Mobile Application for Field Knowledge Data of Urban River Catchment Decision Support System

Fathoni Usman, Rohayu Che Omar, and Lariyah Mohd Sidek

***Abstract*— Water quality monitoring in urban area is a must. Regard to development and increasing of population due to urbanization, it has catapulting degradation effect to water quality of river. River Penchala is one of main river in Klang basin flows crossing urban area where diverse land use established. From historical data on its water quality, River Penchala was facing very polluted water with Water Quality Index range from III to V. Data on water quality periodically collected from several measurement stations along this river but analysis and interpretation of those information require appropriate strategy to implement the correct technique and/or procedure in order to improve the water quality of the river. This paper present development of mobile application for field knowledge data collection to be used by a decision support system. Previous methods on development of water quality decision support system are also discussed. At the end of this paper an initial framework of decision support system for River Penchala river catchment will be presented.**

***Index Terms*— decision support system, mobile application, urban river catchment, water quality monitoring**

I. INTRODUCTION

WATER and other primary needs of human-being are become main issue of natural resources security. The development of mother nature by creating land marks of civilizations that supposed to be an enhancement to her in the real fact has worsen her. River as an ancient living stream still become a strategic place for human-being to life. The most basic law of survival is to live along river basin [1]. Based on Environmental Quality Report (EQR) 2011 published by Department of Environment, Ministry of Natural Resources and Environment, Malaysia, the water quality in most river in Malaysia regards to its BOD sub-index significantly reduced from 376 rivers (2007) and 104 river (2010) to 44 rivers (2011). The trend is shown in Figure 1.

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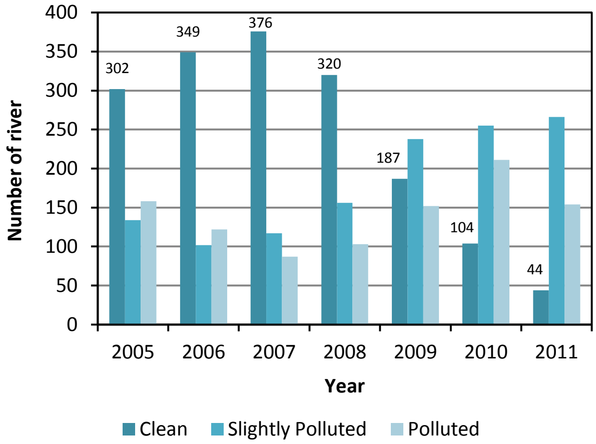

Fig. 1. Trend of river water quality based on BOD sub-index in Malaysia.

The most critical issue of River Penchala, which its catchment area is mostly located at urban area, are managing the solid waste from the urban household, monitoring and controlling the quality of water discharged to its flow. Moreover it becomes further complex by increasing issue on splash flood during heavy rain. It was reported by the Malaysian Highway Authority's (MHA), a portion of the Penchala Link Highway from the Penchala toll plaza heading towards the Taman Tun Dr. Ismail (TTDI) exit was closed due to flooding after a heavy downpour that lasted more than an hour (The Star Online, 2013).

II. RIVER PENCHALA OVERVIEW

River Penchala is located in the outskirts of Kuala Lumpur. The length of River Penchala is about 15 km, which is 4 km in the Dewan Bandaraya Kuala Lumpur (DBKL) area and the rest is laid in the Petaling District. The estimate catchment area is 50 km^2. The river flows from Bukit Kiara through urban areas, industrial parks and residential areas into two main tributaries. First tributaries flows down through Kuala Lumpur Golf and Country Club. Second tributaries flows through Kiara Park, TTDI. Figure 2 shows the Klang basin and Figure 3 shows River Penchala catchment area overlaid on Kuala Lumpur map.

Selangor State's Department of Irrigation and Drainage selected River Penchala to be nominated in One State, One River (1S1R) program. The One State, One River (1S1R) Program was launched in 2002. The program was aimed to organize a river restoration and water quality improvement

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program with full stakeholder participation.

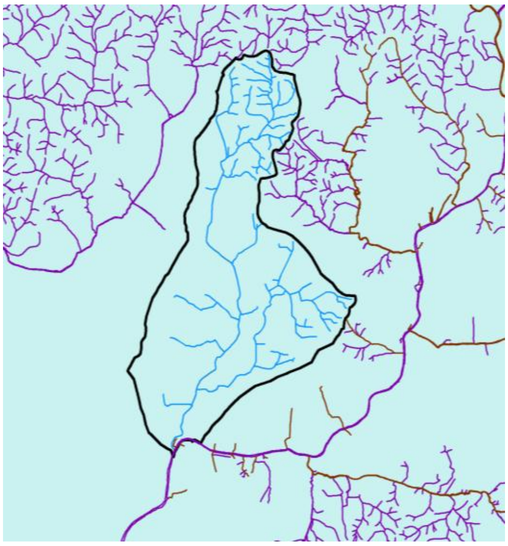

Fig. 2. River Penchala in the Klang basin

Training and talk on river restoration and awareness on the important of monitoring water quality of the river involved local community. The improvement of the water quality of River Penchala was shown after the involvement in the 1S1R program as seen in Figure 4. The Water Quality Index (WQI) shows the positive trend range from class V – class IV to class IV – class III. A continuous monitoring and activities to improve the water quality by involving all stakeholder are still needed.

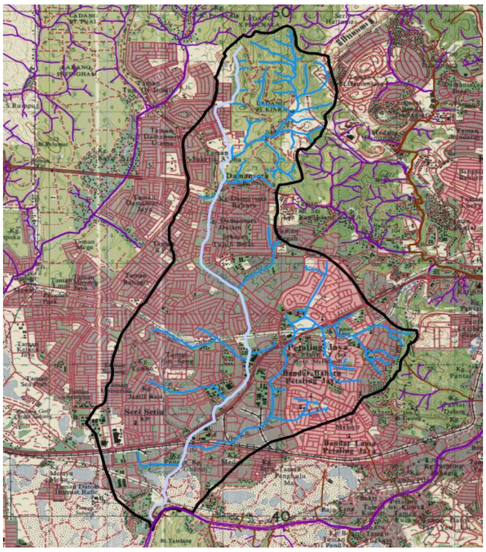

Fig. 3. River Penchala and its tributaries overlaid on Kuala Lumpur map

III. Decision Support System in Water Quality Monitoring

A decision model is an algorithm which performs a selection based on subjective preference information of a decision maker [4]. The concept of the decision support system (DSS) was developed in 1971 based on work on organizational decision-making in year 1960 [5]. A decision support system is employed to help decision makers improve decision quality by integrating information resources and analysis. A number of DSS have developed and applied in the water management, water trading and also water quality monitoring.

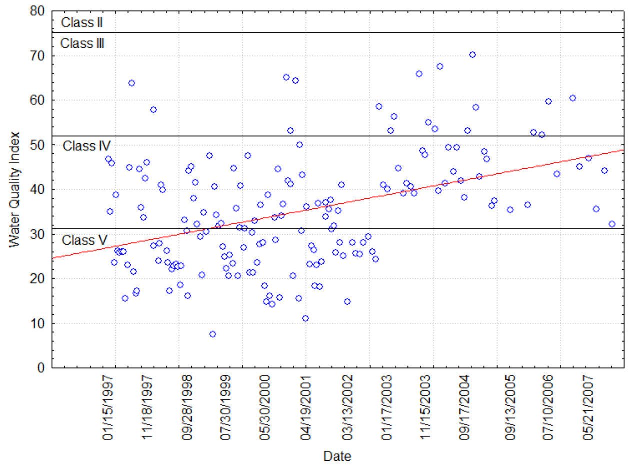

Fig. 4. WQI of Sungai Penchala from 1997 - 200

A Catchment Decision Support System (CDSS) concept have developed by Sydney Catchment Authority (SCA) to determine what actions the authority of Sydney takes to address water quality issues in the catchments. The CDSS was developed based on a wide range of information and methods, including science, spatial data, expert knowledge, modeling, monitoring and program expertise [6]. The CDSS of SCA consist of three main modules i.e. pollution sources assessment, drainage risk assessment and prioritization. In its pollution source assessment, the information on the catchment area developed in GIS based spatial analysis. The information on the key pollutants and source with range of land uses, landscapes and land management practices that occur in the catchments calculated using geoprocessing to determine the hazard index and pollution risk. Spatial analysis with geoprocessing capabilities allow each discrete grid cell to be created, weighted and summed individually in a specific study area. Other method of geopocessing was applied by Rahman et al. with spatial multi-criteria in decision support system for selection of Managed Aquifer Recharge (MAR) [7]. Different types of data are used to calculate retention time and recharge capacity of an aquifer over a wide spatial distribution from geological maps, geomorphologic maps, lineament map and land use map. More recent Fischer et al. applied Markov-based method to determine the spatial variability of dry spell in Tanzania. It used spatial data on surface elevation and its distance about sea shore to produce dry spell map and critical dry spell area [8].

For a web based decision support system using spatial analysis, Halls developed web based DSS by combining two systems to visualize the water quality of the Lower Cape Fear River basin, which incorporates dynamic graphing and GIS software [9]. Zeng et al. also developed an integrated water resources management for Daegu city, South Korea. It consisted of five sub-systems as follow: general user interface, information subsystem, data analysis subsystem, knowledge-based expert subsystem and model subsystem [10].

IV. Framework Development of River Penchala's Urban Catchment Spatial Decision Support System

The development of River Penchala Urban Catchment Spatial Decision Support System is aimed to complement the existing program of 1S1R and also the GIS of the river in place. As mentioned previously, River Penchala have selected to be a river where intensive programs to improve its water quality will be conducted. One of achievement of the program is development of a GIS of River Penchala. The Penchala GIS can be accessed from the following address, http://penchala-gis.selangor.gov.my/. The system currently is under upgrading process. The Penchala GIS consist of information on the catchment area of River Penchala, land use map and location of water quality measurement stations. Generally it allows visitor to access information from water quality measurement stations located along River Penchala.

There are limitations in the existing GIS of River Penchala. It is only present raw data of water quality from the measurement stations. There is no integration of data and information can be analyzed to provide more meaningful result to the user. The system do not allow user to interactively adding information to enrich the available information and data. There is also issue in accessing the system (i.e. the GIS map could not appear and long time of populating data from its server). Those limitations and issues need to be rectified.

A catchment decision support system using spatial geoprocessing with community and stakeholder involvement will be a good combination for River Penchala decision support system. Based on the existing system, GIS-Penchala where some layers of data are available, a new framework is developed. Mainly there are four layers of interfaces analyzing different types of information as shown in Figure 5.

In the first layer, spatial data module in GIS format will integrating different data generated from eco hydrology, hydraulic, water quality, location of discharge points, land use and also topographic in a form of digital elevation model (DEM). The field knowledge is the module where information from stakeholder (i.e. community, NGO and private) will be incorporated. Information can be in a form of comments, picture and also specific questions related to the status of the river in particular location and condition. Information from the stakeholder mostly more subjective and in a certain level it can be bias due to different interpretation or observation. The weighting process is required to normalize and generalize those information.

The next layer is basically aiming to determine the source of pollutants and its risk level to the water quality of river. A scaling process set to group the risk level. Using spatial analysis, the distance and buffer of the risk zone can be determine. From this layer a risk map will be generated. In general the pollutant risk (PR) can be represent as function of weighted values of eco-hydrology (ehyd), hidrolic (hid), soil erosion (Ser), land use (Luse) distance (s) and time (t) in (1):

$$PR = f(ehyd, hid, Ser, Luse, s, t)_{weighted} \quad (1)$$

Using (1) the water quality risk (WQR) can be generated as a function of the pollutant risk (PR) in (2).

$$WQR = f(PR) \quad (2)$$

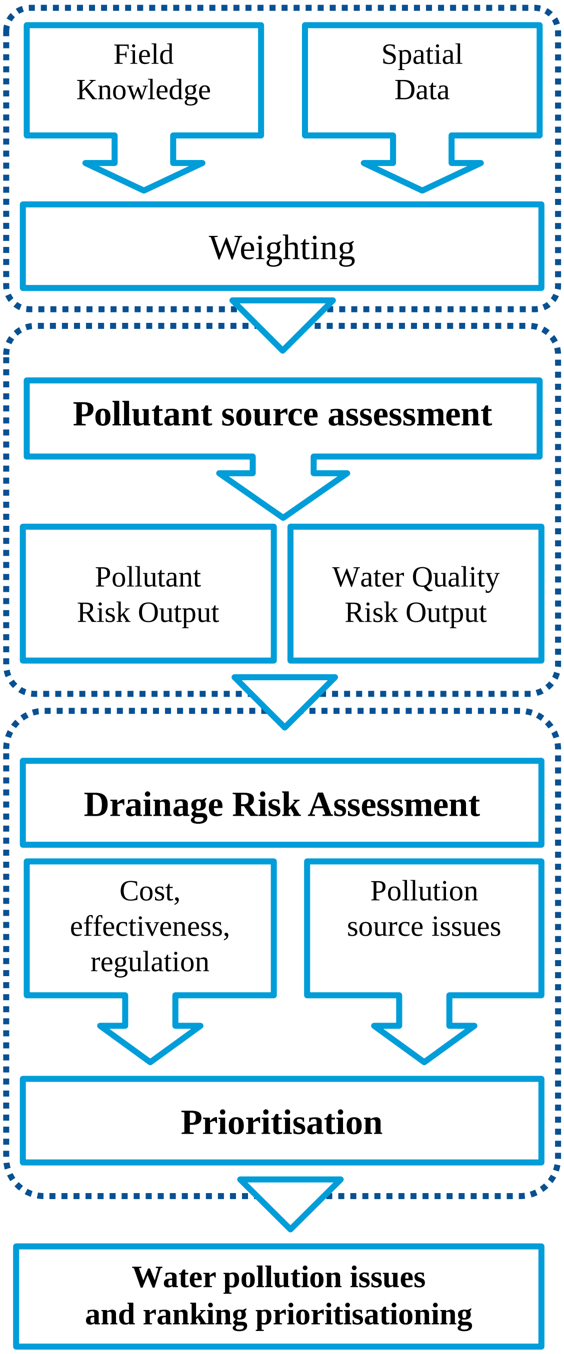

Fig. 4. WQI of Sungai Penchala from 1997 - 200

Geoprocessing model and scripting will be use to manipulate the information to generate the risk maps. The second layer cover macro level of assessment and analysis. Based on output from the second layer, an micro level assessment process will follow to estimate the cost required for maintenance, installing appropriate pollutant trap, setup a sediment pond or any related permanent infrastructure to improve the water quality. It will also consider the specific issue the pollutants and source of the pollutants. Prioritization on the techniques, methods, source of pollutants will be the output of this layer.

The last layer is an interface where the risk map and risk prioritization that considering the cost and appropriate method to improve the water quality will be presented. This layer will be very useful for the authority and also stakeholders in order to setup enforcements or activities to improve the river's water quality.

This framework will be a basis of development of River Penchal's urban catchment spatial decision support system. The new framework involving the existing activity of the community as one of the field knowledge where their role as river ranger will be more meaningful in the system.

V. Mobile Application for Field Knowledge Data Collection

A mobile application have developed in order to collect data from stakeholders. The public user, community members and/or private user can add data into the system in a form of pictures, comments, GPS coordinate, color of water, its smell and wheatear condition. Figure 5 shows the user interface of the basic reporting of the mobile application for the field knowledge data collection. The information then will be stored in a database for further analysis. Users can record the information directly to the server and users are allowed to call the authority directly if in case there is an immediate action is required such as clogged drainage system.

Fig. 5. The User Interface of the Mobile Application

These information which related to water quality indicators can be beneficial to be used to monitor water quality of the river and it will produce more meaningful information on current condition of river to the user. The information also will be used as field knowledge data for further analysis with spatial geoprocessing in the first layers of decision support system. This mobile application also can be used to increase awareness and growing sense of belonging of public as the custodian of the river to actively involved in improving water quality of the river for future generations. Some user interfaces of the mobile application are shown in Figure 6. Figure 7 shows locations of data that were collected along River Penchala.

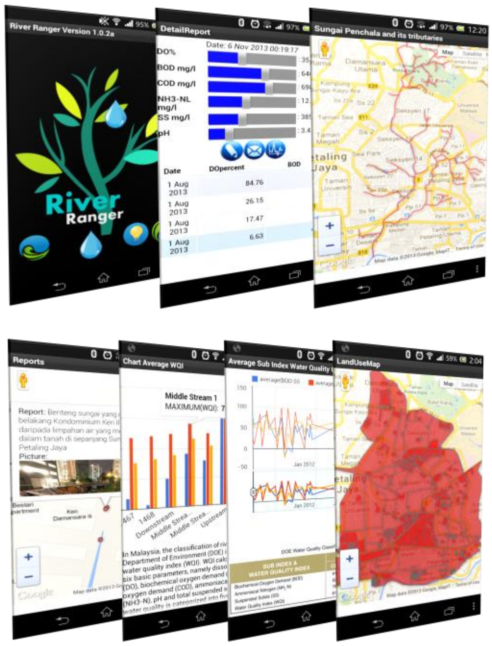

Fig. 6. The User Interface of the Mobile Application

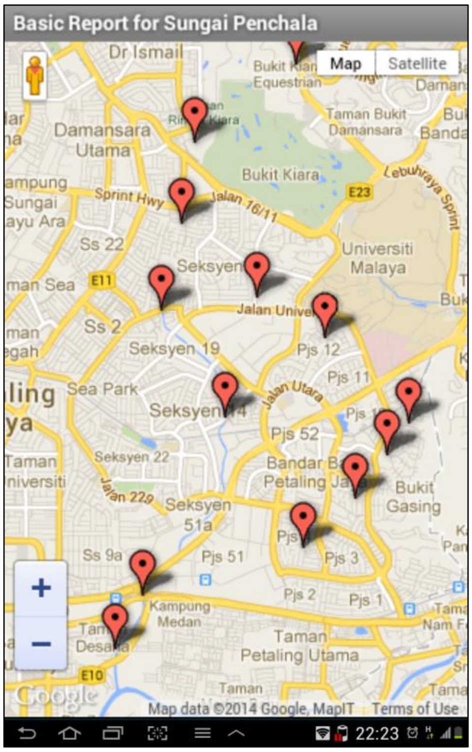

Fig. 7. Locations of recorded data

VI. Conclusion

Clean water is a major need of human being. Efforts in preserving its source, monitoring its quality to distributing to the people are involving many parties and cost to be infested can be rocketing high due to pollution problems. Everybody is a custodian of mother nature. In respect to the availability of clean water, everybody must have responsible to preserve the ecosystem along river basin. In the era of communication and cross barrier information, everybody can easily share their comments, idea and witnessing any circumstances occurred. This paper has discussed the development of framework of a decision support system and field knowledge data collection's mobile application for River Penchala an urban river in Malaysia Peninsular.

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