible online via www.infobanjir.water.gov.my. It symbolizes the Malaysian’s government triviality to aid flood victims and to overcome mishap during the flood season.

Table I shows three water levels or set points monitored by the system in order to trigger alert based on sensors location. An alert message will be released when the water level of a particular location exceeds the ‘Alert’ level and subsequent alert message will be triggered if a water level exceeds the ‘Warning’ level and ‘Hazard’ level.

Features portrayed in the existing system served as a basis for the proposed system to incorporate various enhancements.

### Table I

<table>
<thead>
<tr>
<th>Location</th>
<th>Alert</th>
<th>Warning</th>
<th>Hazardous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sg Lembing</td>
<td>20.0m</td>
<td>21.50m</td>
<td>23.00m</td>
</tr>
<tr>
<td>Pasir Kemudi</td>
<td>4.57m</td>
<td>6.40m</td>
<td>8.23m</td>
</tr>
<tr>
<td>Sg Kuantan at Bukit Kenau</td>
<td>20.0m</td>
<td>21.50m</td>
<td>23.00m</td>
</tr>
<tr>
<td>Sg Kuantan at Pasir Kemudi</td>
<td>4.57m</td>
<td>6.40m</td>
<td>8.23m</td>
</tr>
</tbody>
</table>

III. SYSTEM ARCHITECTURE

As depicted in Fig. 2, the architecture of the system consists of four phases, which are data acquisition, data communication, interface, as well as alert warning notification. This system links with a set of rainfall and water level measuring stations set up over key points in a watershed or its sub-basins.

Every station transmits its information in real time to repeater stations, which are linked to a master station where the data from all basins are received and processed thus the changes in water level at different points of interest can be closely monitored. When flooding is likely to occur, a flood warning will be broadcasted and appropriate action can be taken to reduce damage and save lives or properties.

The changes in water level sensed by sensor will be sent to the data acquisition device, ADAM4017. The data are in volts and later converted into meter reading. Text readable form is logged in notepad file. This standard procedure is executed by ADAM View software. The data logged from the notepad will then be stored in Microsoft Excel, acting as a database with certain attributes such as date and time, meter conversion as well as centimeter conversion.

The meter attributes will be further extracted from the database using Microsoft Visual Web Developer row by row. ASP is used to evaluate the meter attributes with the benchmark value entered by user indicating hazards level. If the reading exceeds benchmark level, SMS is then send to affected communities via Ozeki SMS Gateway. Information is then displayed in victims’ mobile unit. This process is best explained in Fig. 3.
IV. SYSTEM COMPONENT

A. Hardware

A water level sensor is attached with an output cable to relay data in form of voltage as well as a power cable to supply 12V electricity. It basically integrates with ADAM 4017 hardware. Both water level sensor and ADAM 4017 required small battery supply which is around 12v-15v.

The ADAM-4017 hardware provides a 16-bit 8-channel analog input module with programmable input ranges to all channels. This module is an extremely cost-effective solution for industrial measurement and monitoring application. Data acquisition is made by the ADAM modules, which then relay data to the control computer to be converted to text readable form. [7]

The modules are equipped with inbuilt microcontrollers. The ADAM modules can be connected to the control computer and to all other devices by standard communications interface RS-485. Communication between the modules takes place by means of transmitted and received ASCII commands. [7]

B. Software

Fig.4 shows the flood monitoring system that delivers real time data. The changes in water level reading can be displayed in either number or graph format. The hydrograph displays set points and maximum flood information. This will give user a better view of the data to be analyzed for decision making. The system also provides date and time to keep track of the history of water level data measurement. The maximum reading on water level sensor is approximately 200 cm while the minimum reading is approximately 0.2 cm. The system also displays the corresponding reading in meter. This differs from the existing system, where the newly developed system provides a user friendly interface to cater for novice users.

C. SMS Gateway

An SMS gateway application was used as a tool to send SMS from the web application created with ASP VBScript to the mobile phone. The GSM phone attached to the computer using Ozeki Message Server serves as gateway to send or receives SMS messages. 

Ozeki Message Server is installed in the computer in which the web application resides. In order to make the web application interact with the Ozeki Message Server, the ASP codes provided by the Ozeki website need to be embedded into the web page. Subsequently the Ozeki Message Server can send SMS to a particular party once the ‘Send SMS’ button is clicked by the administrator.

V. RESULTS AND DISCUSSIONS

A. System’s Alert Set Points

Fig.5 shows three types of reading. Reading A, shows the corresponding reading at studied area, Sungai Lembing. Reading B shows its corresponding measurement represented in the system whereby The system allows three types of setting, Alert, Warning and Danger. When water reaches the first level of setting, SMS alert will be triggered. The second stage of setting indicates warning and the last setting triggers a danger notification alert. Reading C indicates the actual measurement at the water tank being used to simulate the flood, in checking the sensor.

B. Functionality Test

A functionality test was conducted to check and examine the functionality of each device used as well as the system. Previously, during system development, the existing data acquisition hardware, EZ-430 was not functioning due to...
incompatibility with circuit and control panel. The data cannot read the water level reading because it was initially configured to read temperature measurement. However, the problem was rectified by using ADAM 4017 to replace EZ-430. This fits well with the system.

Another minor problem occurred in choosing the right database for storing the monitoring water level data. Initially, Microsoft Access database was identified. Due to incompatibility issue, the data storage is resorted to Microsoft Excel. The tests were conducted for 10 days by leaving the application and devices running twenty four hours a day. Result of the tests is represented in Table 2.

There is no fault detected during the test. It is found out that all hardware functionalities and software properties are functioning as expected.

C. User Acceptance Test

The test was conducted on 30 subjects comprises of staff at JSP and public from various background to try out the Early Flood Monitoring & Warning System. The objective is to explore user’s level of acceptance in handling the system. Subjects were given a short briefing to simulate the situation as if they were facing a flood. The samples were asked to test and evaluate the system. Upon completion, a set of questionnaire was given to them to evaluate the performance of the system in terms of acceptance and usage. Fig. 6 and 7 show results consolidated from the questionnaire.

Out of the 30 subjects tested, 87% received and aware of the SMS alert notification when the first level of alert was sent or triggered. Subjects were not informed of when this mock exercise will be carried out. This would allow majority to evacuate within a graceful period before situation becomes hazardous.

VI. CONCLUSION AND RECOMMENDATION

An Early Flood Monitoring & Warning System was successfully developed by referring to the case of Sungai Lembing, Pahang. This paper has presented the modus operandi of an existing system and was used to enhance the prototype system. However, additional functionalities can be included to the perfect system. Below are some suggestions:

A. Incorporate Decision Support System (DSS) and Artificial Intelligent (AI) concept.

Incorporating DSS and AI in the system would allow distinct separation of ambiguous decision. This would lead to decisive relay of information as firm decision could be made during vague situation. For example, water levels changes might alternate from low to alert level several times which could lead to hazardous or false alarm.

B. Using Wireless Sensor Network

Implementation of SCADA typed systems using wireless sensors network has shown several advantages. The sensors would be able to relay information more accurately as they can be deployed in many secluded and remote area along river bank and irrigation system. However, power supply would be an issue.

C. Expand Case Study

Currently, the scope of the project is only limited to Sungai Lembing Pahang. It would be better if the research is expanded to cities and not only rural area. A thorough study on the behavior of flash flood would open a new frontier on how technology could be utilized to save precious assets and above all, human lives.
REFERENCES


Izzatdin Abdul Aziz is an academician with Universiti Teknologi PETRONAS Malaysia. He is a member or Malaysian IT Society (MINTS) since 2008 and has been actively publishing papers in areas related to mobile computing, distributed computing, GRID and cluster computing as well as parallel programming. He earned his Masters degree from The University of Sydney, Australia specializing in computer networks. He is now focusing in areas of research in cloud computing particularly using Google Hadoop.

He has been actively involved in consultation work with private and government agency accumulated worth of USD 120, 000 for the past two years in the nature of technology evaluation and training. His recent participation in international exhibition Innovation Technology Exhibition 2008 (ITEX 08) at Kuala Lumpur Malaysia has granted his invention ‘The Blind Echolocation using Ultrasonic Sensor’ a silver medal. Recent journal publication includes Parallelization Of Prime Number Generation Using Message Passing Interface WSEAS Transactions on Computers Volume 7 , Issue 4 (April 2008) Pages 291-303 year of Publication: 2008 ISSN:1109-2750.