Early warning system on flood hazard in river flow area based on radio frequency

A Finawan, R Tahir, E Eliyani, A Fauziah and A Jannifar

Abstract. Aceh Province is rich with river flow attractions, and foreign tourists who use the location as a tourist spot for bathing or to enjoy the cool and peaceful natural scenery. These tourism objects often experience sudden flooding in the event of high intensity rain in the upper mountains of the river. Flooding can be caused enormous harm to humans both property losses and loss of life. These problems need to be pursued with a number of steps including measuring the signs of flooding upstream, sending information on signs of flooding from upstream to tourist attractions, and building an Early Warning System (EWS) for flood hazards. This system consists of two parts, namely the flood level detector that was applied in the upstream part of the river and the delivery section of river status information in the form of a siren alarm and an appeal through loudspeakers. Information conveyed to tourists in form by loudspeaker that visitor have to be careful and danger. Flood status was sent to the recipient system in the river flow of tourism area by using radio frequency. The ultrasonic sensors were used to detect the distance of the water surface of the river to the sensor up to 300 cm. The frequency radio can transmit data in the range of 550 m. River status was stated in 3 statuses, namely danger, standby and normal with the distance of the sensor to the water surface of each less than 260 cm, less than 275 cm and more than 275 cm. This system has been tested and can work well as a EWS to avoid properties losses and fatalities. A critical finding about this study is EWS could be adopted by a method using flood level detector and siren alarm.

1. Introduction

Aceh Province is rich in river tourism attractions, many local and foreign tourists who use it as a tourist place for bathing or to enjoy the cool and peaceful scenery. River flow attractions often experience sudden flooding in the event of high intensity rain in the upstream mountains. Floods can cause enormous losses to humans, both loss of property and casualties. A EWS needs to be sought to find out more quickly about the arrival of floods. This system must be able to read the signs of floods coming upstream and give a warning to tourists who are on the river to immediately avoid the river flow. A complete and effective EWS comprises four inter-related elements, risk knowledge, monitoring and warning service, dissemination and communication, and response capability [1]. To realize the above, it is necessary to do a number of things including measuring the signs of floods coming upstream, sending information on signs of flooding to tourist attractions, and building a EWS for flood hazards.
There are many flood EWS that have been developed as a warning against sudden flood hazards, both local/community, national and regional/global. A national level EWS flood has been developed with a combination of water level and rainfall measurements using SMS and WEB technology [2][3]. There is also a wireless sensor-based sensor network that measures water levels and sends video recordings [4]. A number of previous studies, there have been no studies conducted on river tourism attractions. The EWS developed is a local/community level system, a form of warning can be voiced through loudspeakers [5]. Objective of the study is to produce a EWS prototype for flood hazards in watershed tourism areas. The state of the art of this study is sending a signal from upstream part of the river by an alarm signal to a tourist attraction place along a river bank.

2. Method

2.1 Hardware Design.

The flood EWS consists of two parts, namely the sender and receiver parts that are far apart. The sending part serves as the sender of flood status consisting of a flood detection sensor, and a flood data sender. While the receiver functions to receive flood status from the sender and inform tourists if there is a possibility of flooding. This receiver consists of a receiving radio, siren, sound module, and speaker. This system will turn on the siren alarm, and information in the form of sound. Ultrasonic sensors can be applied to detect flooding [6]. The sensor used to detect flooding is an HC-SR04 ultrasonic sensor, as shown in figure 1. The ultrasonic sensor emits sound waves with certain frequencies to the object and receives reflected sound waves. The sensor measures distance by calculating shipping and receiving this sound wave time [7]. The distance parameters measured by ultrasonic sensors are calculated based on equation 1 [8].

\[ S = \frac{(v \times t)}{2} \]  

where S is the distance between the ultrasonic sensor and the reflected field, v the speed of sound is 344 m/sec and t is the time difference between the transmission of ultrasonic waves until they are received again by the ultrasonic receiver.

The system for sending flood status information to users can use Internet technology of Thing [9]; Short Message Service [10]. This really depends on the conditions and communication infrastructure in the area.

An area that is not available with an adequate communication infrastructure, can apply radio frequency as the sender of flood data. The radio communication systems for Early Warning can be consisting of two type; Fixed Radio Communication System (FRCS) and Mobile Radio Communication System (MRCS). The Regional Simultaneous Communication System (RSCS)
makes it possible for a disaster information centre or disaster management centre installed in a local to send disaster information simultaneously and immediately to residents to protect public safety when a disaster occurs[11].

The radio used is the YS-C20 frequency radio with GFSK modulation at a frequency of 433 MHz[12]. Figure 2 shows the shape of the YS-C20 radio. The specifications of the radio frequency YS-C20 are as shown in table 1.

Table 1. RF YS-C20 specifications

| RF power | 50mW/17dBm |
|----------------------|------------------|
| Receiving current | < 25mA |
| Transmitting current | = 55mA |
| Sleep current | < 20uA |
| Power supply | DC 5v or 3.3V |
| Receiving sensitivity | -115 dBm ( @9600bps) ; -120 dBm ( @1200bps) |
| Size | 47mmx26mmx10mm (without antenna port ) |
| Range | = 0.8 Km (BER =10⁻³ @9600bps, ) |
| | = 1Km (BER = 10⁻³ @1200bps, ) |

The microcontroller that is used as a system controller on the sender and receiver is Arduino Uno. Port allocation of the Arduino Uno microcontroller to determine the interface relationship between input and output (Input / Output) equipment in the sender and receiver module is as shown in table 2.

Table 2. Allocation of Arduino Uno input and output ports on flood detectors

| Arduino Port | Input/Output | Remark |
|-------------|--------------|--------|
| D1          | Tx serial    | Radio Communication |
| D6          | Output       | Trig Ultrasonic |
| D7          | Input        | Echo Ultrasonic |
| D13         | Output       | R/S LCD |
| D12         | Output       | E LCD |
| D11         | Output       | Data D4 LCD |
| D10         | Output       | Data D5 LCD |
| D9          | Output       | Data D6 LCD |
| D8          | Output       | Data D7 LCD |

(a). Transmitter

The media used for recording and storing sound is the ISD1820 Module as shown in figure 4. 3.2K memory storage capacity can record a maximum of 20 seconds with direct output on 8 OHM speakers or active speakers, and working voltage is only 3.3V[13]. The block diagram of the EWS for floods is as shown in figure 3.
2.2 Software Design
Algorithm of this flood EWS consists of two sides, including the algorithm on the transmitter side and the receiver side as in figure 6 and figure 7.

![Flowchart of algorithm for controlling system](image)

**Figure 4. Flowchart of algorithm for controlling system**

3. Results and Discussion
3.1 HC-SR04 Ultrasonic Sensor Testing
Ultrasonic sensor test aims to determine level sensitivity of the HC-SR04 sensor to the measurement of the distance between the sensor to the water surface as shown in figure 5.

![HC-SR04 Sensor testing method](image)

**Figure 5. HC-SR04 Sensor testing method**

![Error measuring distance on the HC-SR04 sensor](image)

**Figure 6. Error measuring distance on the HC-SR04 sensor**

The measurement of the sensitivity of the HC-SR04 sensor to the distance the sensor and the water surface are already done. The error value in measuring the sensitivity of the ultrasonic sensor can be shown graphically as in figure 6. The results of measuring the sensitivity of the HC-SR04 ultrasonic sensor indicate that effective measurement are applied for a range of 10 cm to 300 cm, because the error value in a range greater than 300 cm shows a very large error or can be said to not be well defined.
3.2. Radio Communication Testing
The communication radio used for data communication has a transmission range of up to 0.8 Km with a $10^3$ bit error ratio (BER) at 9600 bps baud rate. The test carried out is the distance measurement between the radio transmitter and receiver. Data sent to the recipient is flood status data with a notation in the form of "C" for careful status and "D" for danger status alternately per 2 seconds. Data transmission testing is carried out in an open space without a barrier by placing the antenna 2 meters above the ground in accordance with this radio specification procedure. The radio communication test results in table 3 show that the effective communication range between the sender and receiver is 550 meters.

**Table 3.** Radio communication test results

| No | Data Sent Transmission Distance (m) | “C” | “D” |
|----|-------------------------------------|-----|-----|
| 1  | 50                                  | C   | D   |
| 2  | 100                                 | C   | D   |
| 3  | 150                                 | C   | D   |
| 4  | 200                                 | C   | D   |
| 5  | 250                                 | C   | D   |
| 6  | 300                                 | C   | D   |
| 7  | 350                                 | C   | D   |
| 8  | 400                                 | C   | D   |
| 9  | 450                                 | C   | D   |
| 10 | 500                                 | C   | D   |
| 11 | 550                                 | C   | D   |
| 12 | 600                                 | -   | -   |

3.3. Testing of Flood Hazard Early Warning System
Changing the distance of ultrasonic sensors is done by moving the flood detection device above a water bath up to 310 cm. Table 4 shows the results of testing the flood hazard warning system based on water level or distance measured between ultrasonic sensors and the water surface.

**Table 4.** Results of testing the flood early warning system

| No | Distance of Ultrasonic Sensors (cm) | Status  | No | Distance of Ultrasonic Sensors (cm) | Status  |
|----|-------------------------------------|---------|----|-------------------------------------|---------|
| 1  | 10                                  | Danger  | 16 | 160                                 | Danger  |
| 2  | 20                                  | Danger  | 17 | 170                                 | Danger  |
| 3  | 30                                  | Danger  | 18 | 180                                 | Danger  |
| 4  | 40                                  | Danger  | 19 | 190                                 | Danger  |
| 5  | 50                                  | Danger  | 20 | 200                                 | Danger  |
| 6  | 60                                  | Danger  | 21 | 210                                 | Danger  |
| 7  | 70                                  | Danger  | 22 | 220                                 | Danger  |
| 8  | 80                                  | Danger  | 23 | 230                                 | Danger  |
| 9  | 90                                  | Danger  | 24 | 240                                 | Danger  |
| 10 | 100                                 | Danger  | 25 | 250                                 | Danger  |
| 11 | 110                                 | Danger  | 26 | 260                                 | Danger  |
| 12 | 120                                 | Danger  | 27 | 265                                 | careful |
| 13 | 130                                 | Danger  | 28 | 270                                 | careful |
| 14 | 140                                 | Danger  | 29 | 275                                 | careful |
| 15 | 150                                 | Danger  | 30 | 280                                 | Normal  |
The status of the river is declared normal when the distance of the water surface to the ultrasonic sensor is in the range greater than 275 cm. Status will be declared idle at a sensor distance of 261 cm to 274 cm. While the danger status will be informed if the distance of the ultrasonic sensor to the water surface is in the range 0 to 260 cm. Standby status will be sent to recipients of flood status if there is an increase in normal river water levels up to 15 cm.

The real applications of this system may be applied to tourist destination rivers to reduce the danger of flooding. The distance between the sender and receiver that allows this system is relatively close, can be overcome by applying the relay station on the communication system. The energy source needed can use solar cells.

4. Conclusion
The HC-SR04 ultrasonic sensor used to detect river water levels can detect the distance of the water surface to the sensor in the range of 300 cm. Radio frequencies in which the YS-C20UA module can transmit data with a range of 550 m, making it feasible to be applied to early warning systems against flood hazards. The status of the river is expressed in 3 status, namely danger, standby and normal with the distance of the sensor to the water surface each less than 260 cm, less than 275 cm and more than 275 cm.

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