DECISION SUPPORT SYSTEM DEVELOPMENT THROUGH GIS FOR COMPUTER AIDED RIVER MANAGEMENT AND ENHANCED AGRICULTURAL PRODUCTIVITY

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Abstract

Managing river is an acute and more attentive area where it faces heavy water feeds due to rains and problems of sedimentation caused by high sloped terrain in catchment. Pahang River is an example of such situation which receives heavy runoff generated through 220 mm average monthly rainfall. Malaysia is going on fast track of development including infrastructural developments and change of land uses from forest cover to other non-green land uses. Keeping in view this fact, the vulnerability which may cause due to floods in Pahang River seems to be a threat for the sustainable development of the area. The study has main objectives of to find out possible technology tools for the fine tuning of existing computer aided river management system (CARM) with a priority of healthy growth of the country with minimized threats of flood disasters. Learning lessons from Australia which itself under the process to adopt computer aided river management, is discussed as an example of improved river management with an investigation of adaptive implementation of modified system for Pahang River in Malaysia. This, on-going study, has presented that if modified CARM is implemented, the risk of flood disasters not only can be reduced but also river water availability for various sectors including agriculture, food industry would be more sustainable. Possible ways of actions for the adaptive implementation of CARM system are identified with key role of all stakeholders. This analysed investigation has demonstrated a satisfactory estimated system performance so that it can provide more management options for flood control while its adaptation is in the benefit of the country. To comply with datasets requirements for intelligent decision making for plans, a variety of datasets were generated using remote sensing and GIS system, integrated with field held GPS aided surveys. The representations of these datasets further analyzed to ensure the input data quality and reliability of output results. The resultant outputs, in the form of unlike decision options, generated under different set of criteria, would be utilized as a helping tool in the process of decision making for river management and to develop a fine tuned system for development plans in relevant research/operational institutions of Malaysia, especially Department of Irrigation and Drainage

***Key Words**: flood mitigation, computer aided river management, geodatabase, GIS, flood disaster, decision support system*

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1. INTRODUCTION

History shows that Pahang River has been facing problems of floods in different sub basins causing losses of life and property. Reasons for those floods were due to improper implementation of hydrology practices for river management moreover infrastructural and industrial activities causing deforestation and un-planned land use as described by Tekolla [1]. Pahang River drains off water from the inundated area of Pahang Basin to the South China Sea during wet season caused by the northeast monsoon its management is a challenging task. This challenge becomes substantial due to extreme rainfall (220 mm average monthly) which is main source for overflowing of Pahang River resulting flood events in Pahang River Basin [2]. Keeping in view the fact that vulnerability which may cause due to floods in Pahang River seems to be a threat for the sustainable development of the area. This was major motive to explore technology dimensions for improved river management. This study has examined different available tools and techniques which can be proved to be more sophisticated and time efficient.

1.1 CARM project

Australia's Computer Aided River Management Project (CARM) (see Fig. 1) costing $65 million for Murrumbidgee River is an up gradation of infrastructure and operational processes which provides opportunity to investigate new methods of water measurement, integration of real time data for improved operations of river management to minimize wastage [3]. This paper discusses the factors which need to improve and to consider as a part of CARM system development for Pahang River, taking an example of best practice adopted by Australia. The difference is that concept of CARM is discussed under local circumstances and challenges.

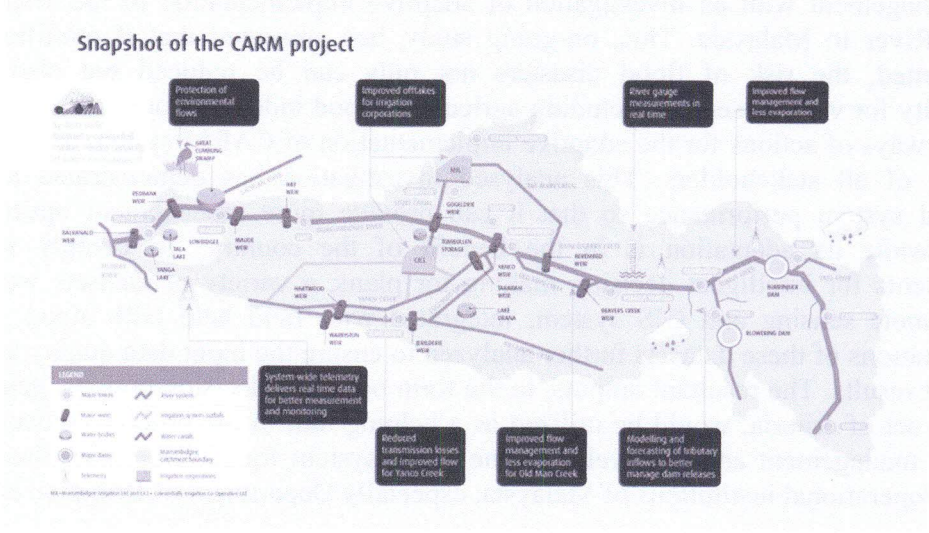

Fig 1: Australia's CARM project and its components, Source [4]

2. CHALLENGES FACED BY RIVER

Challenges faced by Pahang River include water quality, floods and flood related impacts of soil erosion and heavy sedimentation.

2.1 Flood monitor and early warning

Improved monitoring of river flows and optimized water use in the basin to draw maximum potential from river water are desired objectives. Otherwise poor monitoring and improper water usage will cause to increase the dangers of floods. Damages can be reduced at its maximum if alerts for dangers propagate timely and quick response to combat the flood situation through rehabilitation and evacuation plans. Isochrones maps (map showing water travel time in a given stream) and flood zone maps can be digitally combined to identify the safe places and response time. How we can adopt this kind of strategy? The answer to this is the adaptation of Computer aided River Management (CARM) system for Pahang River. The feasibility for its implementation required sound hydrology study and development of technology infrastructure.

2.2 Watershed management

The subject of watershed management is broader, here in this study discussion includes hydro-informatics tools which can help to understand the river flow phenomenon and to develop different scenarios to made decision for best options during the hours of calamity. Decision taking in case of Pahang River is suggested by the concerned authorities under the consultation of field experts having good command over CARM, in other cases for example Red River Basin, public demanded its participation in making decisions for flood management at both of local and watershed scales. This kind of situation may arise due to social conflicts with the government bodies and managers would have to face more crucial state. It can be concluded that public consultations in the basin will result conflicts among social, and damages to environmental values associated with flooding [5].

2.3 River water quality

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 [6]. The threat of deteriorated river water quality is associated with the human activities and then propagation of these pollution agents through rainfall runoff or due to direct diversion of effluents in the river. Water pollution model and its integration with CARM will open new horizons of improved river management system.

1.4 Sedimentation and soil erosion

Factors contributing to floods include, sedimentation, surface sealing due to urbanization, deforestation and increase run-off [7]. Danger of flood increases due to deposition of sedimentation in the bed of river and this sedimentation is mainly caused due to soil erosion as shown in Fig. 2.

Fig 2. Siltation in river due to heavy soil erosion

The siltation along with other contaminants such as ammonia-N also caused to pollute Chini Lake due to strong river current from Pahang River which surge into the lake through Chini River during monsoon season as reported by Othman [8]. This indicates that siltation control must be an important part of river management strategy. CARM system provides integrating opportunities for models related to siltation.

2. CARM PLATFORM DESIGN

In case of Australia CARM can use existing and new monitoring data, including rainfall measurements and forecasts, river flows and levels and these can be used in hydrodynamic river simulation model through DHI's software "MIKE 11". Real time water level and flow measurements are prominent features for automatic update for model input data to demonstrate real river behavior [9]. Similarly CARM system development through locally modified simulation model and improved real time monitoring network will be a breakthrough in Malaysia and prove to be an example of best practice. Real time measurements and accordingly optimized operations of river management are elaborated in Fig. 3.

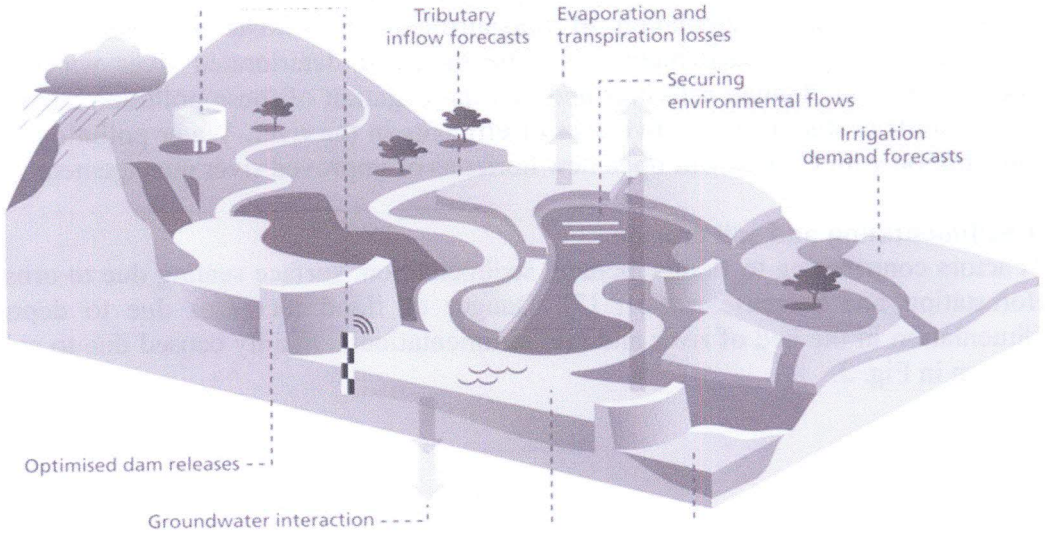

Fig.3. Real time measurements to optimize river operations, Source: [10]

2.1 CARM adaptation and benefits

Possible ways of action for the implications of computer aided river management are identified by [11] and describe that ssimulate all significant tributary inflows below the headwater storages, make full use of existing and new monitoring data, including rainfall measures and forecasts, river flows and levels.

3. BIG WATER MANAGING SYSTEM

Pahang River is big water and it is essential to take advantage of technology tools to develop and implement its improved and computer aided management system. In this study review of Australia's CARM project is a special source of guide lines providing clues to improve existing management system and hydro-infrastructure. Keeping close eyes on the development process of Australia's CARM project, an attempt was made to develop Geodatabase for Pahang River. The future works for the same objective includes integration of models with this Geodatabase with expected output of intelligent decision support system for Pahang River basin. The role of this system will be like computer aided river management system with enhanced features of decision making. Summary of developed geodatabase system for Pahang River basin is provided under following sub titles.

3.1 Efficient water use techniques

In scenario of future demands for the development of CARM system for Pahang River can be judged through role played by Pahang River water. Pahang River plays active roles to the industry and community daily life as Pahang River delivers more than 120 mld of water, via the Public Works Department to meet the demand of domestic and industrial sectors, particularly in urban regions and it also provides water resources to the community and also agriculture industry particularly paddy [12]. Efficient water use techniques guarantee sustainable management of river assets, it is also obvious that technology based improvement in the system requires investment. Malaysia has advantage in the sense of investment as it Wing [13] reported that the cost for future river improvement and flood mitigation works in Malaysia for the next 15 years will amount to some RM17 billion. Under this big budget to manage big water of whole Malaysia particularly Pahang River is a bright side of the picture to secure the natural resources for future generations.

3.2 Geodatabase for Pahang River basin

The geodatabase for Pahang River basin consists of satellite imagery, digitial elevation model, land use map, geological map, and GPS surveys conducted to investigaste on site salient features of river. The advantage of this geodatabse which is developed using Arc GIS, is that it can be integrated with models of river hydrology to generate updated mapping and quick analysis to develop a sense of optimised solution during any desaster related to flood. Some of maps (see Fig. 4, 5 &6) generated using geodatabase, showing geological features, overlay of GPS survey over satellite image and land use map of Pahang river basin are provided as under.

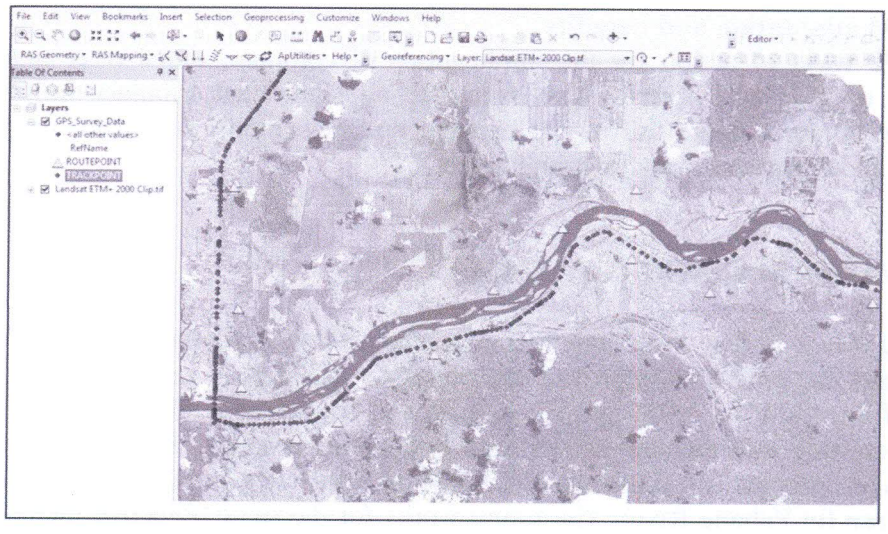

Fig. 4: Real time overlay of GPS survay over satellite image

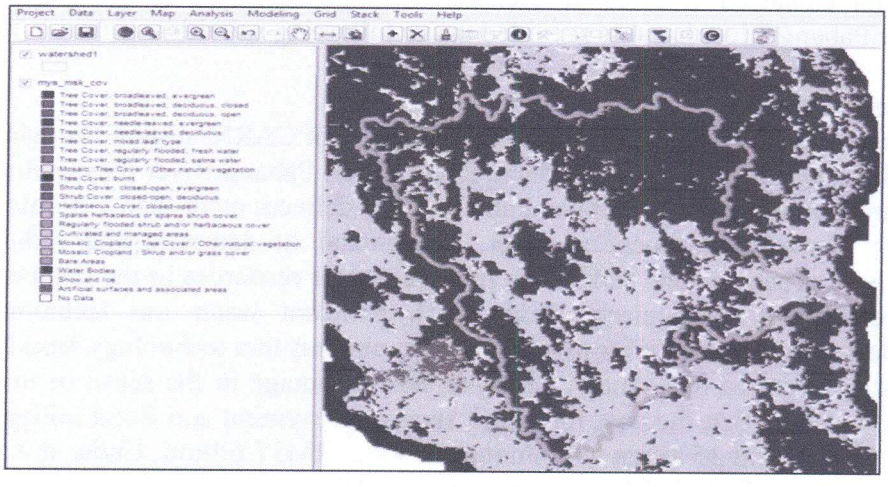

Fig. 5: Land use map for Pahang River basin

Under this study an attempt has been made to develop a geodatabase (under Malaysian Standard for Geographic Information / Geomatics - MS 1759) for Pahang River Basin (PRB) having layers of land use, topographic map, satellite image, flood prone areas, geological features, stream network, GPS survey data, road network and many other relevant data layers. Further work on modified models for better forecasting under real time data input and design of innovative self-protecting flood mitigation at industrial and house hold level is under development. Figure 6 (a, b & c) demonstrate salient features of developed PRB Geodatabase.

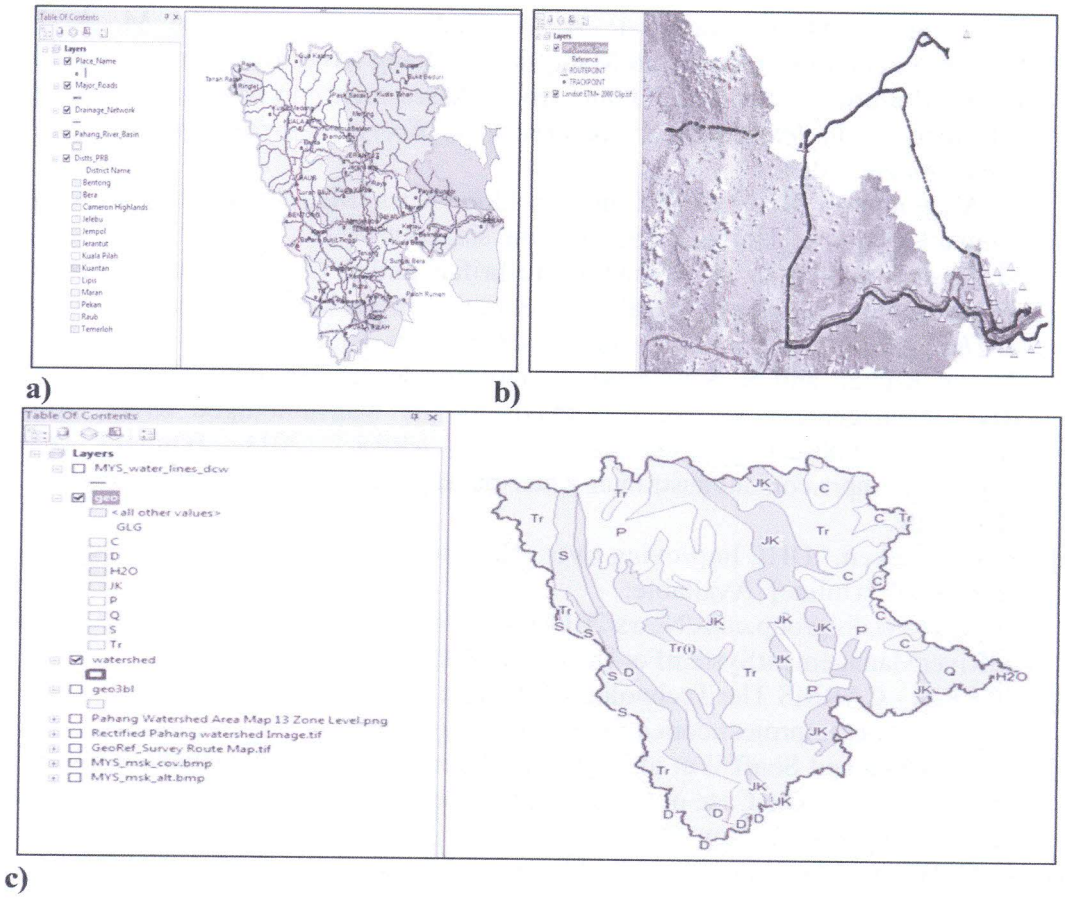

Figure 6: a) Stream Network of PRB, b) Real time GPS aided survey to upgrade geodatabase, c) geological features within PRB

4. CONCLUSION

Pahang river management is not only a vital source of water but also an agent to take part for economic activities of area. Investing and adopting computer aided river management is demand based need. The feasibility to implement CARM for Pahang River is viable and can be achieved through mutual efforts of all stallholders and researcher community. This study imitated research part of CARM implication by developing geodatabase. Future works as next phase of this study will be carried out on hydrology model development and its integration with improved wireless monitoring network of Pahang River.

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