The River Basin Spatial Informative Nesting (E-BASIN) framework as an alternative approach for flood disaster management

M Y Izham1*, R Aznarahayu1, M A Nurul Azni1 and M N Norashila1

1School of Distance Education, Universiti Sains Malaysia, Malaysia, 11800 USM, Penang, Malaysia.

*Corresponding author: izham@usm.my

Abstract. The usage of technology is vital towards flood management. It helps on delivering the information on disasters occurred in the affected areas. Heavy rainfall and flood disaster occur frequently in Malaysia during the monsoon seasons. This causes significant impact towards human life, loss of properties and damage to the surrounding environment. The requirement on effective flood disaster management within river basin boundaries has become a necessity by managing the weather records, simulating present and future flood events; and providing best approach of reducing flood impact assessment before, during and after. This article aims to propose a new framework in flood disaster management as an alternative way to disseminate flood events, namely E-Basin framework. E-Basin is designed via “light and easy” approach to visualise, alert and report flood events among affected local residents, societies and related agencies situated in flood-prone areas. The implementation of E-Basin framework could provide further guideline among the involved agencies for improving effectiveness of flood disaster management geographically in the 4th Industrial Revolution era.

1. Introduction
Flood is considered a major natural hydrological disaster, causing significant impact towards human life, loss of properties and surrounding environment [1-4]. Frequent flood events would contribute negative impacts towards development planning, transportation access, buildings and other properties [5]. Since the 1920s, floods have been reported as a common occurrence in many countries. Previous studies stated that 9% of the total land area and 22% of the total population were directly affected by floods [6-10]. According to [11], over the recent decade, the frequency of floods disaster occurrence has increased. Moreover, the countries are located in the Asia and Pacific are the most badly affected states by the flood including Malaysia [12].

Malaysia is classified as having an equatorial climate with high humidity and experiencing abundant and continuous heavy rainfall every year [13] with the average of approximately 2,500 mm a year in Peninsular Malaysia, 3,000 mm a year in Sabah and 3,500 mm a year in Sarawak [7,10,14]. The amount of rainfall shows that Malaysia has potential to flood disaster exposure and water overflows every year [8]. In Malaysia, there are two basic types of floods that have been classified, namely flash flood and monsoon flood [15]. Flash flood is a fluvial type of flooding triggered by causative rainfall, and the drainage system not able to flow well as a result of the heavy rainfall in a short time [16]. Flash flood may possibly occur very quickly because the water can only move via streams or narrow channels and
the drainages are unable to accommodate for any sudden high-water flow. This has been observed in busy cities as a result of human activities such as infrastructure development near the river areas as well as uncontrolled littering causing clogged drains and waterways [8,17]. However, it takes a short period to recede to the normal water level compared to the monsoon flood. For instance, flash flood disaster which occurred in Cameron Highlands on 23rd October 2013 claimed 3 lives, injuries, heavy mudflows and damage of properties [18]. Based on the interviews carried out by researchers among the victims, they concluded that the early warning system was not operating properly, and safety response requirements and quick evacuation access failed.

Moreover, monsoon flood occurs during two wind seasons that contributes to heavy rainfall, which is from May to August (The Southwest Monsoon) and from November to February (The Northeast Monsoon) [19,10]. Significant rainfall intensity within several hours would generate flash floods, causing damages to infrastructure, contamination of water supplies and harvest losses [20]. Many countries such as Indonesia, west Malaysia, Southern Thailand and Sri Lanka faces significant flood hazards in the year of 2014 due to the northeast monsoon [21]. Malaysia is among the countries with the worst affected area in several states, with more than 200,000 people affected, and 21 people killed due to the monsoon [22]. Researchers predict that frequent catastrophic floods will occur in the future [23]. Thus, related government agencies and communities have begun to enhance current flood models, inventing green technologies, attempting cost effective strategies to reduce negative impacts on living things, properties, infrastructures, agriculture, human health and economic status [5,19,23,24,25,26].

Several organizations initiated positive programs and invented prediction models to deal with the problem. For instance, there are five strategies executed by the Disaster Management and Relief Committee of Malaysia on the development of flood management programs such as prevention, protection, preparedness, emergency actions and recovery [27]. Nevertheless, the policy on information sharing and data compatibility is still disseminated among researchers and government agencies, without involving local communities. In fact, the needs of local community involvements are crucial towards verifying actual flooded areas spatially, identifying the extent of damage in the affected areas within river basin and to provide evacuation guidelines effectively. Moreover, current flood management systems do not integrate the involvement of local societies to participate, report and simulate flood event due to the designation of different users. Hence, the more protections and new legislation need to be reviewed in accordance with such requirements for urban and rural areas.

In the flood’s scenario, several agencies have begun getting attention on enhancing the use of geospatial information [28]. Geospatial information is a very useful tool for geospatial analysis during flood mitigation processes. There are several usages of geospatial information including position, geospatial distribution, location clustering and status of damages related with hazard [29]. Geospatial information must always be in a good condition and must speed up the action towards predicting the possible flooded areas [30]. However, the local community and a few agencies still lack awareness regarding river basin. River basin is important for giving a successful flood prediction, preparedness and post-flood execution. Hence, a holistic approach to flood management needs to be executed by engaging the local community, related government agencies and researchers within a river basin scope [8,31].

Flood disaster that occur at river basin boundary have been an unavoidable problem in many cities around the world. The damages of properties from the flood occurrence provide limitations to the varieties of sectors, either human activities, health or economic issues. In relation to water-resource planning and management mainly in disaster mitigation, decision makers often rely on flood studies, which usually use numerical models to simulate flood inundation. Early warning systems and flood risk mapping are examples of the advantages of flood models [32,33].

Research has been done in terms of developing flood models, environmental assessment and early warning systems; but the issues on information sharing policies and data compatibility cause uncertainty in terms of predicting flood areas, damage, evacuations and executions within a limited time. In addition, current flood management models focus on managing flood disaster from the administration’s perspective and only involve the agencies responsible for managing flood disaster such as government agencies and NGOs. Those models are limited in terms of public or community involvement. However,
according to [34], community or public engagement is crucial for a more effective and efficient flood disaster management.

2. E-Basin for Managing Flood Disasters

In this study, the E-Basin framework is designed as an alternative tool for delivering spatial information via web application. It is as a medium of delivering information for saving lives and reducing damages due to the flood event. The aims of E-Basin are to engage the community, the involved authorities and experts to enhance their responsibilities and collaboration related to managing of flood disasters. Through E-Basin, users can share the information, access the right information and obtain updates easily on news about flood disasters. Generally, this application will design for self-study within smartphone application and personal computers and users can access it anytime and anywhere.

E-Basin differs from the other flood prediction system by easing data transmission within a short period of time. Therefore, it enables users to access the information on the possible flood areas in quick time. In E-Basin, the users would be able to retrieve and update information on current weather events. The community will retrieve the news quickly and take precautions before flood occurs. As stated by [35], the management of flood disasters need to access a vital infrastructure system that is able to provide the right information and timely warnings to assist the community respond about flood events. As a result, this initiative has been implemented to provide great insights into the development of flood.

The main focus of this research work is the designation aspect of E-Basin framework and initial spatial information inventory of flood conditions and river communities. E-Basin encourages community involvement as it allows the user to send the information of flood to the system. It enhances interaction of various involved agencies and system with the affected population and the situation of limited transmission data can be overcome. This will lead to an easy and quick distribution on flood-related information sharing process. With the implementation of E-Basin, the system enables the community to obtain quick references for flood preparedness, evacuation route, access to the nearest help centre, domestic equipment and medical attention.

In accordance with statement of [27], the involved agencies in flood management, i.e. the government will only act after the disaster occurred and overlooked the policy aspect as the preparation for the future. E-Basin would act as a medium in educating "My river basin - my homeland" concept towards the bottom billion by providing the facilities to the society so that they more alert and aware on sustaining natural environmental existence. Most importantly on E-Basin framework is expected to reduce the redundancy of spatial informative delivery and usage among government agencies, which provides a holistic, coordinated, enriched and complete guide towards centralized geospatial natural disaster information centres. Additionally, E-Basin leads to sustainable economic planning, activities and recovery and introduces a more superior, organized system while minimizing conflicts that may exist during the disaster period.

3. Materials and methods

The purpose of this research is to design an E-Basin framework as an additional tool to inform the flood disasters in any area. In this study, the researchers use a river basin extended as the main centre of distributing geographical information. The main focus of this study is on the aspect of E-Basin framework, designing and initial spatial information inventory of flood conditions and river communities. The E-Basin system is embedded within desktop and smart phone so that the users could promptly access the information on floods quickly. The study area is in the Sungai Perak river basin, located in Perak, Malaysia. Sungai Perak is located in the Northern Peninsular Malaysia, which obtain frequent heavy rainfalls and records high water level in the river. Thus, resulting in high vulnerability to the entire Sungai Perak river basin due to frequent floods.

The overall methodology of the study is divided into three phases; the preliminary study (first phase), constructing the E-Basin framework (second phase) and testing the E-Basin framework (third phase). Figure 1 depicts the research activities related in the study.
3.1. First phase
The first phase involves analysing the data on current flood information before disseminating to the users. The data is available to be accessed and shared among researchers, the involved agencies and communities. In E-Basin, the end users (i.e. local community) would be able to simulate predicted flood events and taking part towards observing the river basin.

3.2. Second phase
The second phase involves installation and setup of the server, client server and constructing E-Basin framework and designing E-Basin interface for desktop view (web) and smartphone view (android and iOS). The spatial layers identified in phase one will be captured using ArcGIS, processed and generating flood plain areas via coupling with Hydrologic Engineering Centre-Hydrologic Modelling System (HEC-HMS) simulation model. This phase will then continue with the designing of E-Basin web interface for viewing in desktop and smartphone (android and iOS) application. The system is embedded with spatial results sharing, prompt information updating, flexible expansibility and user response.

3.3. Third phase
In the third phase, the spatial information access via desktop and smartphone will be tested in terms of E-Basin continuous update of flood spatial information and accessibility among the local communities, related agencies and researchers as well as E-Basin information retrieval from these users. The E-Basin framework will be validated with the current available flood information systems.

4. Results and discussion
E-Basin framework is the first research to integrate smart of spatial informative delivery for flood prediction incorporating fundamental aspect of geospatial information for fully geospatial based integration. E-Basin involves related agencies on managing flood issues, researchers and local communities. The E-Basin is implemented as a web-based application to allow users in updating and viewing information regarding flood events. This application is expected to provide the best foundation of participation from the communities via prompt update of possible accurate flood spots and current weather events. Therefore, the communities will be more prepared on the upcoming flood disasters, thus reducing the loss of life and economic losses. E-Basin attempts to centralize the system of flood
management, which involvement of various communities, agencies and researchers. Through E-Basin system, it would educate the communities to be more alert the surroundings of the river basin and sustaining natural environmental existence via the concept of “My river basin – my homeland”. This application will lead to eliminate the redundancy of spatial informative delivery and usage between government and related agencies.

5. References

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