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To cite this article: S Bahri and A W Purwantiasning 2019 *J. Phys.: Conf. Ser.* **1376** 012016

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# An Application of Microcontroller for Flood Hazard Early Warning System to Create Friendly City

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**Abstract.** This paper is aimed to discuss the microcontroller that applied for flood hazard early warning system to create friendly city, particularly in Jakarta city, Indonesia. By using this system, the danger of flood hazard could be anticipated early. The tools and material of prototype system that have been used in this research are microcontroller Arduino-Uno, Probe Sensor, Atwin Quad-Band GSM/ GPRS and mobile phone. The method of this research is design, installment and testing the tools. The probe sensor read the level of water at the surface of water tank and sent it to microcontroller. This information processed by microcontroller and divided it into three categories: Level-3 (the lower sensor referred to the normal condition we called as SIAGA 3), Level-2 (the middle sensor referred to the warning condition we called as SIAGA 2) and Level-1 (the upper sensor referred to danger/critical condition we called as SIAGA 1. This condition will be sent to mobile phone receiver via Atwin quad Band GSM/GPRS module. Based on the test, information of these three conditions received by the receiver with time delay 4-6 second. This time delay varying depended on the strange of GSM provider signal to send the information to a receiver.

## 1. INTRODUCTION

Cities with high population density present a higher disaster risk. Floods are the most common phenomenon, particularly for the tropical country and urban areas. Flooding is considered as one of the major threats to human civilization and is directly attributed to heavy precipitation leading to loss of life, infrastructure damage, as well as huge economic losses [1]. It could cause human suffering, inconvenience and widespread damage to buildings, structures, crops, and infrastructures. Floods have been observed to disrupt personal, economic and social activities and set back a nation's security and development by destroying roads, buildings, and other assets.

Different types of floods can affect urban areas and some of them may be more applicable to some regions than others. These floods are mainly classified into four types: coastal, fluvial, pluvial and flash floods [2]. Coastal flooding results from a combination of extreme climatic phenomena. The sea level exceeds the elevation of the land or of a natural or human barrier; water flows and floods the land behind it.



When the coasts are constantly exposed to large waves, the natural and human-engineered barriers break down, increasing the risk of flooding. Also, this flood can be caused by earthquakes, submarine volcanic eruptions, subsidence and coastal erosion [2].

The flooding that affects the vast majority of the world's regions is fluvial flooding or river flooding. This type of flood occurs when the rivers overflow or burst their banks due to excessive rainfall over an extended period of time and spill onto the floodplain [3,4]. Geographically, Indonesia is one of a tropical country which has two seasons. One of the seasons is a monsoon season. The level of rainfall is relatively high in almost all part of the country. This condition had encouraged the government to manage the rainwater to become one of renewable energy by developing many dams in some areas in the country. This dam has been designed to maintain the level of water entry from the river which is potentially creating a flood in some areas. Many rivers in Indonesia have a high level of water entry to the dam, and thus, when the level of water is too high, then the flood hazard cannot be avoided anymore.

Java island, particularly province of DKI Jakarta has this hazard almost every year. And this hazard is no more just in monsoon season, but also in the dry season when the rain is coming. The level of rainfall which is regarded relatively high in DKI Jakarta is potentially affected Jakarta to be submerged by water. And this has happened in only about 3 hours-rain. Sometimes, the flood hazard in Jakarta is not just because the level of rainfall is relatively high in Jakarta, but also because there is water that comes from Bogor, West Java which is flowing from the river in Bogor to Jakarta. This flowing of water from Bogor to Jakarta has happened because of the condition of the topography of Bogor which is relatively higher than Jakarta. More than 40% the land level of Jakarta is lower than sea level especially in north area and there are 13 rivers flowing through the city of Jakarta. This condition is very disadvantaged for Jakarta. This condition is also an impact on the status of the dam in Bogor named Katulampa is not feasible anymore to accommodate the water in Bogor city. It is complicated to understand the situation of the flood hazard which is caused by the water flowing from Bogor to Jakarta. But this condition could be anticipated earlier if the officer could have a quick respond and standby at the control post and could have a prediction of the flood hazard. Using the information from this control post, people of Jakarta would prepare all the consequences and situation of the danger. Unfortunately, this method is a conventional method which is using a manual system. An officer in the control post will observe the level of water from 150 meters of distance, and this officer will report the result to the central office about the condition of the water level. When the level of water is regarded relatively high, the officer should send the information and report in every 5 minutes, and he has to go back and forth, this is very ineffective and inefficient condition.

Based on the above condition, the we have tried to conduct this research to create a method or a system which would help to find out the level of water that enter to the dam periodically and send all the information to the database center and distribute it to the observer or the community. This paper is aimed to explain how to create a prototype of early warning system for flood hazard which is easy and simple while installing it in anywhere. The system is also building a message system such as Short Message Service (SMS) from mobile phone to observer or the community about the flood hazard warning.

## 2. MATERIAL AND METHODS

The creating process of this early warning system divided into some phases, which is the first step is started by collecting all of the components that will be used to create this system. Those components included: microcontroller Arduino Uno, Probe Sensor, and ATWIN Quad-Band GSM/ GPRS. The second step of the process which is by assembling all the components into one set of tools, first of all is by installing the Probe Sensor with microcontroller Arduino Uno which as a function to detect the level of water in the condition of NORMAL to EMERGENCY, how far the situation could be read by the sensor and the output of the Probe Sensor will be read by microcontroller and the data will be processed by microcontroller.

Afterward, the component of ATWIN Quad-Band GSM/ GPRS will be connected to the microcontroller Arduino Uno. And after all data from Probe Sensor has been received and the output will be forwarded to ATWIN Quad-Band GSM/ GPRS. And from this component, all the received data will be sent to the officer in SMS form to the officer's mobile phone. From this SMS, the officer could define the level of water in the condition of NORMAL to EMERGENCY. The process of SMS sending has been determined by the GSM provider which is used at ATWIN Quad-Band GSM/ GPRS for the communication.

The next phase is the third step is by creating C programme language for microcontroller Arduino Uno as a command work microcontroller. This step will be determined the programming language which consists the command to process all the received data from Probe Sensor. It also includes all the command to send the condition of the level of water from Probe Sensor and will be sent to ATWIN Quad-Band GSM/ GPRS, thus this information could be sent in SMS form to the officer's mobile phone.

After the third step, following the next phase is the fourth step is by applying the C programme language into microcontroller Arduino. And the last step is the fifth step is by testing the tool of early warning system for flood hazard. This final step will be defined either the system could be appropriately worked or not.

### 3. DISCUSSIONS

#### 3.1. *What is Early Warning System?*

Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and early warning for adverse events are all examples of disaster risk reduction. The expression of "early warning" is used in many fields to mean the provision of information on emerging dangerous circumstances where that information can enable action in advance to reduce the risks involved [5]. Early warning system exists for natural geophysical and biological hazards, complex socio-political emergencies, industrial hazards, personal health risks and many other related risks [5]. The terminology of early warning system from UN-ISDR terminology, which is defined that early warning is "the provision of timely and effective information, through identified institution that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response". Early warning systems include a chain of concerns, namely: understanding and mapping the hazard; monitoring and forecasting impending events; processing and disseminating understandable warnings to political authorities and the population, and undertaking appropriate and timely actions in response to the warnings.

#### 3.2. *Creating Friendly City*

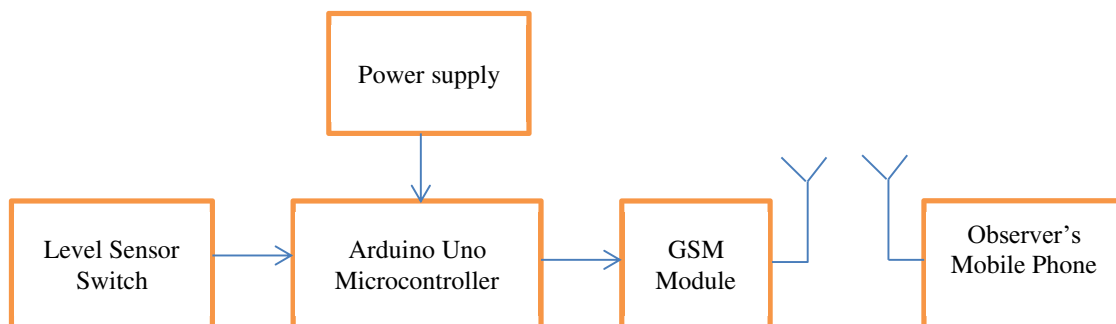
Globally cities around the world are changing and developing rapidly. It is not just the planning of the city which is changing as well constantly, but also the growth of the population is increasing too. This condition will become a burden to the town if it is not well planned. The city should be designed with a sustainable concept; thus future generation could feel the impact particularly the positive impact of the city development. When we talk about town, it is not just a big city but also small city around the world. Recently, many cities around the world have implemented a concept of city planning which is based on people's need. Some countries defined this idea as a friendly city, but some countries call this concept as an eco-city. Both are having the similar fundamental principle and concept because both approaches are based on environment and people's need. Eco-city has been defined as a concept which is responded to global climate changes crisis and combining the ideas from several disciplines such as urban design, urban planning, transportation, health, housing, energy, economic development, natural habitats, public participation, and social justice. In a simple word, eco-city could be defined as a settlement where it allows the citizen to live, work using minimum resources. On the other hand, friendly city has a similar concept with eco-city, friendly city is a concept to plan the city become livable for the community, friendly to live,

to work, to study, to have an enjoyable living area. Those both concepts have a main point; both ideas are about environment and people.

To create a friendly city, some principles should be completed to meet up the requirement. One of the principles is the city should be livable for people. Livable city is a city where we can have a healthy life and where we have the chance for easy mobility as by foot, by bicycle, by public transportation, and even by car where there is no other choice. The livable city should be a city that affordable and decent for all people. That means that the livable city should be attractive, worthwhile, safe for our children, for our older people, not only for the people who earn money there and the go and live outside in the sub urban and the surrounding communities. For the children and elderly, it is especially essential to have easy access to areas with green, where they have a place to play and meet each other, and talk with each other [6].

#### 4. DESIGNING OF THE EARLY WARNING SYSTEM

The designed early warning system for flood hazard in this paper is a warning system of water level in the condition of NORMAL to EMERGENCY in anywhere and anytime via Short Message Service (SMS), also a tool to send a SMS automatically in the condition of water level which is in the level of Siaga 3 (for normal condition), Siaga 2 (for Warning Condition) and Siaga 1 (for Emergency / Danger Condition). All the components that have been used in the creating of Early Warning System for Flood Hazard are as follow and the diagram block of the system as given in figure 1: Microcontroller ARDUINO UNO, Probe Sensor, ATWIN Quad-Band GSM/ GPRS, and Cellular Phone.



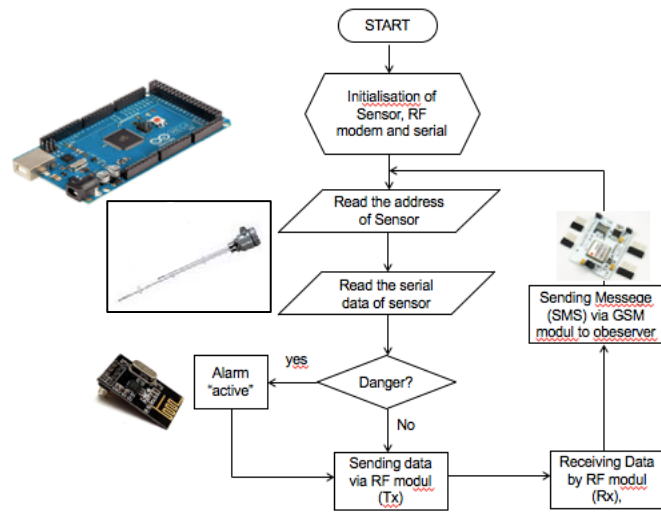
**Figure 1.** The block diagram of Early Warning System for Flood Hazard

Figure 1 shows the design of monitoring system for level of water, which is the sensor will read the level of water in the condition of NORMAL to EMERGENCY. After the water touching the sensor, thus the sensor will send the data and will be processed by microcontroller and afterward will command the Module GSM to send an SMS to the officer's mobile phone about the information of water level in the condition of SIAGA (SIAGA 3, SIAGA 2 or SIAGA 1).

The microcontroller will command GSM Module to send a short message to the officer's mobile phone automatically about the water level information when the water level reaches the level of SIAGA 3, SIAGA 2 or SIAGA 1. These all of water levels also have been appointed which is suitable to the need of the user to define the level of water categories. The flowchart of the design of Early Warning System for Flood Hazard is shown in figure 2.

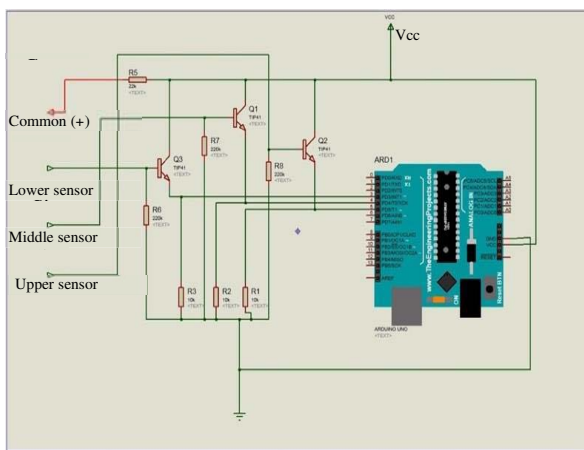
In the selection of sensor, we have used a simple sensor which is quite easy to be used and has high accuracy named Probe Sensor. This Probe Sensor has been used in this research compared with Ultrasonic Sensor [7] or Funduino Sensor because Ultrasonic Sensor has a very sensitive sensor, soon as this sensor

passing through the ultrasonic sensor, then the level of water will be read as a high level of water. On the other hand, the Funduino sensor has an insensitive sensor, this sensor has a low accuracy level, if there is a potential difference then the condition of the level of water cannot be read by the sensor.



**Figure 2.** Flowchart of design of Early Warning System for Flood Hazard

To start the design of the system, the components should be installed; some components will be used in this system, as follow: Modul GSM for Arduino Uno, Modul Arduino Uno, Probe water level sensor, Transistor TIP 41 (3), Resistor 22K (1), 220K (3), 10K (3), GSM Card, DC Power Supply, Connecting cable, and Container. The schematic of the circuit and the prototype of system realization are shown in Figure 3(a) and Figure 3(b).



(a)



(b)

**Figure 3. (a)** The schematic of the circuit and **(b)** Prototype of Early Warning System for Flood Hazard using SMS

## 5. TESTING AND RESULT

This testing step is a final step for the designing of early warning system for flood hazard. This testing aims to prove either the system succeeded or not. The experiment has been done by testing the accuracy of the tool to read the condition of water lever appropriately and sent the information automatically to the appointed mobile phone. The test also did to calculate the responding time of the tool in sending the information to the appointed cellular phone. The experiment has been done by using XL mobile provider to sending the information to receiver and in the sunny weather condition.

The result of the testing could be seen in table 1. The result data showed on Table 1 indicates that the tool is succeeded to send the message of early warning for flood hazard automatically within 5 seconds. The process of sending the MS depends on the available GSM network which is used on the component ATWIN Quad-Band GSM/ GPRS. This component has a function to send SMS to mobile phone.

**Table 1.** The result of the testing

| Condition | Testing   | Received message<br>(Mobile Phone) | Responding<br>Time (second) |
|-----------|-----------|------------------------------------|-----------------------------|
| SIAGA 3   | Testing 1 | SIAGA 3                            | 4                           |
|           | Testing 2 | SIAGA 3                            | 5                           |
|           | Testing 3 | SIAGA 3                            | 4                           |
|           | Testing 4 | SIAGA 3                            | 5                           |
|           | Testing 5 | SIAGA 3                            | 5                           |
| SIAGA 2   | Testing 1 | SIAGA 2                            | 5                           |
|           | Testing 2 | SIAGA 2                            | 5                           |
|           | Testing 3 | SIAGA 2                            | 6                           |
|           | Testing 4 | SIAGA 2                            | 5                           |
|           | Testing 5 | SIAGA 2                            | 6                           |
| SIAGA 1   | Testing 1 | SIAGA 1                            | 5                           |
|           | Testing 2 | SIAGA 1                            | 4                           |
|           | Testing 3 | SIAGA 1                            | 6                           |
|           | Testing 4 | SIAGA 1                            | 5                           |
|           | Testing 5 | SIAGA 1                            | 5                           |

## 6. CONCLUSION

The detection tools of early warning for flood hazard is using a delivery method of information when the water level in on the emergency limit which could danger to the surrounding area by sending information of the water level via SMS to a cellular phone of the officer. The information will give the level of emergency either SIAGA 3, SIAGA 2 or SIAGA 1.

By using this early warning system detection for flood hazard, the loss as an impact of flood hazard could be minimized or even could be anticipated more. This system will create the easy way for people who live in the potential area with flood hazard. The environment will be managed in a friendly way, and the flood hazard could be minimized as well to create a friendly city.

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