Information system for water level and flood warning in NAN river

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ABSTRACT

The most common cause of flooding in Phitsanulok province is prolonged rainfall and excess water level in NAN river. Messaging of alarming water levels by mobile phone was developed using PHP language. The water level was monitored by each water station officer, and data was collected and subsequently reported to the user through a mobile phone. The different water levels will be reported to mobile phone users as the text message and symbol colour following: level one (green colour) is preliminary warning, level two (yellow colour) is escape preparing and level three(red colour) is defined as the people must evacuate to another site.The user will access this program through a membership application, choose the relevant water stations, and the relevant water levels will be sent to their mobile phone as a text message.The efficiency program evaluation determines four parameters as following: (1) Functional requirement test (2) Functional test (3) Usability test and (4) Performance test. The average score of each parameter was found to be at 4.01, 4.62, 4.21, and 4.41, respectively. This research provides an efficient program to predict water levels in the NAN river.The developed program provides easier access through a mobile phone as well as the preliminary warning water level for the community near the water station.

Keywords: warning system, flood, early warning, water level

INTRODUCTION

At the present, the early warning system designed for flood protection and disaster has been challenged by the changing in environment and weather systems. The catastrophic effects of disasters are recognised as causing natural resource, economic and environmental losses. A warning system is a way of disseminating information about an impending emergency and communicating the information to those likely to be affected. It also facilitates informed decision making and timely response by the people in the danger area (Mileti, D.S. and Sorensen, J.H. *et al*., 1990). Several studies have shown that early warning systems can be highly effective tools for saving lives and reducing property losses (Choy, S. *et al*.,2016; Chen, Y *et al*., 2016). For example, the many new scientific technologies of early warning systems such as (1) flood protection barriers and its prediction using developed computation and simulation models, (2) sensor equipment design, installation, and technical maintenance in flood defence systems and (3) applying information and communication technologies in gathering, processing and visualising sensor data. Moreover, the developing middle wave for connecting sensor data, advanced scientific visualisation and providing

internet-based interaction across to CIS for researchers and personnel has been developed (Melnikova, N.B. *et al*., 201; Morss, R.E. *et al*., 2015; Cool, J *et al*., 2016; Koriche, S.A. *et al*.,2016).

In Phitsanulok, the main river is called the "NAN river", causing flooding in nearly regions during the rainy season. During 2013-2015 of September, the water level of the NAN river reached to 9.71-10.51 meter.The excess water entered to the town and agricultural farmland.The agricultural farming loss was 321,001 RAI, while the houses of around 21,940 families were destroyed (Phitsanulok irrigation office3). Additionally, the "Sirikit dam", "Naresuan Dam"and "Kaw Noy Bam Rung Dan" Dam" rapidly released water to the NAN river, also causing flooding in the Phitsanulok region.

Recently, during July 2016, the water level of Sirikit and Kaw Noy Bam Rung Dan Dam was rising after continuous raining. The water level of the NAN river increased to 1.69 metres according to N5A water station monitoring. Hundreds of houses in Tambon Huaror, Muang, and Phitsanulok were attacked without any early warning system from local officers (phitsanulokhotnews.com). Although traditional water level warning systems in Phitsanulok were reported to people through broadcast systems including TV and radio, but it was a basic communication channel.

The mobile phone is one of the challenging devices for an individualised warning system which can be rapidly and directly sent to personal mobile phones. The mobile phone warning system has been distributed and effectively used by several governments around the world (Choy, S. *et al*.,2016). In Thailand, the real-time mobile phone monitoring of water conditions such as water level, flow rate, and precipitation levels were established in Nakon Si Thammarat (www.rdo.psu.ac.th).

Therefore, this paper presents the warning system for early warning water level in the NAN river in cooperation with the Phitsanulok irrigation region 3. The text message will send the water level from the water station which was determined by Google Map API. The text message is composed of water level and emergency colour. The emergency colour will be differently shown depending on the level of hazard.

METHODOLOGY

Context Diagram

This research will develop a water level warning system based on the concept as shown in **Figure1.** The overall basis of this system is composed of two steps:

Process 1 Admin: Admin will report the warning message to alarm the user.

Process 2 User : The user will be alerted to the display data through their mobile phone.

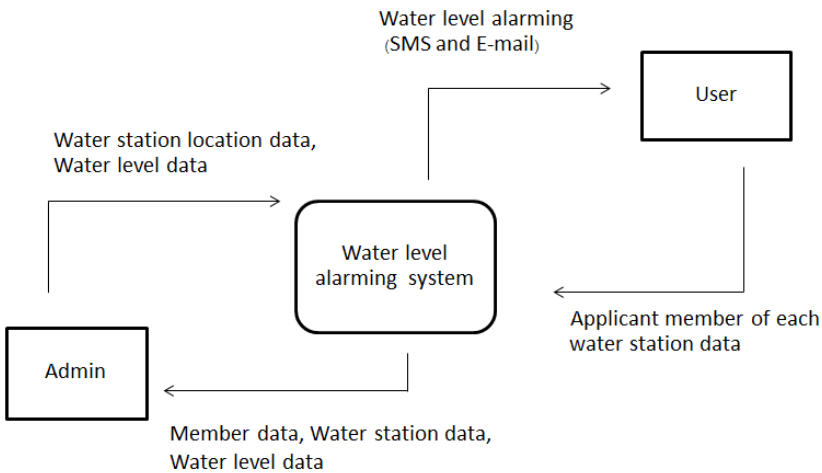


Figure 1 Context diagram

The Database Development Design

The database was designed based on four major steps:

Step 1: Developing data flow diagram

The data flow diagram (DFD) was designed as shown in **Figure 2.**

Process 1.0: Water station file, the water level data was collected, recorded in water station file, and the recorded data subsequently reported to the admin.

Process 2.0: Water level monitoring file, the water level data was filled into the water station file by the admin. The recorded data was also immediately reported to the admin.

Process 3.0: The member data file, the interested people will be applied to this system and the applicant data will be recorded in the member file. The alarm message will be directly sent to the member.

Process 4.0: The water level alarming file, the water level which was recorded in water level monitoring file will be immediately sent to the user by the admin.

Process 5.0: The admin file, the admin will collect the water level data and subsequently keep it in the admin file.

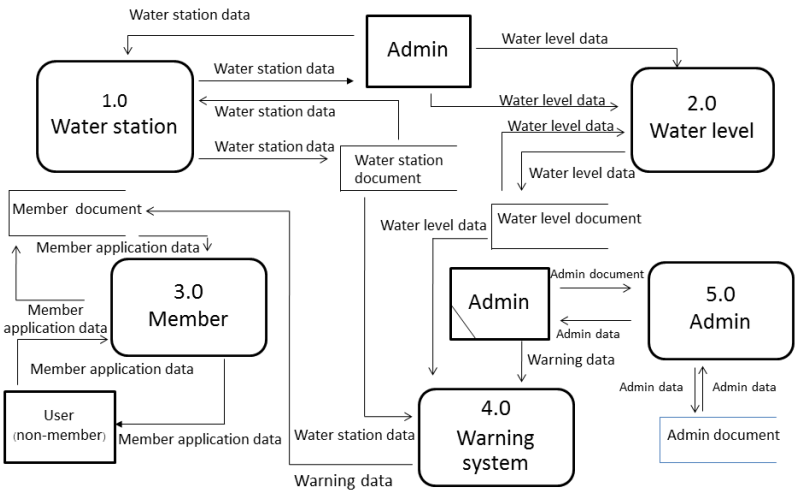
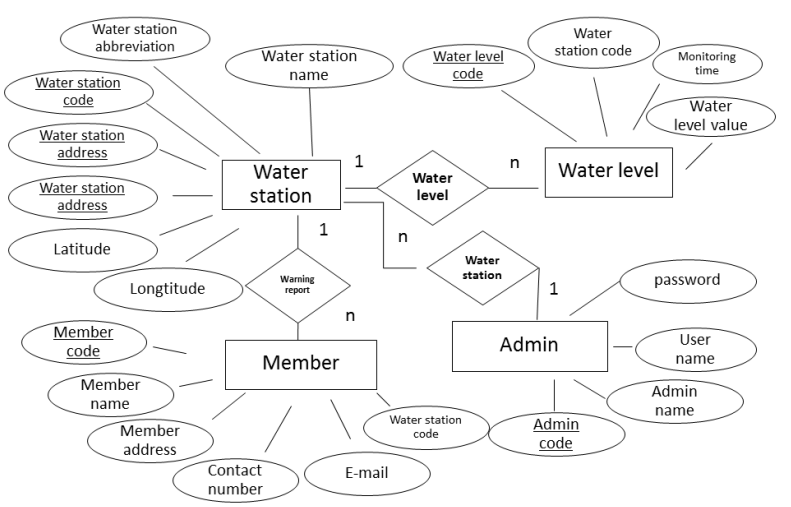


Figure 2 Data flow diagram (DFD)

Step 2: The Database design

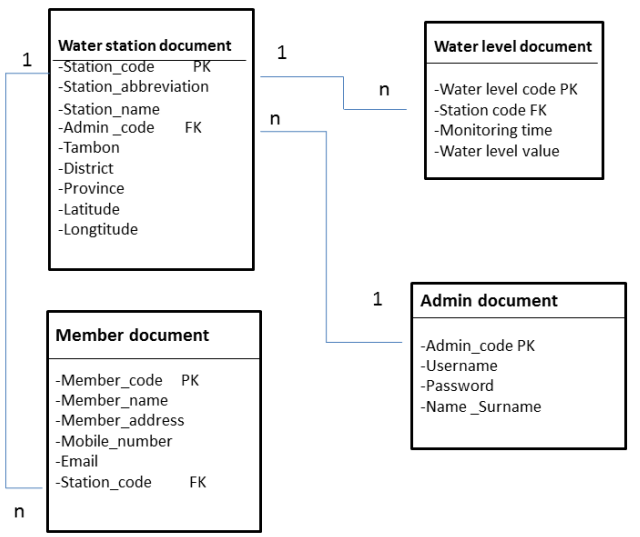
The Entity Relationship Diagram (ER-diagram) and the database relationship of this program were created as shown in Figure 3.

ER Diagram :ER diagrams show the relationship between entity values in **Figure 3a**.The entity relationship between water stations with water level and administration were designed at the ratio of one to many (1:n), many to many (n:n) and one to many (1:n), respectively.



(a)

Figure 3 (a) The ER-diagram (b) database relationship



(b)

Figure 3 (continued) (a) The ER-diagram (b) database relationship

Database relationship: The database relationship was shown in Figure 3b. The database documents of the water station correlate with the water level, admin, and the user database, at the ration of n:1,n:1 and 1:n, respectively.

Step 3: Data dictionary

The water level warning program related-files were constructed as described below:

1. Water station file	= water station code + water station abbreviation name + station name + admin code + water station address (sub-district, district, latitude, longitude)
2. Water level monitoring file	= water level code + water station code + water level value +monitoring time (dd/mm/yy)
3. The member data file	= member code + name and surname + address + mobile phone number + water station code
5. The admin file	= admin code +Username + Name-Surname

Step 4 Data Display Design

The developed program will be sent via text message to mobile phones. The users have to apply in order to receive the warning message alert from admin following their mobile phone number. The text message is composed of the three early warning levels: Level 1, the green symbol, is preliminary flood warning. Level 2, the yellow symbol, refers to the high water level and people should prepare to evacuate, while Level 3 is represented by red symbol which meant immediately evacuate to another location due to the excess water level.

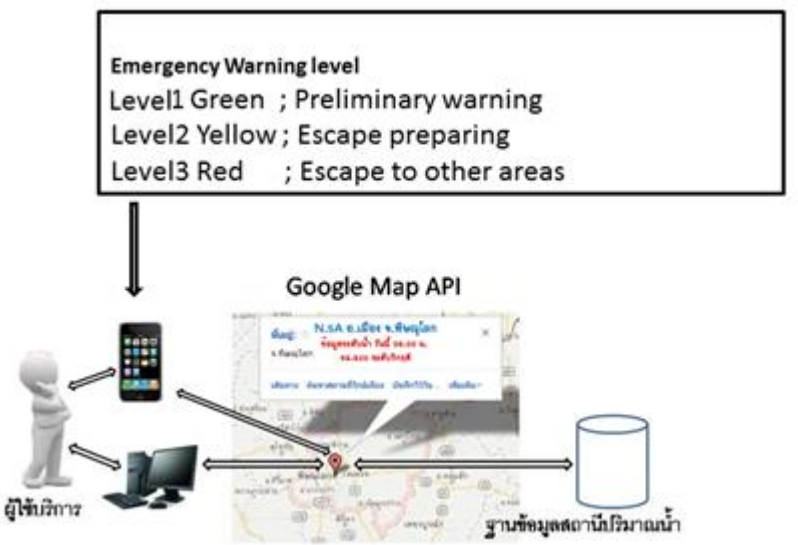


Figure 4 The designed mobile phone data display

Results

The data display of the developed program was successfully designed as seven display windows after the water level data was recorded.

1. **The main display window** The main display window consisted of the developed program name (number 1), menu bar (number 2) and display zone (number 3) as shown in **Figure 5.** Furthermore, the menu bar (number 2) is composed of the following menu;

1.1 Main menu

1.2 Water station name, menu will be shown the location of each water station

1.3 Register menu, will be linked to the display window for the user to fill in the application form to apply.

1.4 Log in menu, will show the display window related to the name-surname, address, username and password to verify users.

1.5 Admin menu, will link to the admin register display window to log-in and mange any related files in this program.

1.6 The admin profile menu, will be shown the name-surname and education of admin and also other descriptions of this program.

Figure 5. The water level warning program display window

2. The Water Station Location Display Window

The water station display window will be designed to provide the location of each water station through Google Map-API as shown in **Figure 6a.**

Number 1 is the data display type

Number 2 is the water station description (water station name, district, sub-district, and province).

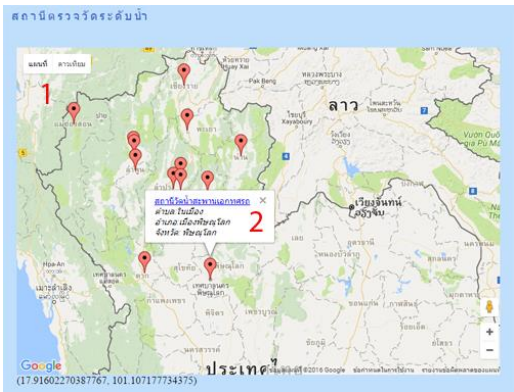
3. The Application Form Display Window

The application form was designed as three sections:

Number 1 is the required data from the application.

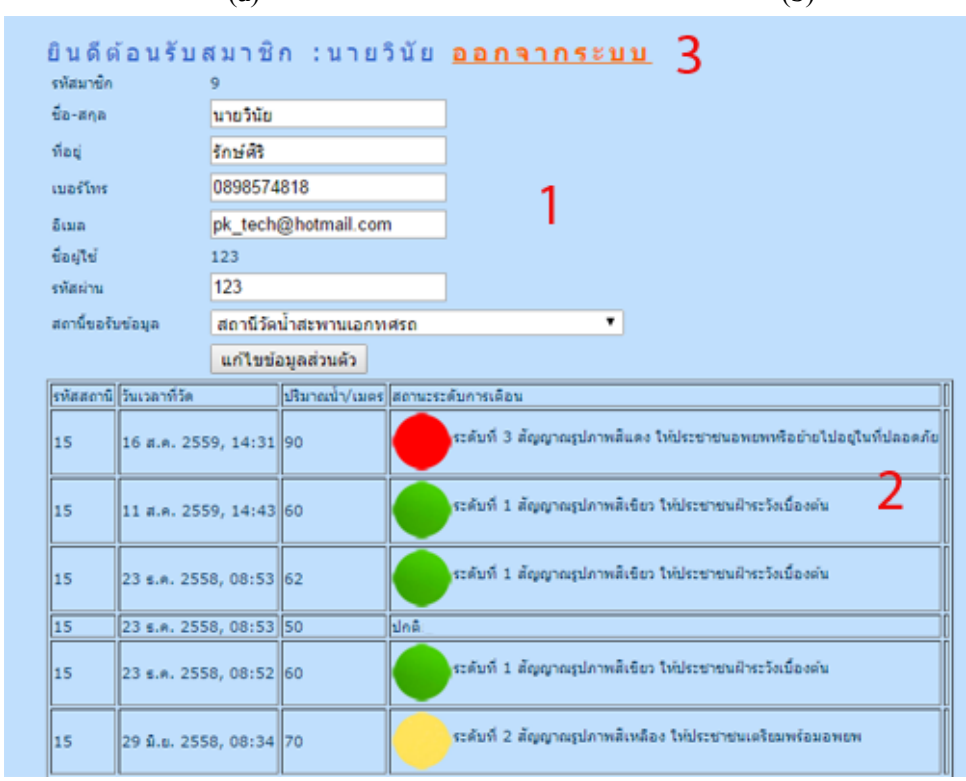
Number 2 is blank for data filling and the applicant can choose water stations near their house.

Number 3 is the submit button to send the applicant data to the admin (**Figure 6b**).



(a)

(b)



(c)

Figure 6 The overall designed display windows of the water level warning program (a)The location of each water station (b) The application form for user application (c) the water level alarming and (d) the admin registration output window.

(d)

Figure 6 (continued) The overall designed display windows of the water level warning program (a)The location of each water station (b) The application form for user application (c) the water level alarming and (d) the admin registration output window.

4. Registered user display window

This window was designed for the user after verifying themselves through the log-in menu.The display window provides the important data to the user which was divided into three sections (**Figure 6c**).

Number 1: the application data, as well as name-surname, address, mobile phone number, and email were shown in this area in order to verify and prove data between admin and user.

Number 2: the description of the water level situation in each water station near the user's house will be shown in this section. The water level in each station was reported as a different colour:

Level 1 (green colour) meaning preliminary alarming
Level 2 (yellow colour) meaning moderately dangerous or prepare for evacuation
Level 3 (red colour) meaning evacuate to another location

5. Registered admin display window

The admin will be logged-in in the register display window, and fills in username and password to verify his data in the box (**Figure 6d**).

6. The administration display window

After the admin successfully logs in through this program, the administrator menu will be shown for data management by admin as described (**Figure 7**):

Admin menu: the admin data correction, adding the other admin and deleting the admin will be successfully done in this menu section.

Member name menu: the admin can delete and add new members and also correct member data.

Water station name menu: the new water station name will be added by the admin in this section, while the old water station can be deleted from the program by the admin.

Water level alarming menu: The admin will use this menu for alerting members following the water level exceeding the limit value.

Admin profile menu: this menu provides the curriculum vitae of the admin.

Figure 7 The administration display window

DISCUSSION

The developed program was designed as shown in Figure 6. The description of water level warning menu consisted of (1) Program title (2) Menu bars including the north water station regions, member application menu, register menu, admin, and description of this system and (3) The display zone after the ordered menu bar. The user can choose the interested water station depending on their region. The data display window will be shown after the user chooses the interested water station. The water station has been shown in the display window through a Google Map API determined by the admin.

The interested people and irrigation officers will apply through a web application to receive SMS via their mobile phone (Figure 6d) .The water station was chosen by the applicant depending on their location. The successfully applied status will be shown and report water and emergency levels to the user as shown in Figure 6d.

The display menu will reported the water station, water level, and emergency colour status. Moreover, this system allows for insertion of the interested water station, latitude, and longitudes in order to determine the water station by Google Maps by the admin.

This system was evaluated by 30 volunteers off our parameters, such as a functional requirement test, function test, usability, and performance test, according to the method of Pimpa, A and Tetiwat, O.,2004. The satisfaction questionnaire was evaluated by volunteers after the efficiency program was tested.

The average score of each parameter was found at 4.33, 4.51, 4.29 and 4.46 respectively. The function requirement test included the performance of the program to report the water station, water levels, the connection capability of the web page and user were also monitored. The water levels and emergency alarm information were also evaluated as a function test. The system usability evaluation consists of the acceptable colour, feature, and data access deemed comfortable by the user. Finally, the speed of the developed program will be concerned as the rate of water level reporting and web page connectivity speed. The developed program for water level reports obtained a good level of satisfaction from volunteers.

CONCLUSIONS

This system successfully collected water levels in each water station in the irrigation lower north region and accurately reported to the users. The interested people in Phitsanulok or related areas can access the system through the developed program by member application through the web page http://webdshop.com/web_research57

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