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Design and Development of a Flood Level Control Model Using Instrumentation System

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ABSTRACT: - Flood is an extremely dangerous and harmful natural catastrophe. Various actions have been taken to reduce severity caused by flooding and flood damages. However, the problem of drainage remains one of the main challenge. Therefore, the main objective is to avoid or minimize the environmental impacts of flood hazards and to reduce the risk of flood and channel migration hazards. In order to address the problem, and to provide flood protection and decrease flood damage different types of works have been undertaken by engineers from all disciplines across the globe. This paper discusses about an interactive model illustrating the flood like situation and its solution to control and manage. The model is designed and created using instrumentation and control-based hardware and software solutions to help manage the situation as well as to work like an emergency flood monitoring and warning system. This model is implemented with level monitoring and measurement system, alarm system, and use of LED's using which people can be warned and therefore help to reduce the after effects due to floods..

KEYWORDS: Climate change, global warming, green engineering, flood, weather, uncertainty, instrumentation and control, automation, PLC, arduino, sensors.

I. INTRODUCTION

Every year many natural calamities hit various countries including India such as flood, cyclone, earthquake. But the damage caused by flood in India is about 90% of total. Figure 1. Illustrates the damage caused by floods in India. A flood is a pour out of water from its original path, that submerges land which is usually dry. Rivers are the main source of fresh water in interior India. Seven major rivers (Brahmaputra, Godavari, Indus, Krishna, Mahanadi, Narmada, and Tapi) along with their numerous tributaries make up the river system of India [1,2]. The flood prone area of India is about 12% to 13% of area of nation.

II. LITERATURE REVIEW

There are many other causes of flooding, including river flooding, dam collapse, clarification, forest loss, climate change caused by greenhouse gases, as well as heavy rains, insufficient drainage systems. Over the past 10 to 15 years, floods have hit India hard. For example, the major flood events that took place in India in the past decade are listed as follows [3,4,5]:

- Recently in July and October 2021 a series of floods affected the western Maharashtra region, Kerala and Uttarkhand including cities and neighbouring areas of Chiplun, Sangli, and Kolhapur.
- Due to torrential rainfall during July and August, 2019, a series of flood affected various states including, Gujarat, Karnataka, Kerala, Maharashtra, and Madhya Pradesh.
- Heavy monsoon rains on August 8, 2018 and in the end of August 2018, severe flooding hit the Indian state of Kerala, killing more than 445 people.
- Heavy rainfall in November and December, 2015 flooded the Cooum River in Adyar, Chennai (Tamil Nadu), causing financial losses and lots of casualties.

- Heavy rainfall in June 2015 caused major flooding in the Saurashtra area of Gujarat, killing more than 70 people. It also affected the wild life of Gir Forest National Park and adjacent area.
- During 2013 rainy season heavy rains from cloud explosions caused severe floods and landslides in North Indian regions, primarily in Uttarakhand and neighbouring states. It is estimated that more than 5,700 people have died.

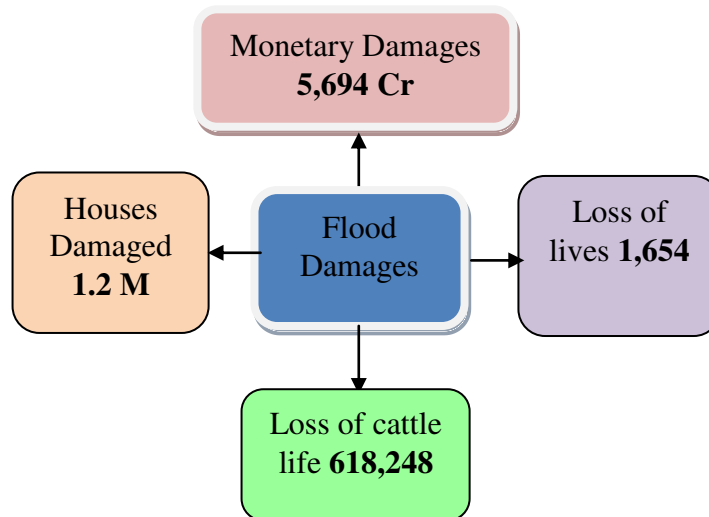


Figure 1. Destruction due to flood (average of years 1953 to 2010)^[1]

In recent 4 to 5 years frequency of floods is increased significantly in Maharashtra. Due to excessive rainfall, flooding in early July, 2021 and early August 2019. At least 200 people were killed and about 1 million were evacuated. Karnataka and Maharashtra faced most appalling condition. Damage caused by these floods is enormous. Flooding in six districts of western Maharashtra affected more than 4.24 hundred thousand people. About 400,000 people were displaced and 30 people died in the rain accident. The government has announced flood damage compensation of 15,000 rupees for urban damage and 10,000 rupees for villages. After a landslide, the Almatty Dam lock was opened. About 18,000 cars stranded on the highway as NH 4 (Mumbai Bangalore National Highway) was closed [6].

After collecting data from various reports and researching about the main reasons of flood situations with special attention to Sangli City and neighbouring areas it was possible to realize the intensity of damage. So it was decided to work on a model based solution to overcome such situations. For example, a miniature model replicating the flood like situation near the Irwin Bridge region (in Sangli City) as shown in Figure 2, is built and a flood control management and warning system was implemented using instrumentation-based hardware and software components such as, sensors, control valves, Arduino, and PLC. In real world it is thought, that by applying this concept perhaps, government or social or private organizations can reduce the risk of loss of life and other damages significantly.

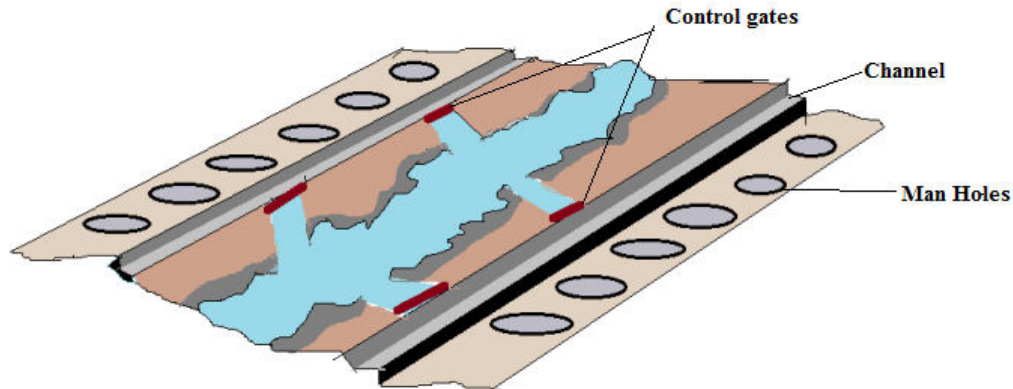


Figure 2. Proposed real time application of the concept.

III. OBJECTIVES

The project discussed in this paper consists is a conceptual model of flood level control & management using instrumentation. The main aim behind the project is to control and monitor the flood level situations in a river like catchment areas using PLC & Arduino.

The sub objectives were as follows:

- To design and build a conceptual model of flood level control system.
- To control the flood using Arduino and PLC technology.
- To improve the warning system and emergency communication.

IV. MATERIALS AND METHODS

A flood level control system consists of four components the ultrasonic sensor, buzzer, PLC, solenoid valve. If the level of water in model river goes above the set point then ultrasonic sensor measure the level of water and buzzer also give the indication of high level of the water. Then the control gate is automatically open and excess water is diverted through channel section to out of model city or town. If the situation doesn't under control and water level is high then the three manholes are open and water level comes under control. In this project, the main focus was on the PLC [7][8] based level control system design & implementation. Here an AB Micrologix 1100 PLC, was used which is manufactured by Rockwell Automation. A Servo motor was also used for opening the model gate and to generate 5V DC control signal according to the level of water.

We are creating a model of flood control & management. In this model we are implementing level monitoring and measurement system, alarm system, LEDs to inform the people and we can try to reduce various effects of flood problem. Our main objective is to avoid or minimize the environmental impacts of flood hazards & to reduce the risk from flood and channel migration hazards. The main aim behind the project is the PLC based water level control with their management. In this project using control gate we can maintain the level of water in flood situations. The level of water was observed before starting the rainy season and made the plan to controlling the level of water and after starting the rains the water level goes become high then all control gates are opened and with the help of control gate the water goes to outside of the cities then water level will be the maintain and less chance of flood. The project discussed in this paper is one of the first of its kind implemented using PLC, where the conceptual model is designed and built. Also the control gate is applied to maintain the water level. Using this technology it is possible to improve the system of warning and emergency communications

IV.a *HARDWARE DESIGN*

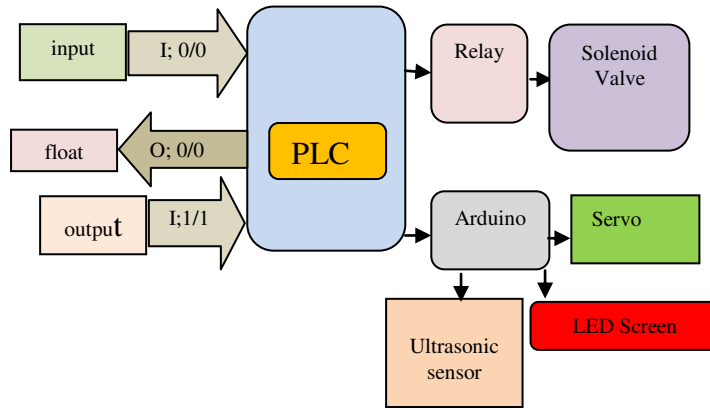


Figure 3. Block diagram of the system.

The hardware requirements set in this project were based on the block diagram shown in Figure 3. All digital sensors and actuators (float switch, buzzer, etc.) were directly interfaced to the PLC and the solenoid was indirectly interfaced via a special relay circuit. Whereas, the led's, analog sensors and the servo motor was indirectly interfaced with the PLC via an Arduino board as shown in Figures 4, 5a and 5b. Table 1. summarizes the list of sensors and actuators along with their specifications used in implementing the model.

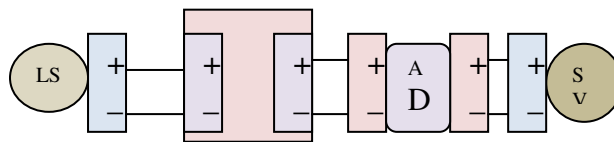


Figure 4. Wiring diagram transmitter loop.

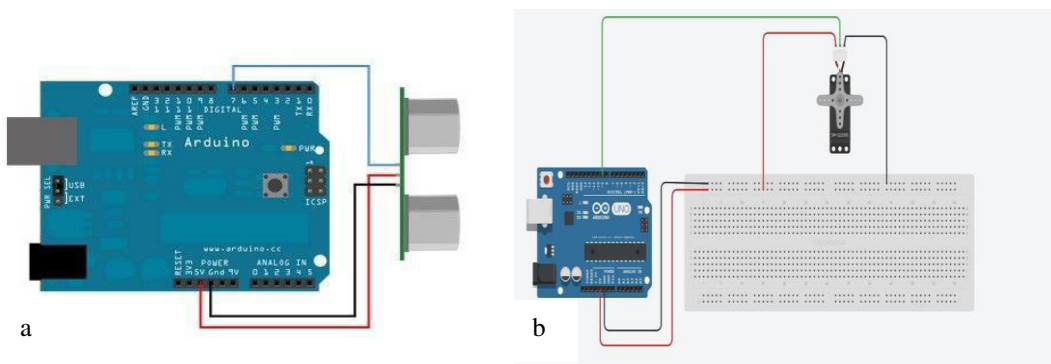


Figure 5. Interfacing diagram for level measurement (a) and for gate opening (b).



Table 1. Components its specifications.

Components	General Specifications
Ultrasonic Sensor	Voltage, current, frequency, max and min range, trigger input voltage : 5V (DC), 15mA, 40HZ, 4m to 2cm, 10 μS TTL pulse
Solenoid Valve	Type, pressure, temperature, coil power : 2 way normally closed, 0 to 150 (AC coil), 0 to 120 (DC and AC coil), 14 ⁰ to 176 ⁰ C and 5 ⁰ to 248 ⁰ F, 20W and 40 W
Buzzer	Type, diameter, height, Input voltage, current, frequency: Low wastage and high voice pressure, 3 to 24v small enclosed piezo electronics buzzer alarm 95db with wires, 33mm, 22mm, 3.5 to 12v, 25mA, 2300+/-500Hz
Float Switch	Color, net weight, maximum switch voltage, maximum switch current, cable length, temperature rating : Black, 24g, 100V DC, 0.5A, 40cm, 10 ⁰ to 85 ⁰ C
LED	Ultraviolet, Violet, Blue, Green, Yellow
SMPS	Input, output : 230V AC, Double 12V DC
Arduino	Microcontroller, operating voltage, digital I/O pins, analog input, flash memory : ATmega328P, 5V, 14 (6 are PWM output pins), 6, 32KB
Servo Motor	Torque, speed, type, gear, weight: 82 kg-cm, Speed:012sec/60 Degree, 3Pole, Plastic, 9g
PLC	Type, digital input, digital output, analog input, analog output : Micrologix 1100, 3, 1, 2, 2

IV.b SOFTWARE DESIGN

The data acquisition and control software were implemented as shown in the flowchart diagram (Figure 6). First the level sensor is read and compared with the set point. depending on the situation, it could either turn on the buzzer, else it could open the gate or trigger the solenoid valves to open the manholes. The PLC were programmed such that 3 situations can be handled by taking appropriate actions. There is option to stay in manual mode or also to switch to auto mode. For e.g., in manual mode if the water level is low then the gate remains in closed position and the buzzer is kept off (Figure 7). In addition to it, when the water levels are sensed to stay between normal low and normal high, then the gates can start opening slowly in proportion the high levels [9,10] (Figure 8). During this situation the buzzer will also turn on to create sign of warning among the people living in neighbourhood.

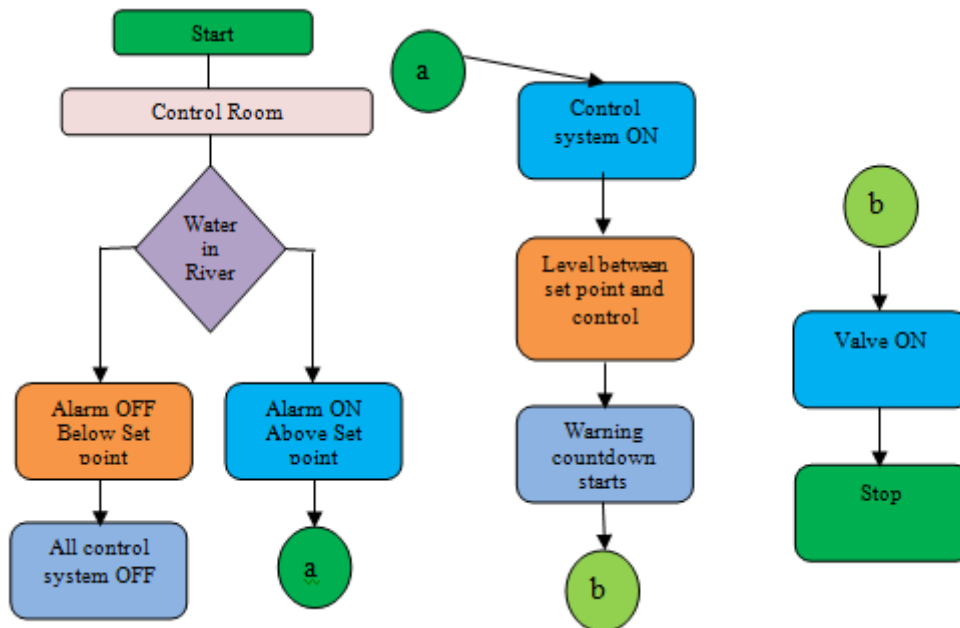


Figure 6. Flowchart of the system operation.



In addition to above mentioned operations, when the water level exceeds beyond the normally high states, then the high-level switch gets activated and the system is automatically switched to automatic mode (Figure 9). During this mode the solenoid valves will open instantaneously and simulate the scenario like opening the manholes to let the extra water to get drained out in bulk. This way two safety measures are taken care by the system. 1) People living in nearby surroundings are kept aware, well in advance and 2) it helps by protecting the area getting affected severely.

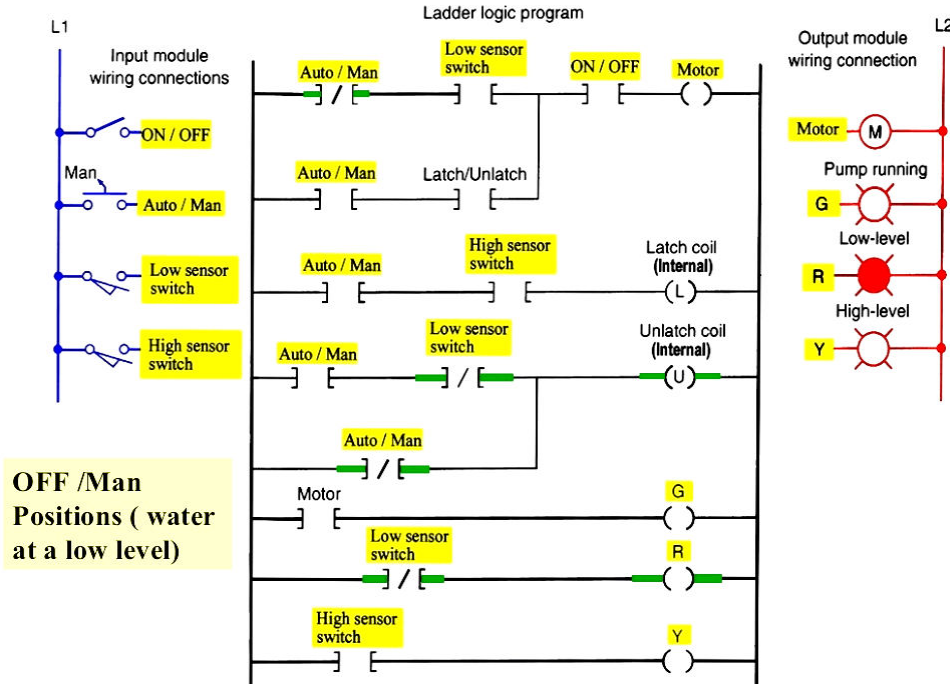


Figure 7. Manual mode is selected, position is OFF and water level is low.

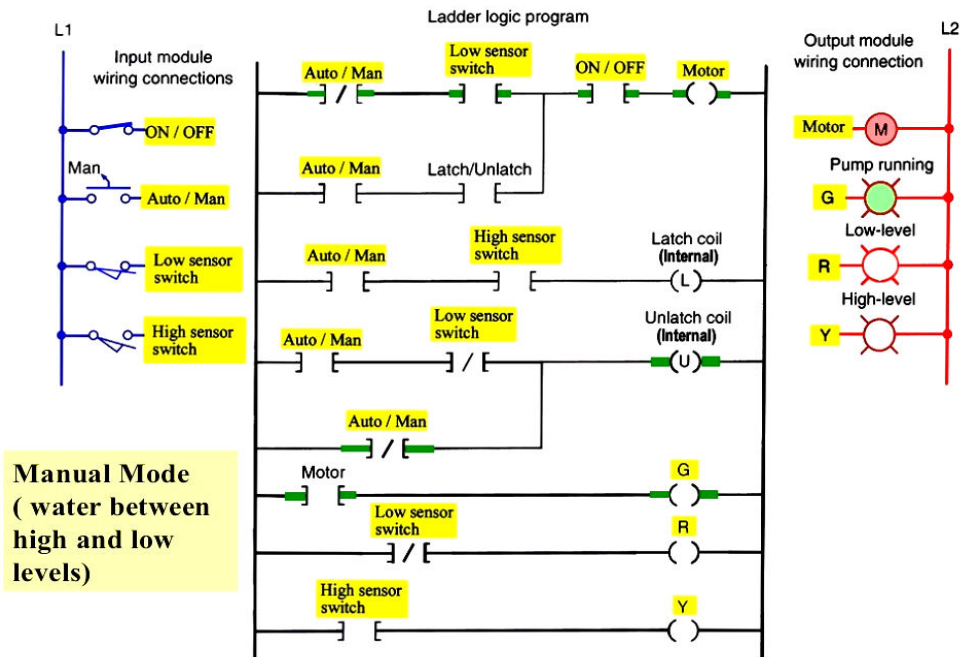


Figure 8. Manual mode is selected and water level is between low and high levels.

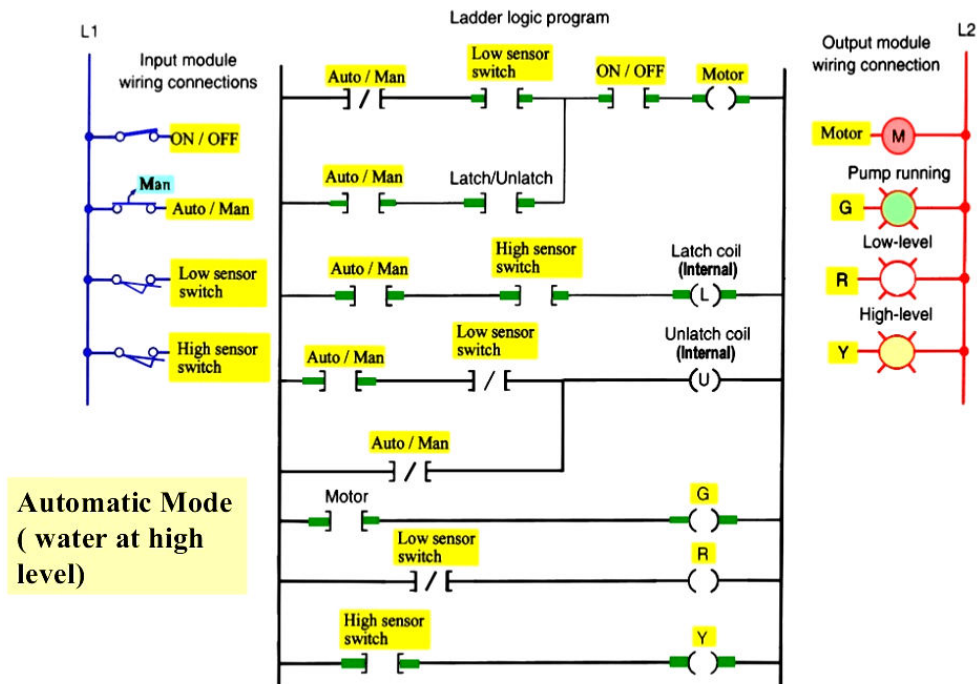


Figure 9. Auto mode is selected and the high-level switch is activated.

When water level rises above set point level ultrasonic sensor detects it and activation of buzzer takes place. At the same time control gates gets opened and the excessive water gets diverted from main stream to the channels. Through channels it goes to out of town and to the manholes such that water level control takes place. Therefore this system gives warning to people as well as controls the water level simultaneously. Implementation of this technology can help farmer and government by preventing loss of life and property. It can greatly reduce emergency relief cost and inconvenience. It can provide security to riverside habitants and reduce damage public and private facilities.

V. RESULTS AND DISCUSSIONS

Figure 5, Figures 10 and 11 illustrate the model/scenario of the flood situation on rivers with special attention to the scene underneath the Irwin bridge located on the Krishna river situated in Sangli city. Figure 12. shows the plumbing system to simulate the manholes for draining out large amount of water during heavy raining seasons. Everything was implemented on a specially designed table top bench.

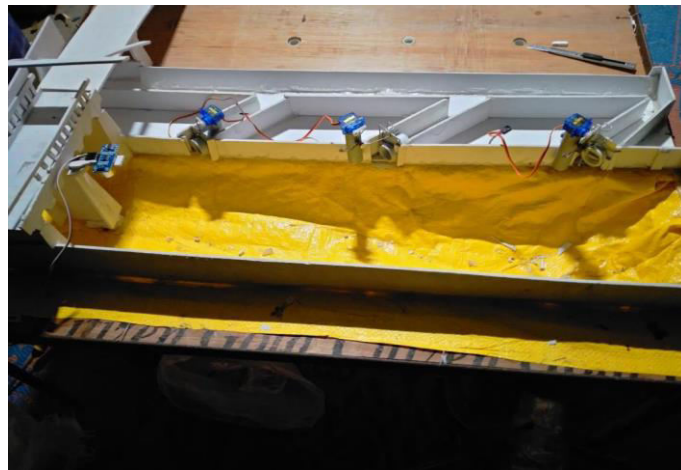


Figure 10. Model of the system.



Figure 11. Model of the area near Irwin bridge in Sangli city.



Figure 12. Model of the manholes and drains.

VI. CONCLUSION

Flood is a natural disaster and is very dangerous because it affects on each and every living creature as well as on natural & manmade resources. Stopping this natural disaster 100% is impossible but reducing its effect in greater extent is possible. In this paper we modeled, designed and implemented one solution for flood control and management. The discussed approach is a practical technology which can reduce the effect of flood greatly. However, the main aim behind the project was to use Instrumentation technologies such as Sensors, Actuators, Microcontrollers and PLCs to measure and control water levels. The system was implemented as; using control gate, water level is maintained in flood situations. The level of water before the rainy season was observed and a set point was calculated to make a plan to control level of water beyond it. In rainy season when water level goes high PLC opens all control gates and with the help of control gates the water diverted to outside of cities so that water level maintains and there is less chance of flood. This was a first attempt, where an Instrumentation based conceptual model is designed and build & then control gates are applied to maintain the water level. Using this technology warning system and emergency communication can be improved.



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