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WATER LEVEL MONITORING SYSTEM FOR NATIONAL IRRIGATION ADMINISTRATION IN CAGAYCAY RIVER

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Abstract. The study is about the Water Level Monitoring System for National Irrigation Administration in Cagaycay River that automatically sends water level through SMS and data then interpreted by the application software on the remote server. It sought answers to the following objectives: 1. To design and develop a water level monitoring device that will: 1.1 send data to the remote server; 2. To design and develop application software that will: 2.1 analyze data received sensor, 2.2 interpret data from the sensor; 3. To evaluate/validate the developed system in terms of: 3.1 functionality; 3.2 reliability; 3.3 usability; 3.4 maintainability; and 3.5 portability.

The Proponent did research through different government agencies and through comparisons of different water level monitoring devices and applications. The researcher reviewed how the government distributes water level, especially flood-related information specifically through the project NOAH. Project NOAH was focused on flood warning devices. The comparisons were done to give the proponent basis for making the prototype. Next, the proponent searches for information on the accuracy of ultrasonic sensors that shall determine the water level reading. Upon completion, the researcher executed accuracy testing of the water level sensor and the responsiveness of the application software.

The proponent of the system follows the phases of the System Development Life Cycle in the development of a prototype of the Water Level Monitoring System for the National Irrigation Administration in Cagaycay River. This included Initiation, Analysis, Design, Development, and Implementation.

The water Level Monitoring System for National Irrigation Administration is a prototype system that has the capability to monitor the water level from the dam and enables to send of data readings of water to the remote sensor and stored as a database through SMS aided by the ACEduino microcontroller.

During the testing phase, IT experts and staff of the Irrigation office evaluated the system's performance as to accuracy and usability. Data gathered during testing time exhibits negative 6.483 percent (-6.483%) as a computer's Average Percentage of Error.

Key Words: *GSM/GPRS, Irrigation Administration, Microcontroller, Monitoring System, Ultrasonic Sensor, Water Level Monitoring System*

INTRODUCTION

A changing climate and rapidly growing exposure to disaster risk presents the world with an unprecedented challenge. For developing countries, both less able to cope with the impact and more likely to be affected, the challenge is particularly severe. These countries face mounting losses from a range of natural hazards, from earthquakes and tsunamis to severe flooding, storms, and drought. We face the threat of decades of development progress being rolled back and poverty becoming entrenched. Meanwhile, climate change cuts across society, from agriculture to health, energy to water resources (UNDP, 2015).

Voices around the world are demanding leadership on poverty, inequality, and climate change. To turn these demands into actions, world leaders gathered on 25 September 2015 at the United Nations in New York to adopt the 2030 Agenda for Sustainable Development. There were seventeen (17) new Sustainable Development Goals formulated, number 13 of which is "Climate Action". This goal aims to strengthen the resilience and adaptive capacity of more vulnerable regions.

The Philippines is basically an agricultural country. The Department of Agriculture is the executive department of the Philippine government responsible for the promotion of agricultural and fisheries development and growth. Republic Act 3601 on 22 June 1963 created National Irrigation Administration (NIA) as a government-owned and controlled corporation primarily responsible for irrigation development in the Philippines. These two agencies may have a crucial role to address climate change in the Philippines setting.

With the difficulties encountered by the subject of the study, The NIA, on its existing water monitoring management, specifically for water level monitoring and scheduling to the different areas of concern, this study aims to provide solutions to the difficulties by developing a water level monitoring system with SMS based technology. Water leveling technology with SMS capability is utilized in this study as the main feature of the proposed system. The function of this is to monitor the level of water in the dam and send information to the system that will be used for decision-making of the National Irrigation Administration.

This study attempted to develop a water monitoring system for National Irrigation Administration – Cagaycay River Irrigation System, San Jose, Camarines Sur. Similar studies and commercial products were already conducted and available in the market but this study offers great advantages over them. The developed system showcases features specially made for the respondents, The National Irrigation Administration – Cagaycay River Irrigation System, San Jose, Camarines Sur.

This study develops a prototype system of the Water Level Monitoring Management System for the National Irrigation Administration. The system monitors the level of the water in the dam through the use of an ultrasonic device. The data captured by the device will send to the server computer as an SMS message. A database module is also developed to receive and store the data. The purpose of this study is to ease the difficulties encountered by the respondents in terms of: a) monitoring the water level of the Dam; b) Distribution and scheduling of water in the different farm fields covered by the NIA; c) controlling the distribution of water.

This study described the proposed water level monitoring system. It was specifically developed for monitoring the water level of the dam, and the proper distribution, control, and scheduling of water in the different farm areas covered by the agency. Visual Basic dot net (.net) was used as the front-end design and MySQL Server 5.1 database as the back-end and Water Level Sensor Device (ultrasonic) and ACEduino 328 v2.1 with software development kit (SDK). ACEduino is a clone of Arduino. Arduino is an open-source electronics platform based on easy-to-use hardware and software. This is intended for an interactive project. The system also utilized the GSM/GPRS Shield to facilitate the sending of SMS messages to the server to use as a basis for the decision-making of the NIA officials.

Specific Objectives

The following were the specific objectives that this study aimed:

1. To design and develop a water level monitoring device that will:
    - 1.1 send data to the remote server;
2. To design and develop application software that will:
    - 2.1 analyze data received from the sensor
    - 2.2 interpret data from the sensor
3. To evaluate/validate the developed system in terms of :
    - 3.1 functionality
    - 3.2 reliability
    - 3.3 usability
    - 3.4 maintainability
    - 3.5 portability

Table 1 - Development Time Frame

Activities	Month/s					
	1	2	3	4	5	6
Initiation Stage						
Analysis Stage						
Design Stage						
Installation and Deployment Stage						

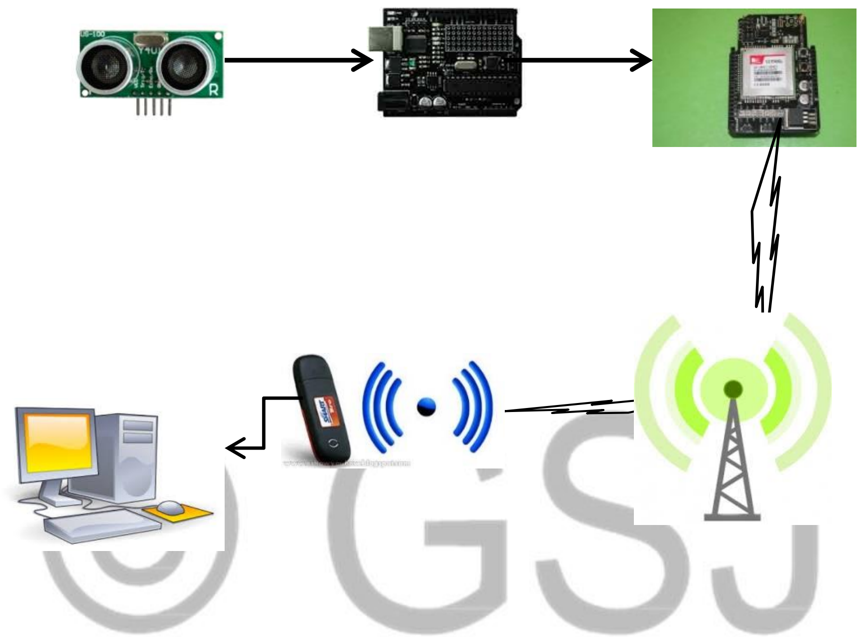

Figure 1. System Architecture of the Proposed Project

Systems Development Methodology

This study will use the descriptive developmental method of research in the context of system development. Descriptive will be used in discussing the results of the testing phase while developmental will be used during the system development. The data will be analyzed using the percentage technique and arithmetic mean after conducting the testing of the water level monitoring. The Software Development Life Cycle (SDLC) will be used in designing the proposed system.

A. Initiation Stage

This is the planning cycle of the system development that includes proposal and preliminary planning. The difficulties of the manual process of an organization are identified and solutions are proposed. Identification of the hardware and software requirements in the development of the system, the scope of the project (water level monitoring), the schedule of activities (Gantt chart), and the total budget cost are also considered.

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B. Analysis Stage

In this cycle, the researcher designs the requirements needed in system development. Included were the system components, system architecture, block diagram, data flow diagram, data dictionary, entity relationship diagram, user interface design, and system flowchart.

C. Design Stage

The researcher will utilize open-source database software. Additional tools for the software development kit (SDK) were used such as a water level sensor, ACEduino Microcontroller, and GSM/GPRS module. Debugging and testing of the program for fixing bugs or errors in the design will be done in this cycle. Finally, the system will be released and tested as a beta version by conducting a pilot test for five days.

D. Installation and Deployment Stage

After the beta testing, minor refinement will be done to integrate corrections of bugs and the users' feedback which were focused mainly on fine-tuning of system, configuring, installing, and usability issues. In this cycle, the researcher will assure of the usability of the system to its target clientele (National Irrigation Administration). The user's manual will be prepared to facilitate using of the system. Screenshots of the human-machine interfaces, simplified diagrams, and software installation instructions were clearly presented in the manual.

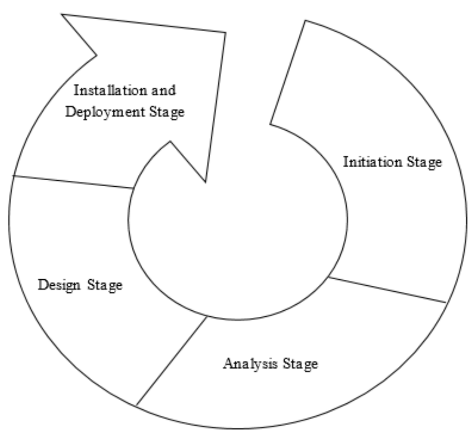

Figure 2. Project Development Methodology

1. Initiation Stage

In this stage, the researcher performed preliminary unstructured interview with the key person in the National Irrigation Administration – Cagaycay River Irrigation System at San Jose, Camarines Sur. There were five (5) NIA employees that are concerned in the monitoring of the water level of the Dam. One hundred percent (100%) of the employees expressed their problem in monitoring the water level of the dam and they are willing to support the proposed project as they considered it as a big help to them in performing their responsibilities in the agency.

During the preliminary unstructured interview, the respondents of the study reveal the difficulties they encountered during the checking, reading, and interpreting of the water level. They checked and read the water level by going personally to the dam site to look at the concrete post with a printed meter unit located at the side of the river which is very risky during rainy days and is almost 20 kilometers away from the agency office. After getting the water level it will be brought to the office for interpretation and the result is used for the distribution of water to farmer-beneficiaries.

When there is a need for consolidation of all the water levels for analysis and interpretation, the consumed time in visiting and recording the water level data. In chapter III, the technical background of the system was presented. Constraints have been evaluated, such as time, scope, and resources. The technical resources were also identified.

Components of the Proposed System

This project is composed of two following parts: hardware and software. The hardware part is composed of a battery, solar panel board, fan, ultrasonic sensor, ACEduino microcontroller with ATmega 328, GSM/GPRS shield, and sim card. On the other hand, the software part was developed using the Visual Studio 2008 as the front end and MySql 5.1 under the Xampp package as the back-end and Arduino IDE was also used for configuring the ultrasonic and GSM module to the ACEduino microcontroller. This software application was used for the interpretation and presentation of data.

ACEduino Microcontroller 328

Figure 3. The ACEduino Microcontroller

The ACEduino microcontroller is a clone version of Arduino Uno, this is a microcontroller board based on the ATmega 328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

The ACEduino differs from all preceding boards that is does not use the FTDI USB-to-serial driver chip. Instead, it features the ATmega16U2 (ATmeag8U2 up to version R2) programmed as a USB-to-serial converter.

Power

The ACEduino can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin headers of the POWER connector.

The board can operate on an external supply of 6 to 12 volts, the voltage regulator may overheat and damage the board. The recommended number of volts to power the board is between seven (7) to twelve (12) volts.

The power pins are as follows: VIN, the input voltage to the ACEduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pins, or, if supplying voltage via the power jack, access it through this pin; 5V - this pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7-12V), the USB connector (5V), or the VIN pin of the board (7-12v). Supplying voltage via the 5V or 3.3V pins bypass the regulator, and can damage your board; 3V3 - a 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50mA; and GND – the ground pins.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20 -50 kOhms. In addition, some pins have specialized functions: Serial: 0 (RX) and 1 (TX) - used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to -TTL Serial chip; *External Interrupts: 2 and 3* - these pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value; *PWM:* 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function; *SPI*: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library; LED: 13. There is a built -in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A 5, each of which provides 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, It is possible to change the upper end of their range using the AREF pin and the analogReference () function. Additionally, some pins have specialized functionality: TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library. There are a couple of other pins on the board: AREF. Reference voltage for the analog inputs. Used with analogReference(); and Reset - bring this line LOW to reset the microcontroller.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels the serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TLED on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A Software Serial library allows for serial communication on any of Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify the use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). The ATmega328 on the Arduino Uno comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2 /8U2 is loaded with a DFU boot loader, which can be activated by: Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2; Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to round, making it easier to put into DFU mode. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader).

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow the user to upload the code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins. Features: 14 Digital Input/Output pins (6 of which are PWM outputs), 6 analog Input pins (with pin for Analog references), Different communication lines available – UART (Rx, Tx), I2C (SDA, SCL) and ISP (MISO, MOSI, SCL), On-board solderable prototyping nodes, 32KB Flash Memory and automatic power selector between USB and DC power.

The HC-SR400 Ultrasonic Module

HC – SR400 compact ultrasonic sensor module is a low cost solution for circuit applications that requires distance measurements from an object, such as walls, furniture, and even pets. User circuit initiates a measurement by driving the HC-SR04 trigger input to logic HIGH. The HC-SR04, in response, will send a short bursts of ultrasonic sound wave, and then outputs a pulse as soon as a returning echo is detected. The user circuit resolves the distance by measuring the pulse width of the output pulse. Distances up to 4.5 meters from the sensor can be measured, with resolving resolution depending mainly on the user circuit.

Ultrasonic Sensor

The Ultrasonic sensor module is a convenient way for measuring distances from objects. This module has a lot of applications such as parking sensors, obstacle and terrain monitoring systems, industrial distance measurements, etc. It has a stable performance and high accuracy ranging from 2cm to 450cm.

The module sends an ultrasonic signal, eight pulses of 40kHz square wave from the transmitter; the echo is then picked up by the receiver and outputs a waveform with a time period proportional to the distance. The connected microcontroller accepts the signal and performs necessary processing.

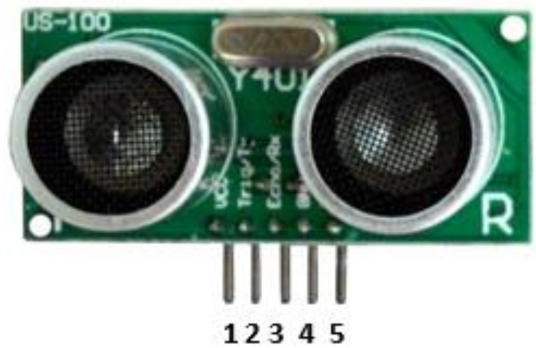

Figure 4 - The Ultrasonic Sensor and Pin Configuration

The pin configuration is shown in Figure 5 as follows: VCC is a 5V DC input power of the ultrasonic; Trig is the trigger input; Echo is a pulse output; and GND is a ground connection for the power input.

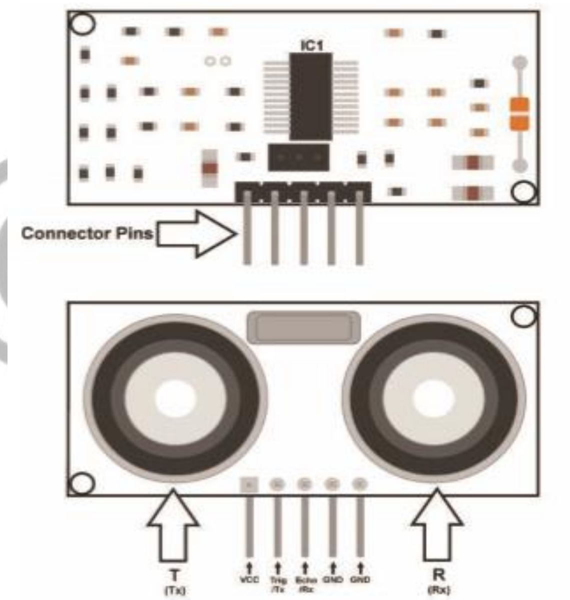

Figure 5. Ultrasonic Sensor module

Figure 5 displayed the major configuration of the ultrasonic sensor that can be used to connect the sensor to the microcontroller for facilitating its water level reading and detection.

Table 2 - Ultrasonic Distance Sensor Pin Assignments and Descriptions

Pin Number	**ID**	**Description**
1	VCC	5V Power Input
2	Trig (Trigger)	Trigger Input active HIGH
3	Echo	Pulse output
4	GND *(Ground)*	Ground
5	GND *(Ground)*	Ground

Table 2 presented the ultrasonic distance sensor, pin assignments, and description.

The Timing Diagram

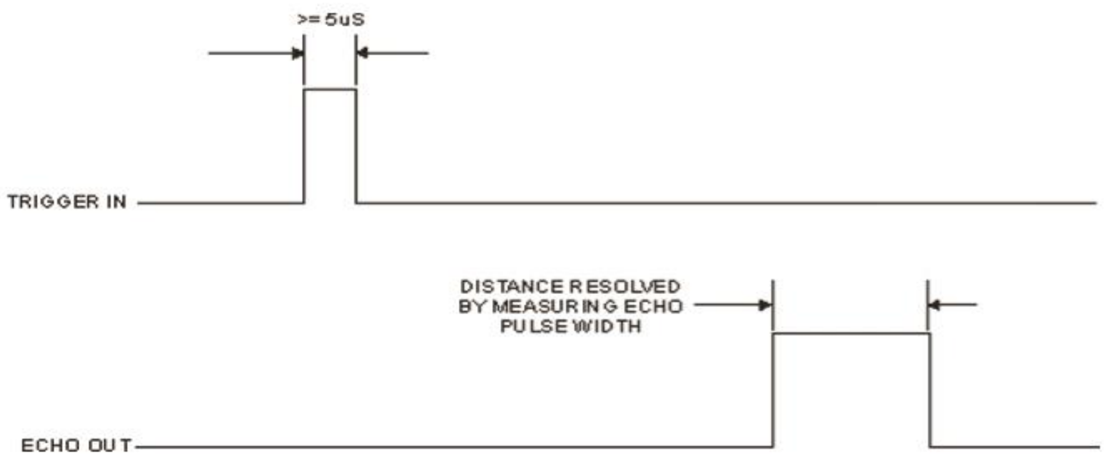

Figure 6 HC-SR04 Timing Diagram

The distance measurement is initiated by sensing a pulse to the trigger input. The HC-SR04 will respond with a pulse with a duration corresponding to the round trip echo time as shown in figure 6.

Resolving Distance

As the timing diagram shown in figure 2 illustrates, distance measurement is initiated by activating the trigger input with a pulse. The HC-SR04 will respond with an echo pulse. The echo response pulse width corresponds to the time it takes for the ultrasonic sound to travel from the sensor to the object and back. Hence the distance from the object can be computed by: Distance = Pulse Width * Speed of Sound / 2. A pulse width value greater than 60mS indicates an out of range condition.

The actual speed of sound depends on several environmental factors, with temperature having the most pronounced effect. The speed of sound in dry is determined approximately by: V = 331.4 + 0.6T m/s, but one of the feature of HC-SR04 is its built-in temperature compensation. Hence, with temperature effect out of the equation, the distance formula is reduced to: Distance = Pulse Width * 165.7 meters; where: Pulse Width is seconds.

Detection window considerations

The HC-SR04 has a detection pattern that spreads out from the sensor mount at >15 degrees angle. One obvious and probably undesirable effect of this characteristics is the sensor will have an effective larger detection window the further away the object of interest in from the sensor. This will allow the sensor to “see” more objects, hence, will be increasingly distracted by other nearby objects, making it more prone to error. Long distance detection requires the target object cross section be large enough for accurate and reliable detection.

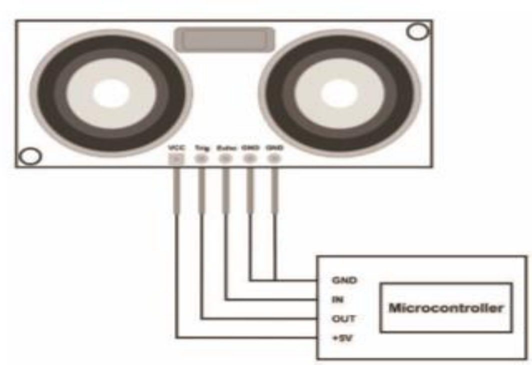

Figure 7 - HC-SR04 to Host Controller Wiring Diagram

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The HC-SR04 will work with power supply voltages 3V to 5VDC. For best logic level matching, use the same Vdd source the host controller is using. Lower supply voltage may result in a reduction in distance detection range.

The HC-SR04 requires only two I/O port interface with a host controller. As shown in Figure 7, the host controller must be assigned one output port to drive the US-100 trigger input, and one input to read and measure the echo pulse width output.

Microcontroller (ACEduino Microcontroller) and Ultrasonic Sensor (HC – SR400) Layout

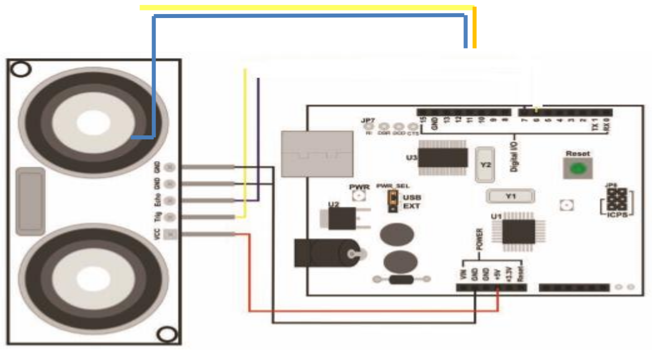

Figure 8 - HC-SR04 Ultrasonic Sensor connected to an ACEduino Microcontroller Kit

Figure 8 reflected the connection layout of the echo and trigger pins of the sensor are connected to pins number 3 and 2 respectively of the microcontroller.

ACEduino GSM/GPRS Shield

Figure 9 - GSM/GPRS Shield

The ACEduino GSM/GPRS Shield is based on SIM900 module from SIMCOM and is compatible with Arduino and its clones. The Shield provides you a way to communicate using the GSM cell phone network. The shield allows you to achieve SMS, MMS, GPRS and Audio via UART by sending AT commands. A short summary of the rest of the features of the Shield: Quad-Band 850 / 900/ 1800 / 1900 MHz- would work on GSM networks in all countries across the world, GPRS multi-slot class 10/8, GPRS mobile station class B, Compliant to GSM phase 2/2+ , Class 4 (2 W @ 850 / 900 MHz), Class 1 (1 W @ 1800 / 1900MHz), Control via AT commands- Standard Commands: GSM 07.07 & 07.05 | Enhanced Commands: SIMCOM AT Commands, Speaker and Headphone ports used for phone calls, Low power consumption- 1.5mA(sleep mode), UART pins are selectable through Digital Input/Output 0-6, and SIM900D. The SIM900D is a complete Quad-Band GSM/GPRS solution in a SMT module. The SIM900D delivers GSM/GPRS 850/900/1800/1900 MHz performance for voice, SMS, Data and Fax with low power consumption. Most of the design that was used in the GSM/GPRS Shield v1.2 can be found in the released SIMCOM reference design for optimal use of the module.

Broadband Stick

Broadband stick is a wireless technology that uses 3G or 4G that provide internet connectivity wherever there is mobile coverage. This is commonly known as broadband dongles.

SIM Card

SIM is a smart card inside a cellular phone, carrying an identification number unique to the owner, storing personal data, and preventing operation if removed. This is also known as a subscriber identity module, is a smart *card* that stores data for GSM cellular telephone subscribers. Such data includes user identity, location and phone number, network authorization data, personal security keys, contact lists and stored text messages.

Battery

Battery is used in this project as the source of electricity of the water level sensor and other components. This a container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power.

Solar Panel Board

A photovoltaic (PV) *module* is a packaged, connect assembly of typically 6×10 *solar cells*. *Solar* Photovoltaic *panels* constitute the *solar* array of a photovoltaic system that generates and supplies *solar* electricity in commercial and residential applications.

Fan

CPU fan was used in this project to ventilate the electronic components like, ACEduino Microcontroller, GSM/GPRS Shield. This is critically necessary to ventilate the heat generated from the components, and actively cools the processor by bringing in cooler air before the heat damages the computer components.

Arduino IDE 1.0 (Integrated Development Environment)

The proponents used Arduino IDE to compile and upload codes to ACEduino microcontroller with ATmega328. Its environment codes are in C or C++ languages.

Microsoft Visual Studio 2008 (Visual Basic 2008)

Microsoft Visual Studio was used in this study for the development of the Graphical User Interface. This is an Integrated Development Environment (IDE) from Microsoft Company. Microsoft Visual Studio 2008 supports different programming languages, some of the built – in languages includes Visual C, Visual C++ and Visual Basic which also known as VB.net.

In this study, the researcher used the VB.Net or Visual Basic 2008 as the IDE for developing the projects User Interface. Visual Basic is a third-generation event-driven programming language and Integrated Development Environment (IDE) from Microsoft for its Component Object Model (COM) programming model.

XAMPP

XAMPP is also used in this study to provide convenience in creating database applications for the project. XAMPP is a free and open-source cross-platform web server developed by Apache Friends. XAMPP stands for Cross-Platform (X), Apache (A), MySQL (M), PHP (P), and Perl (P).

In XAMPP – Apache is a Server application, MySQL is Database, and PHP is Server Side Scripting Language and all these are included as an extractable/executable file. XAMPP works seamlessly on Windows, Mac, and Linux because of its cross-platform nature.

This XAMPP package includes several services and applications all bundled together for fast and easy configuration and deployment, such as Apache, MySQL, PHP, FileZilla FTP server, Mercury, Tomcat, etc.

XAMPP was designed mostly for developers and it's a very easy way for developers to set up their own local LAMP installation for the web-based applications they are developing. A default XAMPP installation also includes several PHP applications like OpenSSL for secure sockets layer support, graphics libraries such as GD, database packages such as SQLite, PhpMyAdmin for administering MySQL database through a browser, etc.

XAMPP provides an easy-to-use control panel, which allows us to start and stop modules like Apache, MySQL, and Filezilla, view PID and port numbers, edit config files, view logs etc. The control panel is very easy to use and it has a user-friendly interface. Pros - XAMPP is a great development tool and it is developed keeping the developer in mind. It's very easy to install and contains all the tools needed, and it also provides GUI based control panel for starting and stopping modules/services and updating configuration files.

MySql 5.1

MySQL was used in this study for the design and implementation of a database that will be received and interpret the data received from the sensor. This is an open-source relational database management system (RDBMS). Its name is a combination of "My", the name of co-founder Michael Widenius' daughter, and "SQL", the abbreviation for Structured Query Language. The MySQL development project has made its source code available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements.

MySQL is a central component of the LAMP open-source web application software stack (and other "AMP" stacks). LAMP is an acronym for "Linux, Apache, MySQL, Perl/PHP/Python".

Windows 8 (Operating System)

Windows 8 was the operating system used to run all other software used in developing this study. This is a personal computer operating system developed by Microsoft as part of the Windows NT family of operating systems.

2. Analysis Stage

In this phase, the researcher analyzes the current water level monitoring management system of the National Irrigation Administration and determines its entities and processes. Procedures and objects of the existing system were identified and new systems were planned.

***2.1 Existing System*.** When the planting season of rice is coming, the employee in-charge in water level monitoring in the NIA manually checks the level of water in the dam wherein the dam is located separately from their office. The NIA office is located at del Carmen, San Jose, Camarines however, the dam is approximately 20 kilometers away and it is located at Barangay Cagaycay, Goa, Camarines Sur. This checking of water level is to prepare the agency to respond to the farmer's need for water in preparation for their rice planting. The agency has a total of 2,725 hectares of irrigated land (cultivated) area covering the municipality of Goa, San Jose, and Lagonoy to supply water for farming. These lands are divided into a lateral division from Lateral A to Lateral E.

In monitoring, the employee in-charge is personally monitor the water level of the dam by looking at the concrete post with printed meter level which is located at the side of the river. Figure 12 shows the water level monitoring device of the NIA. After the reading of the water level, the data will be brought to the office for validation and interpretation. The result will be the basis for the distribution of water to the farmer beneficiaries.

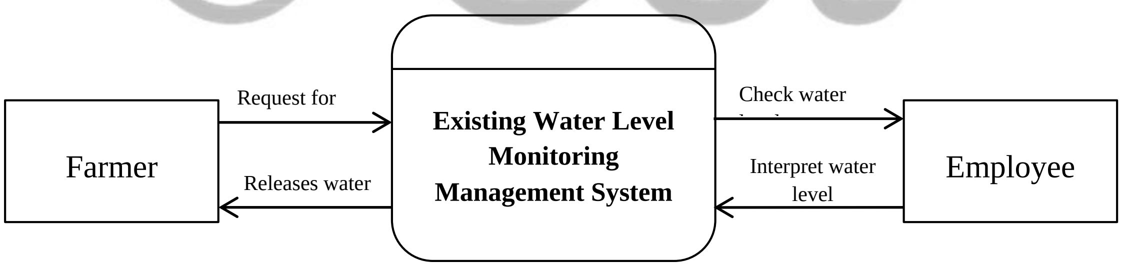

Figure 10 - Existing Water Level Monitoring Management System

Using the data flow diagram, the existing water level monitoring management system of NIA shown in figure 10.

Figure 10 - NIA Existing Water Level Monitoring System

***2.2 Proposed System*.** The system architecture is presented in figure 1. This shows the flow of the proposed system relative to the objective of this study such as water level monitoring devices with SMS technology, application software, usability, and accuracy.

This proposed system will answer the need of the end user in terms of speed, ease of use, accuracy, and usefulness is addressed. The end-user will now end up with the risk of personally checking the water level of the dam in times of need and also during heavy rains. This project offers great advantages because it applies an SMS technology that will send data from the water level sensor to the remote server located at the agency office. The data will be treated and analyzed by the application software and give a result that corresponds to the need of the client. This will help also the end-user to reduce time in analyzing and interpreting the water level of the dam for which they released the water intended for farming.

This proposed system will also have a capability to send messages to the farmer or to the Watergate master for their information about the water level and other water distribution concerns. This message is sent an end-user manipulation and cannot be sent automatically by the system.

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3. Design Stage

This stage presents the logical and physical design of the proposed system. Several modeling tools were utilized by the researcher to realize the objectives of this study. Logically, the project is developing a water level monitoring device and a simple application system with SMS capability that will analyze and interpret the data read by the water sensor. This application is remotely installed in a computer that will consider as a server of the proposed system. The server will display the water level data in the office of the agency for real-time monitoring. This is displayed in a millimeter and in meter unit.

Logical Design. Water Level Monitoring Device. A logical design of the water level monitoring device is presented in Figures 13 and 14.

Figure 13 showed the block Diagram of the functionality of the device for water level monitoring. This illustrated the testing and analyzation of the circuit design, connections of every component. In this part, the researcher ensures the proper circuit connection to avoid error or failure in connectivity or short circuit. Next, after checking and validating each component if they are properly functioning when integrating together, the researcher then proceed to the design and coding of the program needed for the water level sensing. The researcher troubleshoots and considers certain adjustments on the sensor and how the water level readings will be presented on the application support.

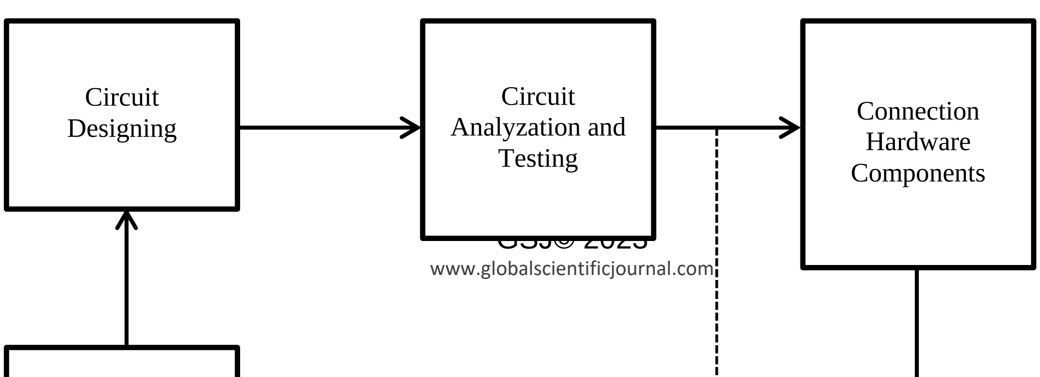

Figure 13 - Block Diagram of the Functionality of the Water Level Monitoring Circuit Design

The researcher also started the designing and coding of the GUI for application software. After having completed the coding and designing of GUI, the researcher started designing of the back-end part of the system where data from the sensors are stored to the server.

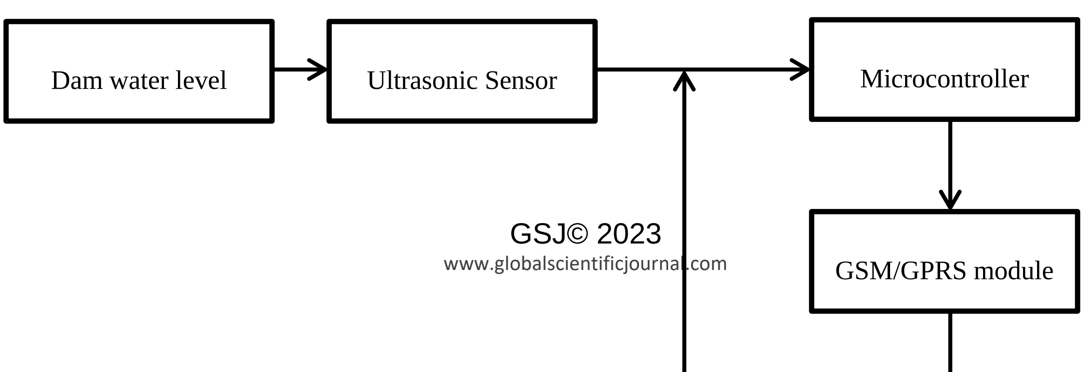

Figure 14. Block Diagram of the Logical Design of Proposed Project

Figure 14 showed the Block Diagram of the logical design of developed Water Level Monitoring Device.

Physical Design. The physical design of the water level sensor and all its components is shown in figure 14. This prototype of the water level sensor is composed of a casing, ACEduino microcontroller, US-100 ultrasonic sensor, GSM/GPRS shield, and SIM card. The external connections are the battery pack connected to a solar panel board with 9v capacity.

On the other hand, the user interface of the application software is very simple, the main interface of the display of the water level data that send by the sensor to the server presented in figure 16. There are other miscellaneous parts in the GUI such as the main menu which is composed of System, Management, Report, and Help. Under System, it has a submenu that is composed of the following: Water Level Monitoring Window and Close button. The Management Menu has items such as Employee, User Account, Farm Field Information, and Farmer Information; while in Report Menu there are items such as Print Water Level and Print Farmer; the last is Help Menu with items such as; About the System and How to.

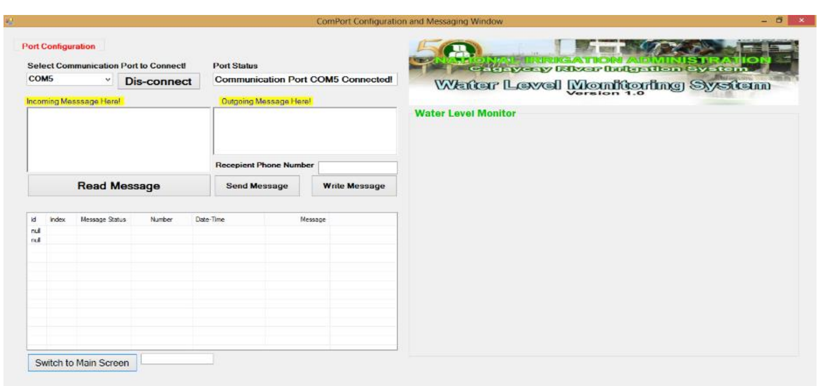

Figure 15 - Port Configuration Window

Figure 15 showed the port configuration window of the Water Level Monitoring System for National Irrigation Administration.

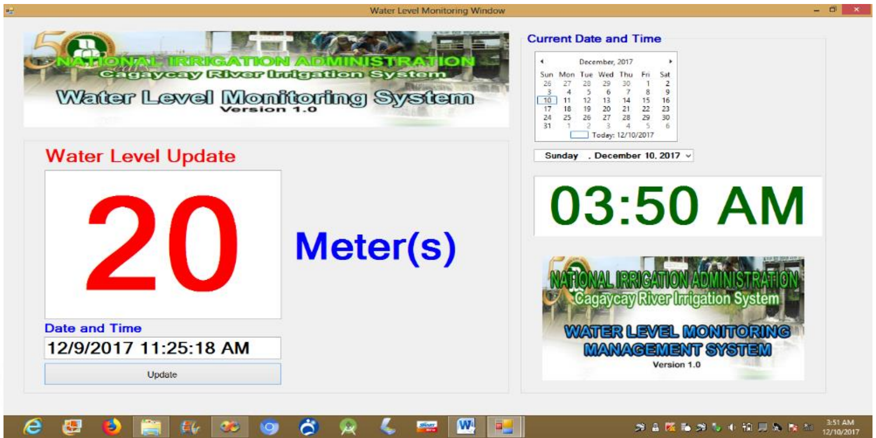

Figure 16. Water Level Monitor Window

Figure 16 showed the water level monitor window of the developed Water Level Monitoring System for National Irrigation Administration.

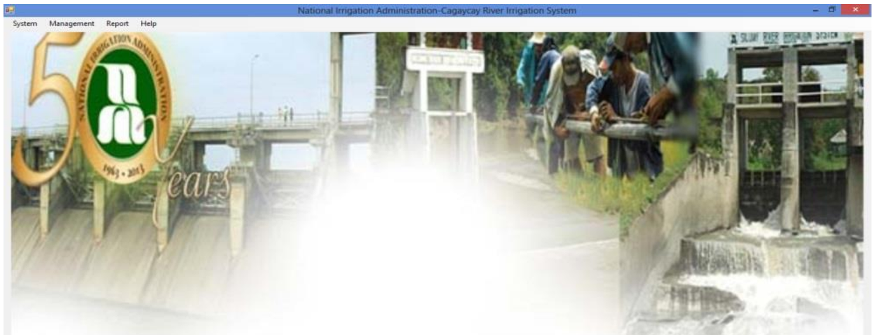

Figure 17 - Main GUI of the Developed Application Software

Figure 17 showed the main GUI of the developed Water Level Monitoring System for National Irrigation Administration.

Figure 18 - The System Menu with Sub-Menus of the Developed System

Figure 18 showed the system menu with sub-menus of the application of the developed Water Level Monitoring System for National Irrigation Administration.

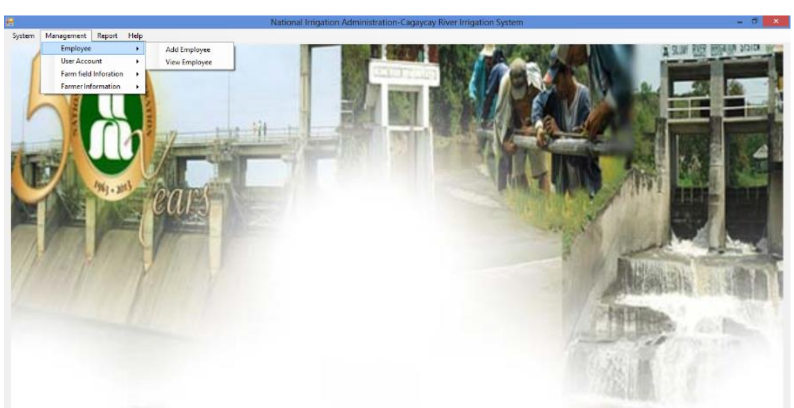

Figure 19 - The Management Menu with sub-menu of the Application

Figure 19 showed Management Menu with sub-menu of the developed Water Level Monitoring System for National Irrigation Administration.

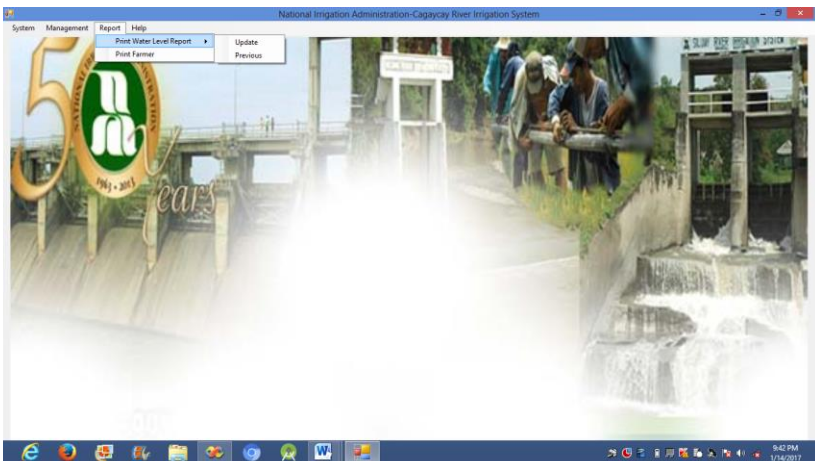

Figure 20 - The Report Menu with sub-menu of the Application

Figure 20 showed Report Menu with sub-menu of the developed Water Level Monitoring System for National Irrigation Administration.

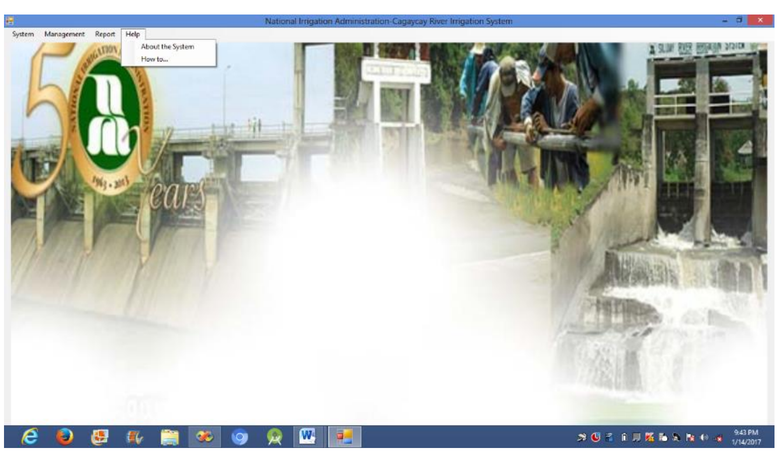

Figure 21 - The Help Menu of the Developed System

Figure 21 showed The Help Menu of the developed Water Level Monitoring System for National Irrigation Administration.

4. Development Stage

Construction. In this stage the researcher translated the design in an actual application. The water level sensor is constructed and assembled; see figures 24, 25 and 26. Different components are interfaced together such as ACEduino microcontroller, HC-SR04 ultrasonic sensor and the GSM/GPRS shield are connected to each other. Figure 27, shows the battery pack and the solar panel board are assembled and tested.

The application system was done with the Visual Basic 2008 as front –end and MySql as the back-end. XAMPP served as connector. On the SMS support module, the researcher utilized the ARDUINO IDE for embedding the code to the microcontroller.

System integration and testing was done by the developer. System audit and evaluation criteria are in consonance with the objective of the system and documentation criteria set on this paper. The variable of this research had been considered, such as water level monitoring device, usability and accuracy of the system as to water level sensing is concerned.

Testing. To evaluate system performance as to usability and accuracy*, Validation and Verification for the system had been made by the proponent.* The project was evaluated and rated by the IT experts and in the field of Irrigation system. Tables are presented at the preceding pages showing the results of the testing of the sensor .

Table 6 - Reading Comparison between the Actual Measurement and the Water Sensor

Actual Measurement (cm)	Using Sensor (cm)
50	57.15
50	57.15
100	104.14
130	133.35
150	159.33

Table 6 showed the reading comparison between the sensor and the actual testing. Testing distance is from 0 to 450 centimeters. The testing was conducted in a controlled setup that contains a water drum then the researcher varies the amount of water to correspond different level height.

The average of percentage error of the water level sensor is -6.483%.

Table 7. Summary of Evaluation Result

Parameters	IT Experts	NIA Staff	Mean
Functionality	4.7	4.7	4.7
Reliability	4.6	4.8	4.7
Usability	4.8	4.9	4.9
Maintainability	5.0	4.6	4.8
Portability	4.8	5.0	4.9
		Overall Mean	**4.8**

Table 7, shows the result of the evaluation conducted by ten (10) IT Experts and five (5) NIA Staff. The proposed system was rated in terms of its functionality with a mean of 4.7, reliability have 4.7 also, usability have a mean of 4.9 while maintainability have 4.8 as mean and portability have a mean of 4.9. The overall mean is 4.8 which means far more than the expected quality characteristics.

5. System Implementation

System Installation and Deployment is a limitation of this project. Thus, the project proponent and developer recommend suggested installation manner and methods.

Cost – Benefit Analysis. Cost versus benefits of the system had been evaluated as to usefulness issue of the proposed system. National Irrigation Administration is not in the top priority concern of the present administration hence, this agency suffer in a budget deficient in all their operation such as; construction of dam, construction of farm – to - market road, maintenance of the dam and canals, repair of the dams are some of the main project of the NIA.

Table 7. Estimated Cost of the Project

Name	Cost
1. ACEduino ATmega 328	P 750.00
2. Ultrasonic Sensor	P 450.00
3. GSM/GPRS Modem	P 3,500.00
4. Battery/Solar Panel	P 3,600.00
5. CPU fan	P 150.00
6. Casing/aluminum	P 250.00
7. Connecting wires (assorted color)	P 150.00
8. Wall bracket/braces	P 200.00
9. SIM Card	P 20.00
10. Broadband Stick	P 1,000.00
11. Computer Unit as Server	P 45,000.00
Total	**Php 55,070.00**

Table 7 showed the estimated cost of the implementation of the developed Water Level Monitoring System for National Irrigation Administration.

Implementation Plan

Implementation of the system is suggested with the recommended factor such as the specified hardware and software requirements. Network infrastructure is also presented for recommendable performance of the system. Suggested users and clients are also specified as stakeholders of the system.

Implantation of the system is highly recommended by this paper. Appropriate protocols, bind with rules of implementation duly authorized and approved by the concerned official of the National Irrigation Administration.

Findings

To answer the foregoing problems the researcher used the descriptive developmental method of research in the context of system development. Descriptive was used in discussing the results of the testing phase while developmental was used during the system development. The data analyze using the percentage technique and arithmetic mean after conducting the testing of the water level monitoring. The Software Development Life Cycle (SDLC) was also utilized in designing the proposed system. Specifically, the following are the findings:

1. The National Irrigation Administration – Cagaycay River Irrigation System currently used the water level concrete gauge constructed near the river as their monitoring in determining the level of the water of the dam. They record the data gathered from the water level concrete gauge manually and computed it using the calculator or by the use of electronic spreadsheet. During rainy season, the NIA employee in-charge in monitoring the water level of dam had experienced difficulty in going to the dam site to check the water level and there are situation that some of their dams having overflow of water and it affects nearby barangay that makes them flooded. Generally, it takes some time to monitor the water level of the dam.
2. The feasibility of implementing the proposed water level monitoring device is seen important and timely in technological aspect for National Irrigation Administration as they are facing the new trend of information technology. It was shown from the results that the respondents approved and highly recommended the adaption and used of the proposed system.
3. Upon review of the gathered data and the result of the evaluation of the study, the researcher proposed for the development of Water Level Monitoring System exclusively for National Irrigation Administration in Cagaycay River.
4. The developed Water Level Monitoring System was found by the experts to have strongly usability as shown by 95% of them, and found 90% in terms of its accuracy.
5. It can also be observed from the results that the respondents highly believed that the developed water level monitoring system was easy to used and operate. The developed system shows a sense of competency and the design was also conform to the type of system. Most of the respondents had believed that the system would provide reliable information in terms of water level monitoring. Similarly, information found in this system would have shown relevant information.

Conclusion

Based on the findings of this study the following conclusions are formulated: Based on the existing means of monitoring the water level of the dam in National Irrigation Administration – Cagaycay River Irrigation System, the proponent have concluded that the proposed Water Level Monitoring Management System could measure the height of the water level of the dam and the data can be interpreted by the application software that can be used by the agency for their decision making in distributing the water to the farmer beneficiaries. Instead of existing ways of measuring and monitoring the water level of the dam which are through personally checking at the concrete post with printed meter line located at the river, using this device will save time and effort and has real – time update. The Water Level Monitoring Management System could be portable and installed not only in one dam but as well as to the other dam of NIA. It is therefore also concluded that the system exhibits accuracy and usability.

Recommendations

Based on the conclusions the following recommendations are hereby offered:

1. The developed device can be enhanced; its composition, color, or even making it more minimal.
2. It is also recommended to use the device as flood warning system.
3. The data gathered by the sensor is recommended to be sent to LGU's nearby the river as flood warning system.
4. The developed device can also be used by other researcher having related projects for their references and comparison.