PILOT RESEARCH PROJECT ON REAL-TIME MONITORING OF RIVER WATER LEVEL AND IRRIGATION MANAGEMENT AT GRAVITY OUTLETS (NILWALA RIVER)

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Abstract—**Flooding has become a major problem in most of the countries around the world, causing huge damages. It affects the farming community, incurring disturbance to day to day activities, mainly by damaging the farming land and infrastructure. Although there are methods to forecast rainfall or to track storm path precisely from the satellite images in the world, the need for real-time monitored data such as river water level is essential to make a reasonable decision on the actions necessary to prevent flooding in an automated manner. The rivers are usually located in the low lying lands and agriculture productions usually utilize river water in these areas. In wet zone areas due to heavy rain small streams and canals of the main river which are feeding agriculture land gets more water compared to upstream sections. In this situation, Gravity Outlets (GO) come into action where the decision is taken to transfer the water by using gravity or forced pumping, after comparing the upstream water level (riverside) and downstream water level (Yaya or protection side). This system is widely used in Europe.**

At present, all the pump houses are fixed with river and landside conventional manual gauges to monitor the water level and also to make decisions for pump operation. Since, this is a manual, individual dependent and less reliable system, GO operation is not efficient. It is observed by the Department of Irrigation that one-centimeter level gravity difference can save pumping costs in the order of magnitude.

Last few years it has faced more disputes due to less finance allocation from the government for these routine tasks. Paddy fields of farmers and low land residential areas are severely damaged during the flood instances.

Through an automated, reliable and quick data providing solution based on the Internet utilizing GPRS (General Packet Radio Switch), information can be delivered to the action points that can streamline the operation of gravity outlets. It will greatly reduce the cost of daily operation and farmer conflict for the Department of Irrigation.

Keywords—Irrigation; SCADA; Flood; GO; GPRS; River; Pumping; Internet

I. INTRODUCTION

There are 13 pump houses under Gin and Nilwala river flood protection schemes. The basic concept of the scheme is to protect the lower basin from river flooding by pump houses at GOs evacuating excess water from the protected area (Yaya side) to the riverside. Every GO is equipped with several water gates in a row separating the water at the riverside and protection side, where most of them are motorized. Pumping and gravity draining is used to evacuate the excess water in protected areas depending on the river and protected side water level [1]. However, pumping is a highly costly process to operate and maintain. Gravity outlet operation if possible is very important to cut down the above overhead cost. In a study by the Department of Irrigation, published in 2017, it is estimated that Rs. 60 Million is spent annually for fuel and electricity on force pumping.

The proposed system consists of electronics, communications, IT and automation amalgamated as a Supervisory Control and Data acquisition system (SCADA). The Main Processor Unit (MPU) which is an embedded controller is responsible for collecting water level information from remote places of the GOs and Diesel level of Storage Tanks in a local Ultrasonic Sensor Network (USN) [9][5][7]. Three data inputs (upstream water level, downstream water level, and diesel tank level) are transmitted via a GPRS link to a Web-based database server (or more common name WS or 'Web Server' based on PHP and MySQL) with real-time and past data. Presentation methods are used to take management decisions [3][4]to key authorities concerned [1][2]. Also, the system incorporates the facility to get critical alerts on flood warning, pump automation, etc. The client connectivity is available to any geographic location using a mobile phone or personal computer through relevant authorizations..

II. CASE STUDY

Office of Director of Irrigation Galle dealing with the two main rivers Nilwala and Gin has this water management issue of flood avoidance and supplying of water for paddy farming. A pilot project was defined and commenced for three gravity outlets Magallagoda, Thalgahagoda and Thudawa in Nilwala river area of Matara (Geographic location Fig. 1) Sri Lanka. The system discussed and the data presented in this paper are related to this pilot activity. The approximated paddy farming area irrigated through this pilot study is 5000 acres.

To better manage [1][2] river water while saving fuel on forced pumping, monitoring at real-time [10] at GOs (Thalgahagoda Fig. 2, Magallagoda Fig. 3, Thudawa Fig. 4) is necessary because it depends on heavy rain to riverside and protection sides (Yaya) as well as sea tidal effects. The technology solution involves electronics, communications and IT. The interesting water level monitoring at the riverside and protected side (Yaya side) with reference to the Mean Sea Level (MSL) are done using USN and MPU operating from main power and solar panel connected battery power in main power failure situations (heavy rain or flood). This MPU is equipped with relevant optional accommodations to connect additional sensor modules through USN (ex. sensing diesel tank level at pumping stations in close proximity GOs as in Fig. 5) and energizing actuator contactors (future automating pumps).

Collected water levels at real-time will be displayed on site and communicated via GPRS [10][8] to WS installed with the specific software. Water level information will be recorded (with date time and location stamps) in the database of the server to be accessed from remote terminals, as processed data.

Irrigation Engineers or Managers who are authorized to the system can access data (real-time or past processed data) with geographic location through a computer or laptop or mobile using standard browsers. During critical situations [6] (ex. after heavy rains) SMS (Short Message Service) will be sent to decision-makers about water level data.

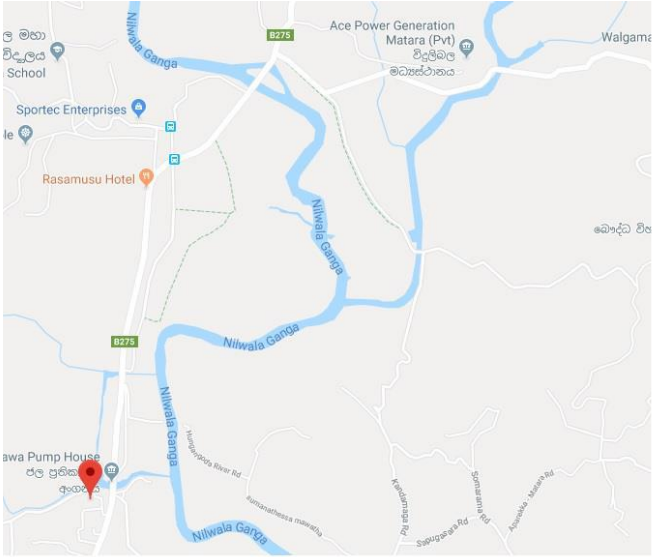

Fig. 1. Pilot Project Geographic Location

Fig. 2. Thalgahagoda GO

Fig. 3. Magallagoda GO river side

Fig. 4. Magallagoda GO protection side

Fig. 5. Pumping station diesel tanks

III.DISCUSSION

The system scenario is as shown in Fig. 6. The main system units designed are the MPU having a communication module using GPRS [10[8] and with the interfaces to USN, power module and WS. Remote connections in the form of a computer or smartphone can utilize the standard browsers to access real-time and processed data.

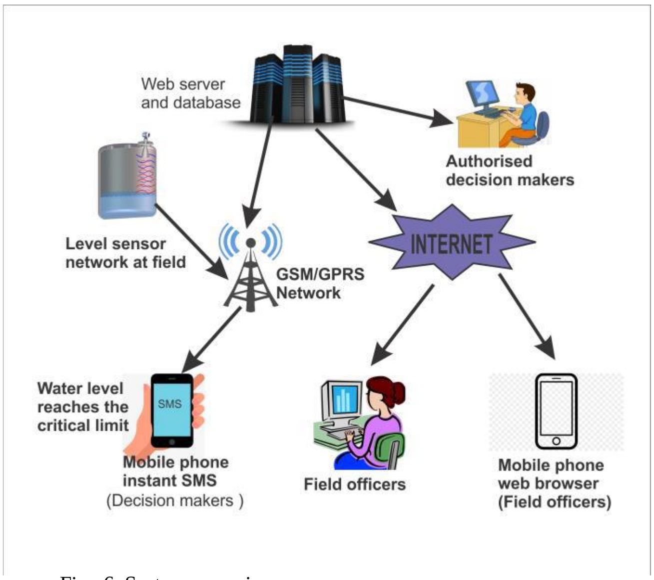

Fig. 6. System scenario

A. Main Processor Unit (MPU)

This is the main site installation system based on microcontroller technology with IP65 outdoor installation standard for river water level data collection from the USN (river water level and diesel tank level) which is installed in the river GOs after signal processing and necessary calibration process. The detailed block diagram is as per Fig. 7 and the system is as per Fig. 8. The onboard GPRS communication module transmits real-time data to the WS using standard protocols. Also, this unit has a feature of displaying realtime records at the site and to control (actuator) pumps based on decisions. The unit powers directly from 230VAC and in the absence of line power it can utilize solar power using the solar panel installed. The flow diagrams related to the MPU firmware programs are listed as per Fig. 9, Fig. 10, and Fig. 11

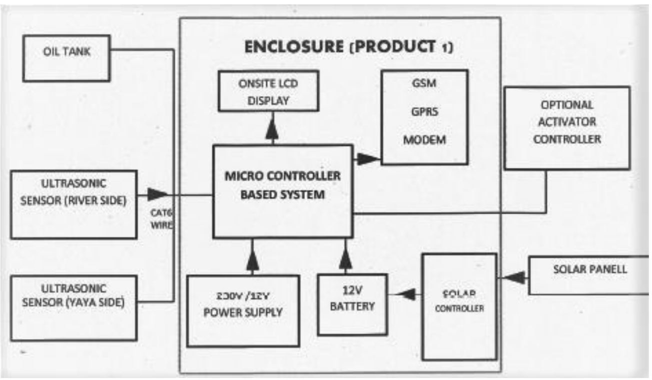

Fig. 7. MPU block diagram

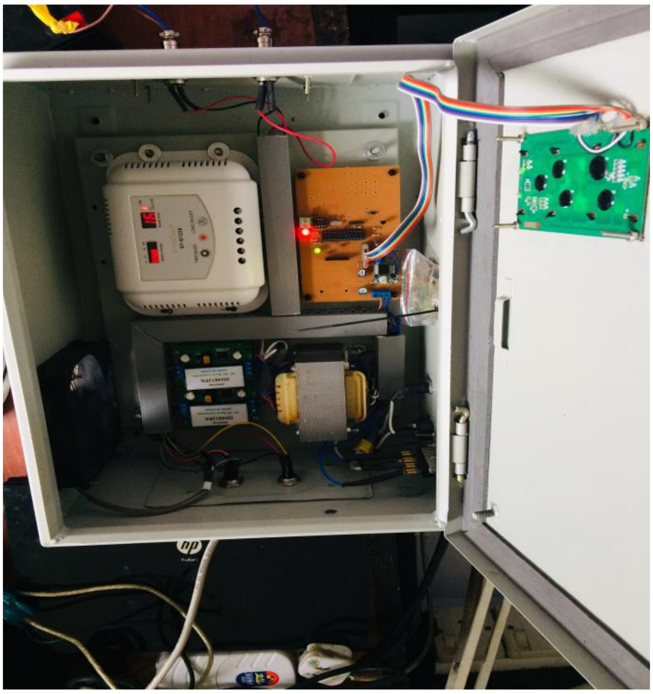

Fig. 8. MPU installed at site

B. Ultrasonic Sensor Network (USN)

The basic concept used for water level detection in a wide range of 5m to 10m is obtained using the ultrasonic sensor [9][5] technology having less than 1cm accuracy. To achieve that much accuracy and stability it is the best sensing method in river environments since submersible methods may incur disturbances from objects which might flow in rivers. The sensors (riverside, protection side, diesel tank level) used in a GO are connected in a serial network after converting the current output to a voltage data and sent using a custom protocol in an RS-485 signaling methodology due to its' outdoor application suitability and connectivity of the MPU is at a distan

C. Web based database access server System (WS)

This is the software [2] installed in the WS with internet connectivity at a central location (geographically at any establishment) which collects real-time GPRS data sent from the MPU. It also handles the database records both real-time and past data, which can be retrieved by authorized connections (through PC, Laptop, Mobile) remotely. The software developments were done in a generalized manner using PHP and the database is stored in MySQL. The flow diagram of the program is as per listing in Fig. 12. The application user (browser end) interfaces are as per Fig. 13 and Fig. 14.

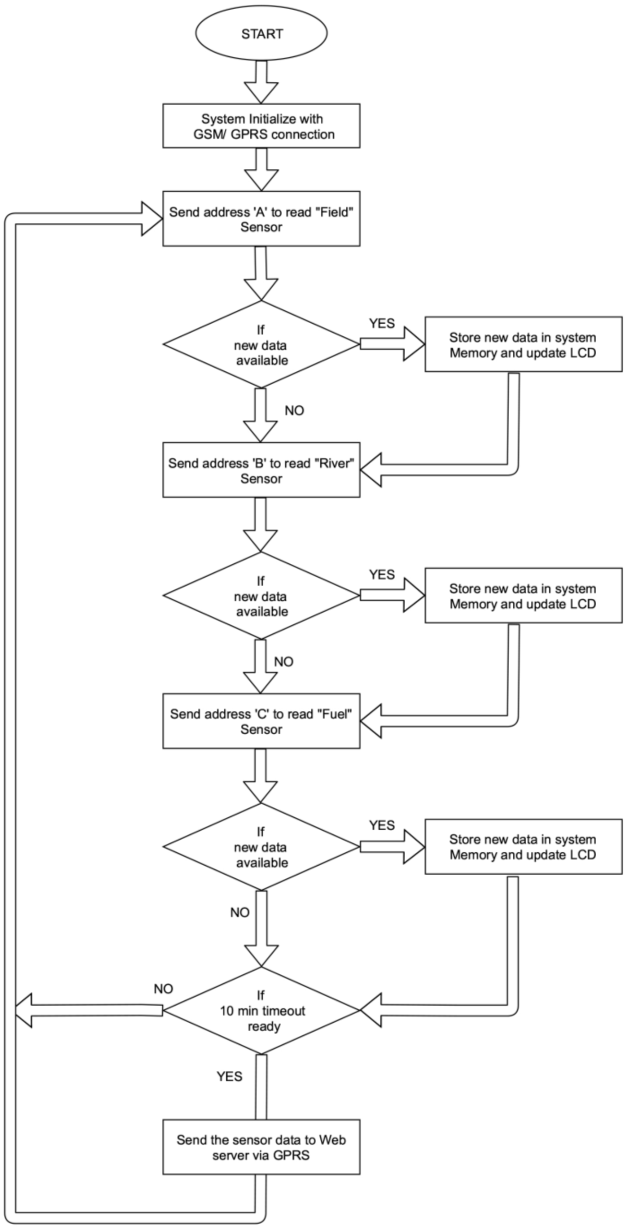

Fig. 9. MPU firmware flow of controller

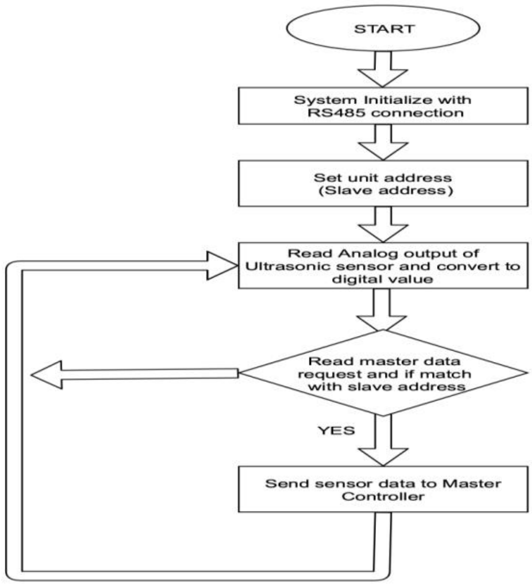

Fig. 10. MPU firmware flow of sensor network

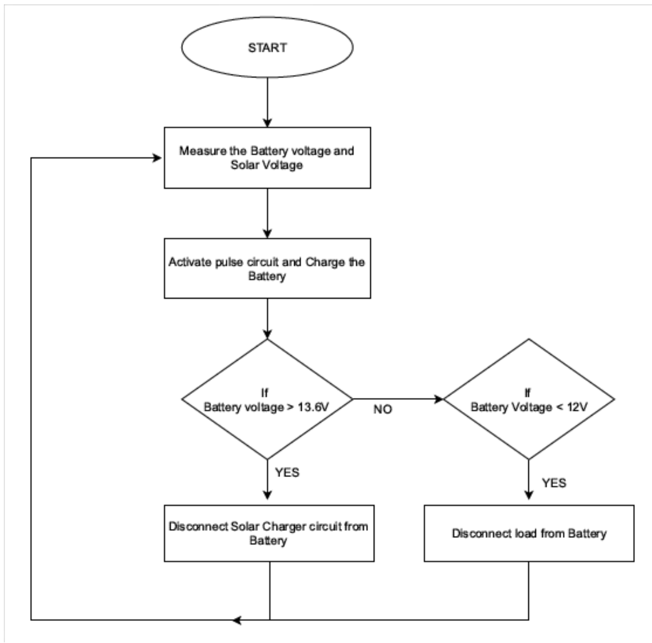

Fig. 11. MPU firmware flow of solar control

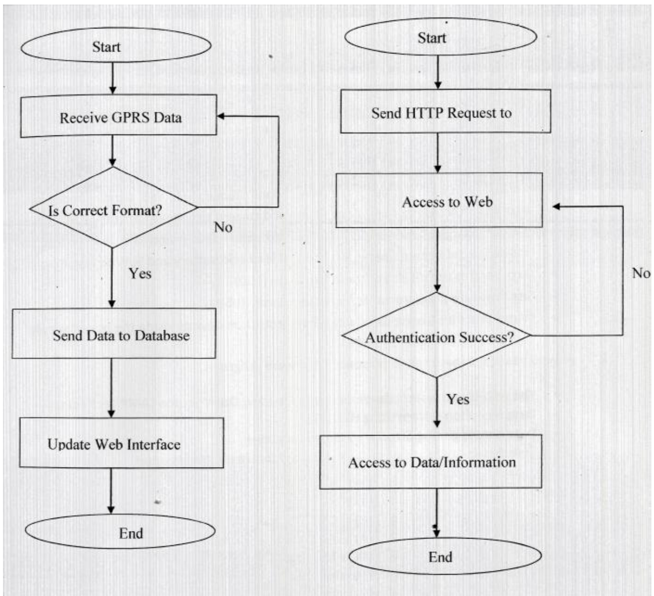

Fig. 12. Flow diagrams of the Program

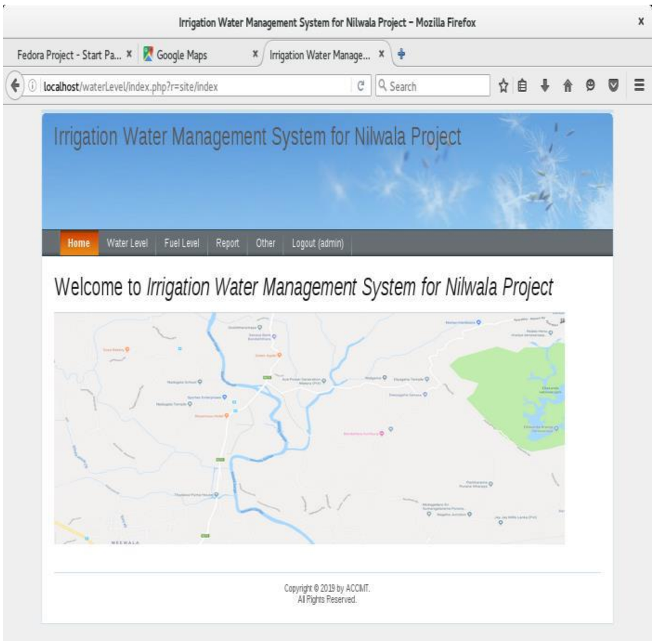

Fig. 13. WS Access Browser Interface Main Page

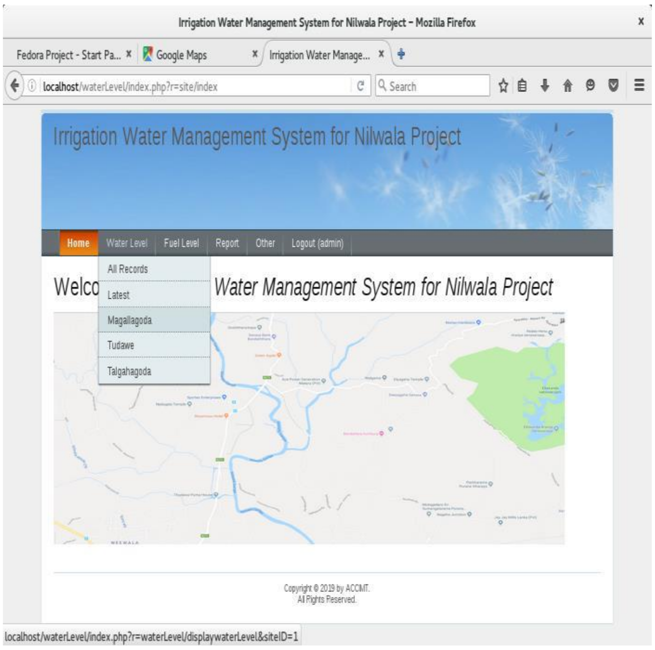

Fig. 14. WS Access Browser Interface Menu

IV.RESULTS

The day to day gathered level information (update through GPRS link at hourly intervals) is stored in real-time (Fig. 15) and used to generate level graphs for a particular day (Fig. 16 and Fig. 17). With this system implementation data gathered throughout a year can be used in forecasting and make approximations for the usage of fuel for forced pumping and management of irrigation water for the farming. During critical situations (ex. Flood) alarming messages can be issued based on real-time data. Since the data generated in this type of automated system is accurate to 1cm and after proving for operational reliability for a certain time period, drawbacks in conventional methods based on gauging (using human intervention) can be avoided. Key information of, whether water has to be gravity flown or forced pumped at GOs in day to day operations can be communicated with accurate data on engineer's fingertips

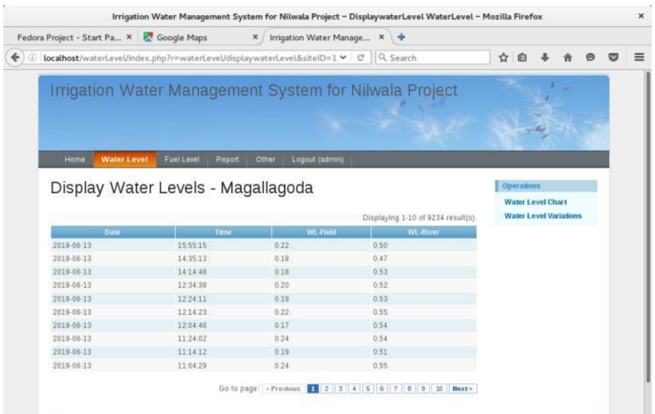

Fig. 15. WS Access Browser Interface Data display

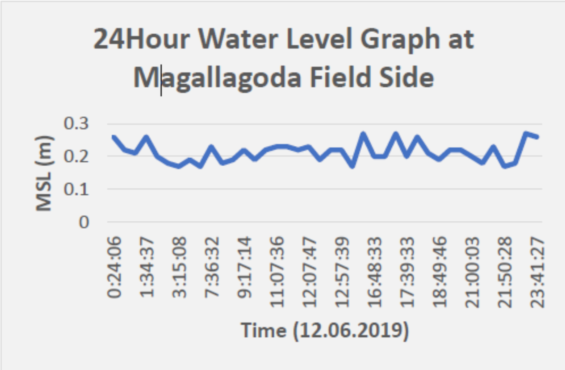

Fig. 16. Field water level graph

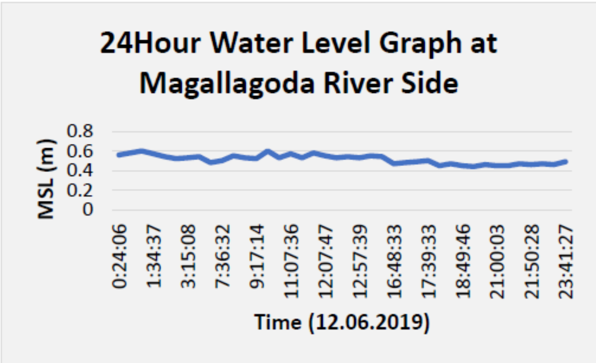

Fig. 17. River water level graph

V.CONCLUSION

This type of proposed system will have potential advantages in terms of time and cost-saving. Through this system, one can use it to indicate accessible and inaccessible roads to help commuters during critical scenarios also.

The system design under this paper was focused on the client of the Irrigation Department. The client-based pilot project for the three sites of the Nilwala river in the current scope was further to be extended in the monitoring of the river, reservoirs, tanks, canals of the island in a central database server for decision actions, planning work, flood avoidance, and better irrigation water management.

REFERENCES

[1] Mekong River Real time water level monitoring, viewed on 1st March 2012, Available: http:// monitoring .mrcmekong.org/

[2] J. Windarto,"Flood Early Warning System Develop at Garang River Semarang using information Technology base on SMS and Web". The International Journal of Geomatics and Geosciences, Vol.I, no. 1.2010

[3] Guangli Feng, Chunying Gu Research on river water level remote monitoring and pre warning based on GPRS(J) Computer Measurement and Control, 2013.21(3):620-522

[4] Creutin, J.,Muste, M., Bradley, A. , and Kim, S. 2003 River Gauging using PIV Techniques: A Proof of Concept on the lowa River, Journal of Hydrology 277, 182-194

[5] L. C. Lynnworth "Ultrasonic measurements for process control: theory,techniques applications": Academic press 2013

[6] M. S. Tampke,"Monitoring and alarming and alarming system and method, "ed:Google Patents, 2010

[7] Chang, N. and Guo Da-Hai 2006 Urban Flash Flood Monitoring, Mapping and Forecasting via a Tailored sensor Network System, proceedings of the 2006 IEEE International Conference on Networking, Sensing and Control 2006, issue 23-25,pp.757-761, April 2006. Chang, Y., and Chang N 2002.The design of a web based decision support system for the sustainable management of an urban river system, Water Science and Technology 46(6), 131-139

[8] NXN Technology 2010 GT-511 GPRS Data Transceiver, http://www.nxn.comtw/GT511php

[9] Yongiun Lv. Jianmin Xu, Dongmei Jin The application of ultrasonic level meter in hydrological station in Heli. Heilingjiang Science and Technology of Water Conservancy , 2011.1(39):145-146

[10] Jianke Jia. Research on river water regiment real-time remote monitoring system based on GPRS and internet (J)Modern Electronic Techniques, 2016,39(6):132-135