Environmental Degradation in Malaysia's Pahang River Basin and its Relation with River Pollution: Strategic Plan from Assessment to Mitigation using Geo-Informatics

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ABSTRACT

This is an established truth that with the growing world, the environmental degradation process cannot avoid but the technology is a solution to minimize this process. A sustainable development depends on plans, which are design on the strong basis of comprehensive datasets. Under this research studies, the required datasets were generated using remote sensing and GIS system integrated with field GPS surveys. The representations of these datasets further analyzed to ensure the data quality and output results. The objectives of the study were to find out the Pahang River pollution and environmental threats by assessing and analyzing different data layers of topographical, geological, hydrological, land cover, GPS surveys and satellite image. The methodology adopted to achieve the desired goals and to combat the complexity of the hydro-environmental system of Pahang River drawn from the idea to integrate the engineering tools with the geo-informatics techniques. This resultant output of the project enabled to develop a system of system for the existing and future development datasets in different research institutions in Malaysia for the decision makers and researchers. This hydro-environmental system is GIS-based and primarily data driven. However, it also has features, which were included to develop a strategic plan for the assessment of environmental degradation and its mitigation measures by focusing on the concept of sustainable healthy river for future generations and environment friendly development activities in the watershed area of the Pahang River. The planed roadmap for response functions is the salient feature of this research study, which consists of quantitative and qualitative relationships that help to the decision makers to make it understand how changes in the state of environment and river water will take part in the mitigation process for the environment degradation process.

Keywords:
Environmental degradation, Pahang River, River Pollution, Strategic Plan, Pollution Assessment, Mitigation Plan, Geo-Informatics

1. INTRODUCTION

This study mainly proposes a plan and highlights how important it is to make a sustainable use of Pahang River Basin natural resources in order to ensure the water requirements for its water supplying functions. It is paramount to consider the environmental aspects related to Pahang River

Basin management as under a project its raw water will be transfer from Pahang state to Selangor State, Kuala Lumpur and Putra Jaya for water supply purposes. This plan will be to complete by 2013 as proposed in the Ninth Malaysia Plan (2006-2010). The Pahang River basin is facing problems of population growth, high siltation and pollution. This fact draws attention toward the threat of polluted drinking water as its water planned to fulfill the domestic needs. Hence, an authentic and strategic plan is needed which requires to involve all the stakeholders to address the aforementioned issue.

Managing river basins through the involvement of all stakeholders is not a new subject, and now this kind of management is a well-established and effective approach towards a cooperative manner to ensure the sustainable management of river basins resources [1]. The watershed area of Pahang River is 25,600 km^2 and its urban areas are facing challenges of ecosystem disturbance. Technically speaking, rivers of Malaysia are considered with low sediment yield but human development activities are causing an increase to the sediment load in rivers. As a result, 80% of the total suspended sediment load is generated from human activities [2]. Local agencies despite of low human resources are important to handle environmental aspects at urban levels [3]. Moreover, other stakeholders such as International agencies and industries have now started sharing their role environmental protection and management, a fact which constitutes a positive paradigm shift.

1.1. Rational of Research and Study Area

Malaysia has setup a national development plan, called "Vision 2020" and Malaysia will conserve and manage its water resources to ensure adequate and safe water for all including the environment. In support of this vision the country will conserve and manage its water resources to ensure adequate and safe water for all including environmental protection. Such is the Malaysian vision for water in the 21st century, with the key objectives of the vision being Water for people, Water for food and rural development, Water for economic development and Water for the environment. In this context, a framework has been setup that will assess the water resources of Malaysia, make a geographically referenced estimation of future water needs, and ensure the sustainable use of water. The theme of this research study cannot directly achieve the desired goals of the Malaysian vision, but it will offer a tool to assist the decision makers at governmental and research levels through consultation of the geo-database of hydro-environment, which is the product of this research study.

The study area of Pahang River basin is located in the eastern part of Malaysia. The Pahang River has main two tributaries Jelai River and Tembeling River, which join with the main Pahang River at Kuala Tembeling. The Pahang river system begins to flow in the southeast and finally passing through Pekan town near the coast it falls into the South China Sea. The basic characteristic of the study area are given in table 1 [4].

Table 1. Basic features of Pahang River

River characteristics	**Description**
Location	N 2° 48' 45" - 3° 40' 24, E 101° 16' 31" - 103° 29' 34
Catchment Area	25,600 km^2
Main geological features	Shale, Mudstone, Limestone and rook
Main tributaries	Tembeling river (5,050 km^2), Jelai river (7,320 km^2)
Main reservoirs:	Southern Abu Bakar Dam of TNB, Chini Lake and Bera Lake
Mean annual precipitation	2,170 mm
Land use:	Virgin jungle, Rubber, Paddy, Oil palm, agricultural crops, Urban

Fig.1. Panoramic view of the Pahang River at Pekan

The stream network, sub-basins, overlay of Pahang basin over Digital Elevation Model (DEM) and rainfall pattern are shown in fig. 2 [5].

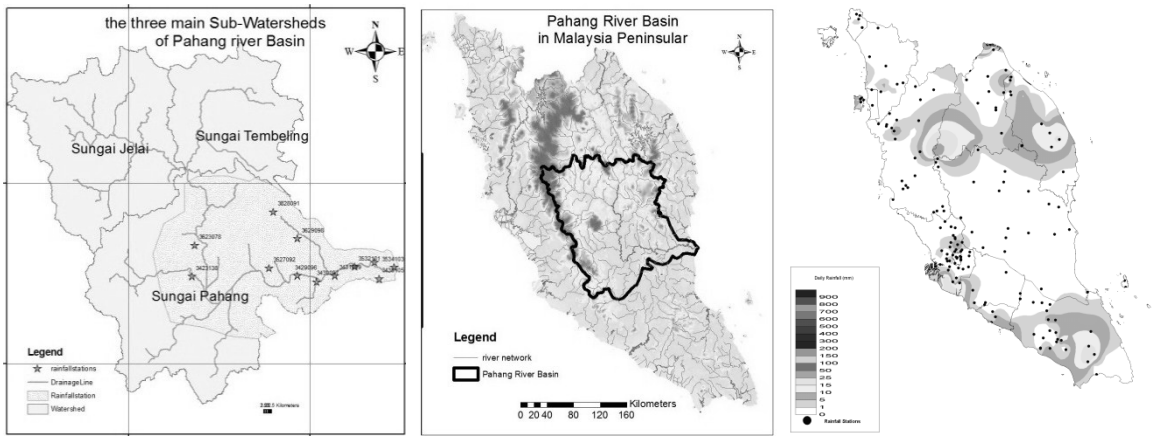


Fig.2. Pahang River sub-basins and rainfall pattern

1.1.1. Malaysia development and role of riverine waters

The development of the country is an ongoing process interconnecting to economic parameters. Water resources consider as a hub to uplift and gear up growth of economy of any country. Hence, Pahang River is not only a source of water but also a source to ensure the economic development of the country, which should carried on in a sustainable manner. To meet this objective, it is of utmost importance that all stakeholders contribute as a joint venture with the government towards an effective and sustainable management of river basins in Malaysia.

1.2. Factors causing Environmental degradation

The natural resources of Malaysia have continuously exploited through massive land reclamation and development for livestock production, uncontrolled discharge of industrial and domestic wastes, and energy development projects. These activities are the root cause for land-based and sea-based pollution phenomena that have now reached a serious level [6].

River water pollution is a great concern all over the world. This pollution is a result of environmentally degrading activities, which directly affect the river water quality. In Malaysia, the

main sources of chemical, organic, and thermal water pollution are the effluents of palm oil industry, percolation of uncontrolled solid waste disposals and untreated wastewaters of human settlements. A study conducted by the Department of Environment (DOE) on 120 rivers in 2001 found that 13 rivers (10.8 %) were seriously polluted while 47 rivers (39.2 %) were slightly polluted based on Water Quality Index (WQI). The WQI serves as the basis for environment assessment of a water body in relation to pollution load categorization and designation of classes of beneficial uses as provided under the National Water Quality Standards for Malaysia (NWQS).

1.3. Pahang River Flow Trend

The discharge data of Pahang River collected for average monthly and average annual shows the flow trend as shown in fig. 3 & 4 respectively. Average monthly flow showed that peak flow period starts from January and continued to December, period which corresponds to the seasonal peak in rainfall precipitation. Besides contributing to the pollutant transport, rainfall also affects the pollution load by accelerating the soil erosion phenomenon.

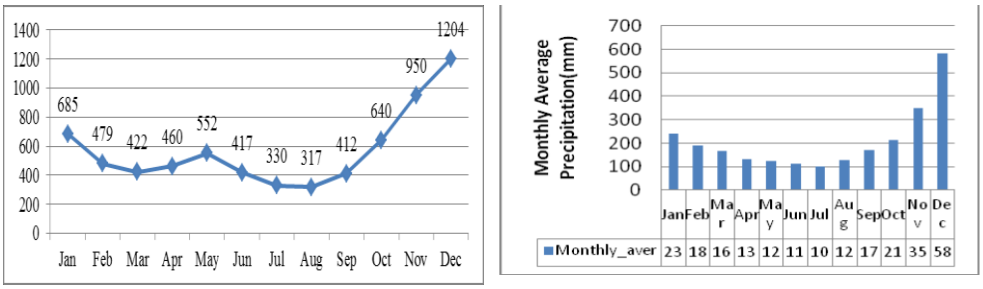


Fig.3. Average monthly flow & Precipitation of Pahang River at Lubuk Paku (1972-2008)

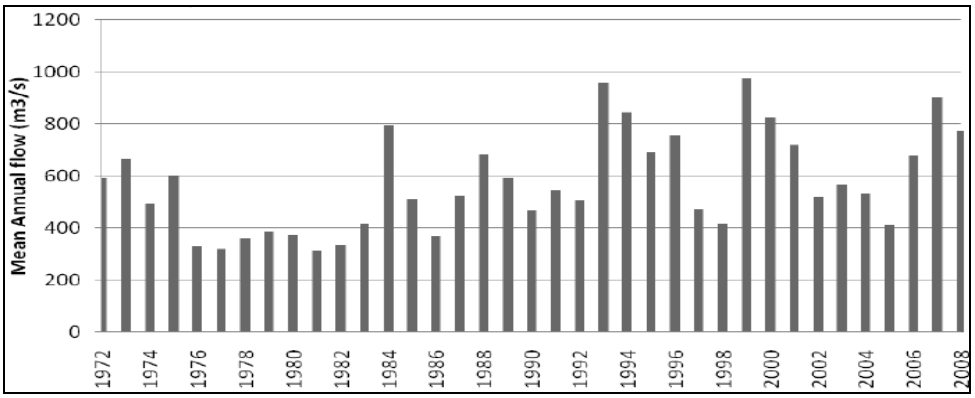


Fig.4. Mean annual flow of Pahang River at Lubuk Paku (1972-2008)

2. PROCEDURAL APPROACH

The procedure for achieving the goals of study has involved three steps: the first step consisted of collection and preparation of hydro-environmental datasets. As second step, these datasets were embedded in geo-database by using Arc GIS 10 to develop a template. Under this step, data review and verification was done by adopting the steps as provided by WMO's "Guide to Hydrological Practices", [7]. In the third and last step, different scenarios for identification of critical sites for environmental pollution sources and their

link with river water quality by using different sets of analysis combinations are planned. These steps of procedural approach are provided in fig. 5.

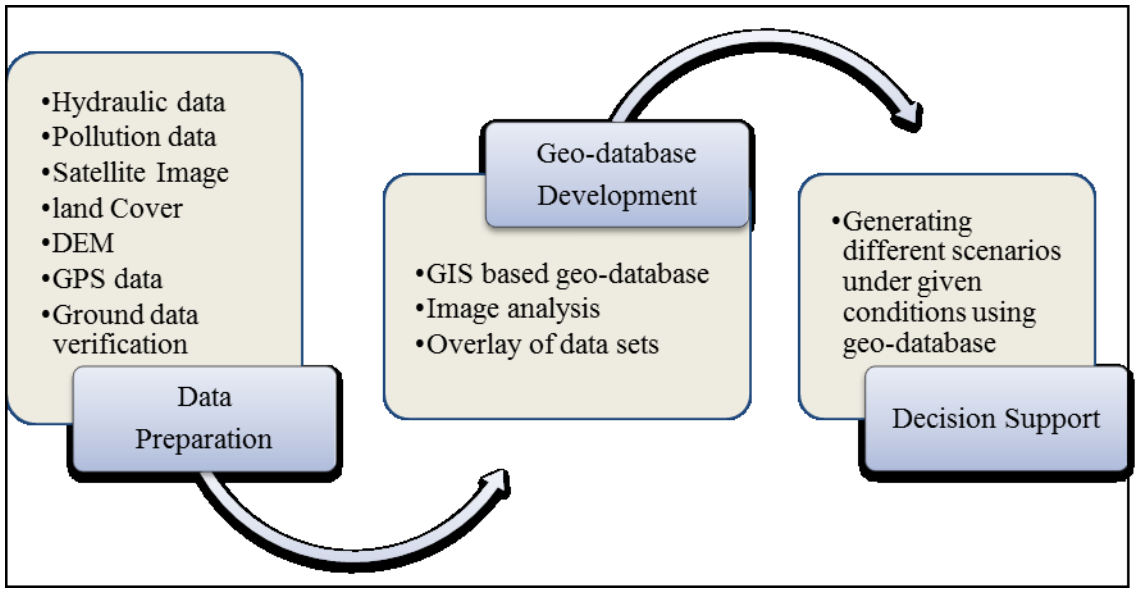


Fig.5. Procedural approach to develop hydro-environmental geo-database

3. RIVER BASIN SYSTEM ANALYSIS

In order to get the hydro-environmental parameters necessary to the geo-database development, the river basin system can be analyze keeping in mind the objectives of the geo-database to use it as a support tool towards initiation of the strategic development plan. The inventory for the hydro-environmental geo-database will consider under given aspects:

- Relation between environmental degradation and sustainable development
- River pollution factors and environmental threats
- Geo-database as a support tool towards initiation of the strategic development plan
- Salient features of Hydro-Environmental system
- A Roadmap for response action
- Mitigation plan for the Environmental degradation

To answer these questions, the developed geo-database can be used to view the different scenarios for pollution and land cover change based on time series and to compare different results under different boundary conditions. This analysis was the base to initiate the strategic development plan the performed analysis, which was the main goal of this study, would constitute the base to initiate the strategic development plan in the framework of the Vision 2020.

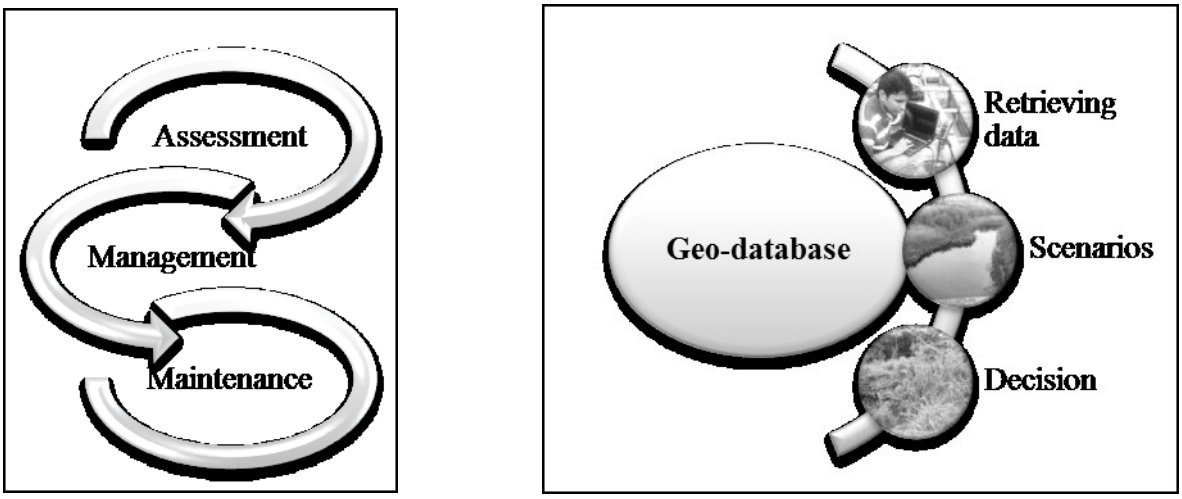
4. RESULTS AND DISCUSSION

5.1. Strategic Plan: Assessment and Mitigation

The development of strategic plan was a complex stage in this study. This strategic plan is based on the output results from the hydro-environmental geo-database and expert opinion. On the other

hands, the modeling approach is another option. Yongming et al. [8] established a water quality model for river system to estimate decay rate of biochemical oxygen demand (BOD) and dissolved oxygen (DO) as observed in river water. This was an approach based on model to estimate the quantitative results for environmental degrading parameters. Gregersen et al. [8] suggested some preventive measures which include implementation of holistic environmental management, public education, efficient pollution control through research efforts and the acquisition of clean technology to achieve desired level of pollution abatement.

The procedural steps for the preparation of assessment and mitigation are shown in fig. 6 (a,b). In fig. 6 (a), this is the key to develop a roadmap for the final plan and in fig. 6 (b) this is the methodology to get help from the developed system to take the decision for mitigation.



a. b.

Fig. 6(a, b). Procedural steps for the preparation of assessment and mitigation

The procedural approach as compare to adoptive management process for watershed management as described by Gregersen et al. [8] is shown in fig. 7. Matrix analysis method was considered easy [10] but this method is descriptive and for comparison analysis it is difficult to generate accurate scenario. The advantage of procedural approach over those two is that this system was proved to be flexible and it provided different scenarios and accordingly changes can be adopted in the applied plan.

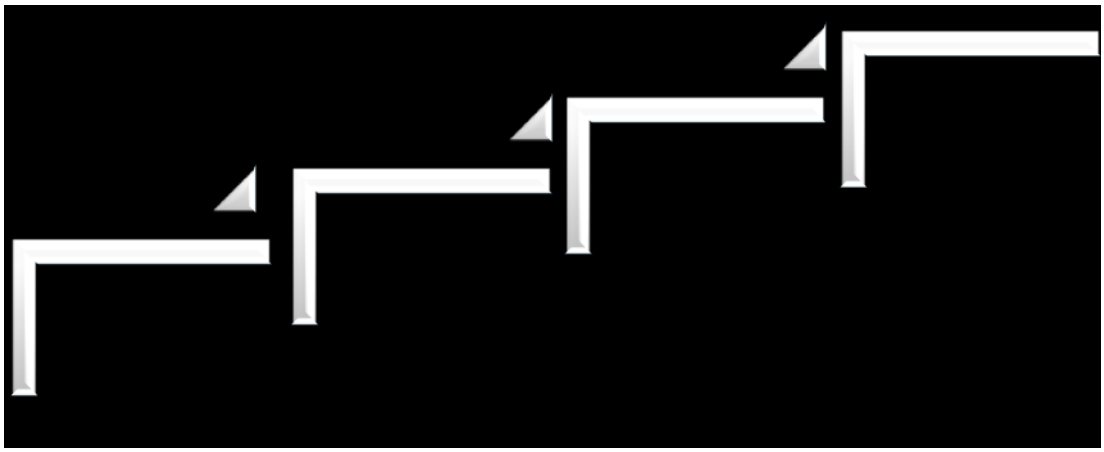


Fig.7. Steps for Adaptive management process for watershed management

5.2. Hydro-Environmental Geo-Database

The quality of water in rivers and other water bodies receiving runoff is the result of a complex mix of natural and human influenced processes [11]. Due to the complexity of the system, this study was not able to separate anthropogenic and natural sources of pollution and their impacts on the riverine ecosystem and the ecosystem services it provides. However, the results for time series pollution change and identification of critical areas acting as point source of pollution can be extracted by using the template database by considering these two kinds of activities as one unit. The fig. 8 (a, b) shows the screenshot from the developed hydro-environmental geo-database in Global Mapper (software) environment. This was used to overlay different time series images to analyze the water pollution and land cover changes which occurred for different time of year. Under this study, the developed database was generated as a template that can be updated with new datasets for improved and updated scenarios and results.

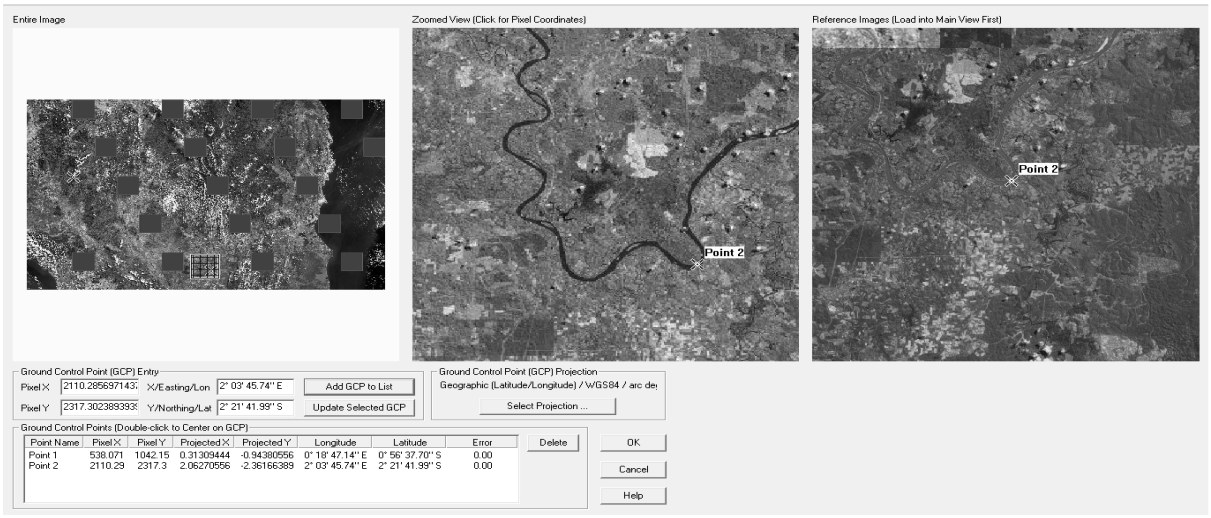


Fig.8 (a). Overlaying of satellite images for time series changes

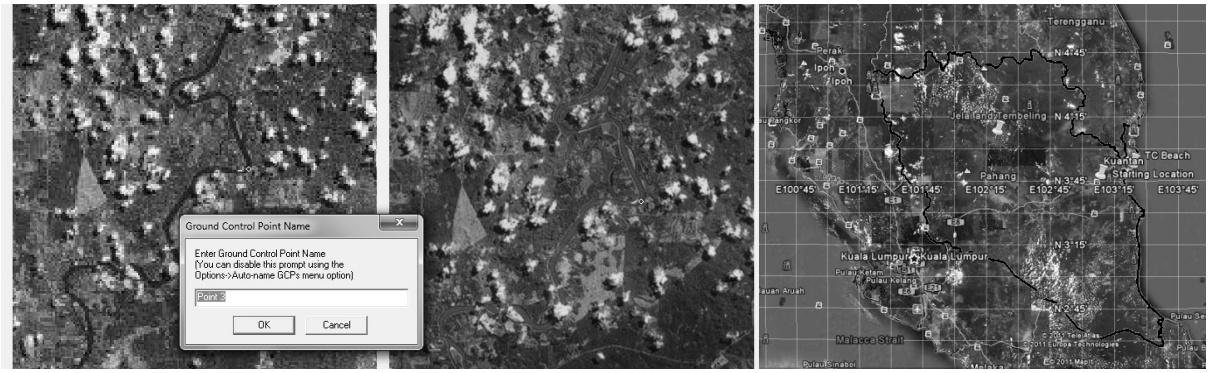


Fig.8 (b). Overlaying of satellite images for time series changes

6. CONCLUSIONS

The most cost effective approach for water quality protection in a watershed is to identify the source of pollution and to develop an implementation plan to eliminate or mitigate those critical sources [12]. This study has adopted this idea which is cost effective and rapid mitigation to handle the environmental degradation phenomenon. According to Matishov [13], river water pollution is a

natural phenomenon to which statistic and balance models of water dynamics and geochemical processes can be applied; however, under this study these models were not used rather a roadmap to develop a strategic plan for implementation by using geo-database was generated which will help for accelerating response action. The roadmap for the future to make best utilization of this database is to use high resolution datasets of imagery and quality field based surveys for river water quality.

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