A GIS Approach in Evaluation of Metropolitan Green Area: A Case of Sungai Pulai Wetland

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Abstract

Wetlands are among the most important ecosystems on Earth as it improve water quality, control floods, regulate global carbon levels, have significant cultural and recreational values, and also provide habitat for plants and animals uniquely adapted to living in the wet conditions. However, through progressive management, wetlands have been modified from their natural state by the influence of man. Chapter 22 in the 9th Malaysian Plan cater for environmental resource protection which shows the government's concern on environmental aspect in the future development. Therefore, any type of development planning in wetland areas should present serious consideration on planning guidelines as well as elements that may possibly threaten the natural condition in order to conserve the environmental and ecological attributes of the wetlands for the benefit of future. One of the basic problems in planning for the management of mangrove and other natural resources is to correctly evaluate the environmental, economic, legal and social issues existing on the resource. As integrating all these datasets required for wetland and mangrove management is usually difficult, there is a need for an approach to speedily identify the types of suitable development. A study on Ramsar area involving Sungai Pulai in the state of Johor was done using the GIS application, with emphasis on sustainable wetland issues. This paper will discuss the appropriate wetland management guidelines and suitable tourism activities for these areas as identified in the study based on the use of the multi criteria analysis approach.

1.0 INTRODUCTION

Due to pressures from new development both in urban fringes and urban centres, urban green and open spaces are seen to be rapidly declining in term of allocated spaces and quality. Without careful urban land use planning, urban green and open spaces will be filled with residential and commercial buildings to cater for rapid development growth. Therefore, there is a need for proper planning control to ensure that the provisions of green spaces are adequately being conserved for current and future generations.

This paper demonstrates that GIS can be an effective tool in preserving and monitoring green and open spaces in an urban area. The study was approached from the aspect of natural resources management and eco-tourism development potential using GIS.

2.0 THE IMPORTANCE OF URBAN GREEN

It is well recognized that green area plays a crucial role in improving urban environment, such as preserving water and soil, controlling temperature and humidity of air, preventing pollution, flood prevention, functioning as buffers between incompatible land uses, preserving natural habitat, and providing space for recreation and relaxation. Therefore, development should be sustainable and be focused on previously developed land, while protecting and enhancing urban green and environmental assets.

The expansion of the city due to pressures for new development within the city and urban fringes have systematically seized the limited green area available. In effect there is a decline in the urban eco-environment. Nevertheless, with increasing public awareness, there is a growing concern about the

impact of urban green declining within and near the city, and the importance to preserve and value the green area.

2.1 The Sungai Pulai Wetland

Wetlands occupy about six per cent of the Earth's land surface. They vary according to their origin, geographical location, water regime, chemistry and dominant plants, and they usually sustained by water sources other than direct rainfall.

The Sungai Pulai Forest Reserve, Pulau Kukup and Tanjung Piai State Park are rich with natural resources. These areas have been declared RAMSAR site on 31st January 2003. These areas which constitute the only protected mangrove areas in the South-West Johor region provides 35% of the total mangrove cover (including the gazetted Sungai Pulai waterways) for the state of Johor. Their significance include in terms of ecological functions such as retention, nutrient retention, toxicant removal and micro-climate stabilization (hydrological, nutrient and material cycles and energy flows of mangroves); reserve of economically viable wetland products like forest resources, fisheries and energy resources (firewood); direct functions such as coastal protection from natural forces (strong wind and sea currents), water transport, recreation and tourism, research and education; and qualities as a support for spectacular biological diversity (flora and fauna), provider of critical habitats in the life-cycles of notable flora and fauna (e.g fish, birds) and as a unique living heritage for future generations to savour.

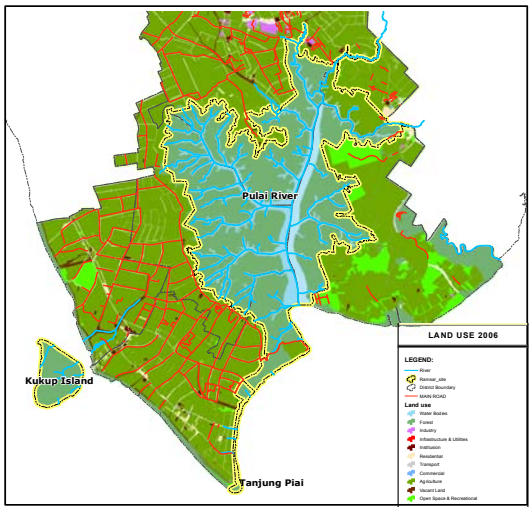

Figure 1: Current Land use

The Sungai Pulai wetlands which are occupied largely by Sungai Pulai Main Forest Reserve consist of mangrove, intertidal mudflats, sea grass bed and fresh water riverine forest. Sungai Pulai remains as the largest intact block of mangrove forest in Johor and the largest remaining intact riverine mangrove area in Peninsular Malaysia. Sungai Pulai wetlands form the district boundary between the mangrove forest located in Pontian and Johor Bahru. The Pulai River itself is of major ecological importance because of its continuous input of fresh water into the upper reaches of Sungai Pulai estuary.

2.2 The Need for Metropolitan Development Control

Metropolitan characteristics were recognized by its rapid development and population growth with high density population, massive building construction, fully equipped with modern facilities and services, infrastructures, road networks, etc. The development of metropolis is induced by the pressures within the city and sprawl outside the territory due to large migration and force of development.

Sungai Pulai wetland is considered to be part of the South Johor Economic Region development. While its surrounding area is undergoing the process of metropolisation, the Sungai Pulai wetland area holds much potential in the tourism industry. The metropolitan region will soon be exposed to urbanization problems such as urban sprawl and scattered development, land use conflicts, land shortage, inevitable high land prices and the degradation of environmental quality if due measures are not being taken. The urban sprawl, for instance, if not well countered for would promote more problems and issues. Much of the original forest cover has the potential of being replaced by urban

land use due to influence by the urbanisation process which consequently led to forced and pressured development to further cater for the urban needs.

With its associated sea grass beds, intertidal mudflats and inland freshwater riverine forest, Sungai Pulai which is the largest riverine mangrove system in Johor State located at the estuary of the Sungai Pulai river represents one of the best examples of a lowland tropical river basin, supporting a rich biodiversity dependent on mangrove. The site fringes play a significant role in shoreline stabilization and severe flood prevention in the adjacent 38 villages. The local population depends on the estuary as its mudflats, an ideal feeding, spawning and fattening ground; support a significant proportion of fish species. Other mangrove uses include wood cutting, charcoal production, aquaculture activities and eco-tourism (Ramsar Convention on Wetlands, 2003).

Although the site had been gazetted as State Forest Reserve and declared as World's 1288th Ramsar site *(Ramsar Convention on Wetlands, 2003)*, vulnerability of wetland area characteristics to changes especially due to the surrounding development has become an immense concern. All the same, there is a need for a mechanism to facilitate development planning and monitoring toward sustainable metropolitan development. This is to ensure that the original forest cover will not be replaced by urban land use, exposed to surface erosion and finally resulting in increased incidence of geohazards such as flash floods. Also, among the main current and future issues of the area to be given serious consideration include erosion, sedimentation, pollution, new development, deforestation and extinction of wildlife. Therefore, support of an information system is particularly important for strategic planning at macro level and local planning at the micro level.

3.0 MANAGEMENT PLAN FOR SUNGAI PULAI WETLAND

One of the basic problems in planning for the management of mangrove and other natural resources is to correctly evaluate the environmental, economic, legal and social issues existing within the resources. As integrating all the relevant datasets required for wetland and mangrove management is usually difficult, there is a need for an approach to speedily identify the types of suitable development for the area.

A preliminary study was undertaken using a GIS spatial analysis approach in the attempt to identify current development in the area as well as its surrounding area that has given impact/threat upon wetland's resources and habitat. Several scenarios were developed to determine suitable wetland management guidelines for the area and how the natural resources will be managed. The study had also identified potential areas for tourism development.

3.1 GIS Database Development

Information in spatial and aspatial type will assist Johor State Park in managing current information and view it for management, tourism and also part of education and research resources as well as for monitoring and planning purposes.

The GIS database components developed for this study include Site and Administrative Boundaries, Physical and Bio-physical elements (flora and fauna layers), Planning and Legislative elements, Hydrology (water bodies, river reserve and river), Environmental Quality and Resources, Tourism (recreational activity, tourism facilities, and tourism resources), Transportation (road and seaport), Socio-economy and Local Community, and Infrastructure and Utility (electrical line reserve, telecommunication, water supply, sewerage and waste disposal).

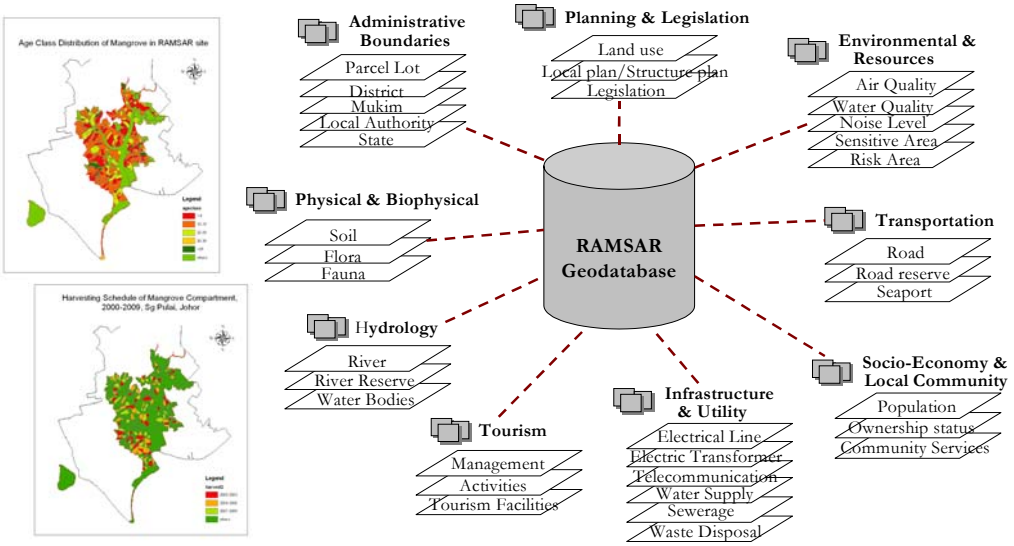

Figure 2: GIS database structure and part of the fauna layers

3.2 Identification of Spatial Management Guidelines for Sungai Pulai

The identification of management plans for the area was approached by three management scenarios namely preservation, conservation and development. Although the same analysis model is used to formulate each of the three wetland's management scenarios, different approach and objective were deployed to produce the conservation, development and preservation management plan. The underlying rational for each of the three scenarios was different and so the criteria requirements for executing the scenarios slightly differed. The analyses were supported by ArcGIS 9.0 and "What if?" software which made use of the multi criteria analysis approach.

Table 1: Criteria and sub criteria for the analyses

Objective	Criteria	Sub criteria
To determine conservation area. (Determine the specific area / highly risk area possibility affected by the land use activities so as the area could be conserved)	Inside risk area concerned with human activities.	• Inside major land use activities area • Inside risk area • Inside polluted area • Inside and near to the committed development area
	Species critically threatened.	Priority to: • Threatened species • Young generation mangrove tree • Newly logged
To determine preservation area.	Area that has an establish wetland species	• Matured mangrove tree • Dense canopy
	Critically threatened Species	• Within endangered species area
	Untouchable area	• Inside water catchment area • River reserves • Any reserved area under provision of legislation
To determine suitable area for development in the wetland area while minimizing the impact of development activities.	Outside the constraint area.	• Outside erosion area • Outside reserved area • Outside water catchments area
	Within existing/ committed development	• Within /surrounding existing development
	Available area based on wetland characteristics.	• Hazard area

i. Preservation Management Plan

Preservation is a protection of ecologically important wetlands or other aquatic resources in perpetuity through the implementation of appropriate legal and physical mechanisms. Sites with major impacts will generally not be accepted as suitable preservation sites although they may be valuable as restoration sites (Guidelines for Siting Preservation Mitigation Banks, 1998). In this study, four categories for management purpose has been identified as below:

1. ***Not recommended*** – involves area with low sensitivity thus development is more preferable to conservation.
2. ***Recommended*** – Sites with several impacts of development and degradation of environmental quality value.
3. ***Moderately recommended*** – under protection as it still contains diverse species and is important for maintaining wetland function.
4. ***Highly recommended*** – protected area consists of biological diversity, important sources, vulnerable, endangered or critically endangered species. In ensuring the area is protected, it is important that the area is stipulated under law and legislation.

Three scenarios were generated for this plan. Scenario 1 showed that percentage of the 'highly recommended' area for preservation is slightly lower (11%) compared to 'moderately recommended' (41%). Compared to the other categories, the 'not recommended' area is quite low and it shows that the plan is quite rigid and highly protective. While Scenario 2 is shown to be more rigid than Scenario 3 with the percentage of 'moderately recommended' and 'not recommended' of 26.7% and 20.6% as compared to 22.2% and 25.8%.

ii. Conservation Management Plan

The analysis for identifying conservation management plan adopted an approach based upon the objectives of conservation. In order to conserve and maintain the ecological character of the study area, it is a vital step to identify the possible area to be affected by certain activities. This problem can only be identified by looking at the current condition of the study area manifested by the physical characteristics and performances such as water quality, noise, type of current land cover, erosion zone and distance of surrounding activities. This scenario also include the characterization of the major land use activities affecting wetland area. Each of the criteria is quantifiably represented by spatial criteria that are assigned relative weighting of condition, importance and impact of major land use activities measured by distance. The result may be used to address some of the environmental problems apparently within the study area which include the possibility of land encroachment, decreasing of water quality and continuing wetland loss cause particularly by the immense development and agriculture activities (large planting estates).

The analysis carried out resulted in four categories of management plan namely 'not recommended', 'recommended', 'moderately recommended' and 'highly recommended' for conservation. The 'Not recommended' category involved untouchable area with possibility of high biodiversity value mostly in the high dense canopy area and gazetted area. On the other hand, the 'Recommended' category represented sites with minor impacts of development and environmental quality value are slightly reduced. 'Moderately recommended' areas referred to areas in which its quality is being reduced and so require urgent attention for restoration and monitoring action. For suitable tourism activities, bird watching, tracking and camping are allowed accordingly due to the low impact produced. While the 'Highly recommended' areas require the most urgent attention. These are areas with major impact of development and currently in low environmental quality value and highly need for conservation in reducing a continuing and cumulative wetland loss. These areas need to be conserved continuously including infrastructure development and eco-tourism activities so as to maintain the essential ecological processes and life-support systems of wetland area.

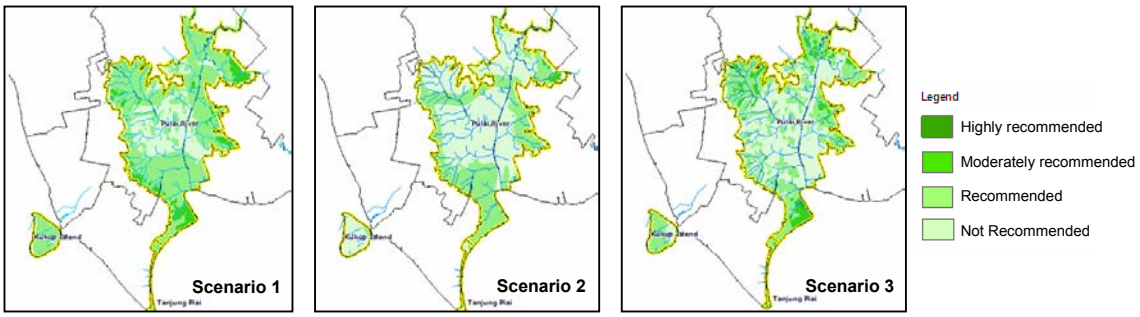

Figure 3: Conservation Management Plan Alternatives

Altogether, three alternative scenarios for wetland's conservation management plan were generated. In Scenario 1, the percentage of 'highly recommended' area (0.003%) is not significant in giving impact to the conservation management of the study area but the size of land gives an effect to study area. However, the scenario showed an urgent need of attention as the 'moderately recommended' area for conservation covered 56% of the total study area. Meanwhile in Scenario 2, only 6.7% of the area was under urgent attention and requirement for conservation and thus, the stipulated area is identified as a critical spot. As for Scenario 3, although only 6.2% of the total wetland area required for urgent conservation management, it also consists 0.1% of the 'highly recommended' area which is to be expected as the current condition and management within the wetland area contributes more impact than other factors.

Apparently, the plan portrayed by Scenario 1 is more comprehensive and need a particularly full attention compared to Scenario 2 and Scenario 3. However, Scenario 3 should be taken into account so as the management will be more effective and significant.

iii. Development Suitability Guideline

The rationale of the analysis is to determine suitable areas for development while minimizing the impact of human activities. In this case, the 'Not suitable for development' and 'Less suitable for development' categories involves the most sensitive area and development activities within this area which will led to disaster and threaten the natural characteristic of wetland area. The 'moderately suitable' category allows for mild development but with high consideration on construction work and detail assessment of environmental impact. While the 'Highly suitable for development' category involves area with low sensitivity and available for exploitation. Still, development should be conducted in an appropriate manner with respect to minimizing development impact.

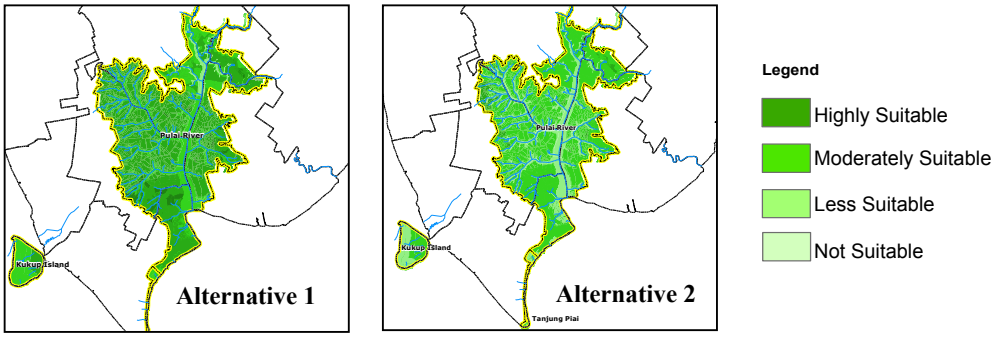

Figure 4: Alternative Plans based on Development Suitability

Through the analysis done, Alternative 1 demonstrated that highly suitable area for development is significantly lower (1.9%) compared to moderately suitable area (61.7 %). This showed that

development of the study area is acutely limited whereas preservation and conservation is more considerably required. While in Alternative 2, moderately suitable areas covered only 1.4% of the total area compared to less suitable areas of 75%. This indicated that study area is not highly suitable for development. It is shown that Alternative 1 plan is more flexible than Alternative 2 with total percentage of less suitable and not suitable of 36.6% and 94.6% respectively. Thus, it can be said that those who placed more stress on development-based uses will favour weak conditions for sustainability.

3.3 Eco-tourism Development Potential

The analysis model used in this study to identify the eco-tourism potential area was based upon intrinsic resources and suitable location regarding to the availability of provided infrastructure. The analysis approach was undertaken with consideration of highly eco-tourism's potential area for an affluent of biodiversity species, attractive landscape, unique natural area, well resources value and in chorus, restrained by limited area for exploitation and development in the study area. The analysis incorporates two sub-models namely eco-tourism natural resources potential area and eco-tourism development suitability area through the deliberation of wetland resources and characteristic, accessibility index, location factors and development constraints. The selection of the criteria for implementation of potential eco-tourism adopted the spatial multi-criteria evaluation (SMCE) technique which considers the selection of specific factors with the use of grid analysis. The final output of the analysis could be used for supporting eco-tourism management and facilities development.

i. Eco-tourism potential resources

In this analysis, the potential resources area was determined. The output of this analysis is based on level of potential for eco-tourism. Simple analysis such as reselect, buffer, and union were used to produce data layers for eco-tourism resource potential analysis. Then, rating, weights and scores were assigned to every layer used (Table 2). Rating of 1 indicates 'No potential'; 2 'Less potential'; 3 'Moderate'; 4 'Good potential'; and 5 'High potential' in term of eco-tourism resources. While as for the weightage, 1 represents 'Less Important; 2 'Moderate'; and 3 'Most important'.

Table 2: Rating, weight, and scores given to each layer.

Layer	Preliminary Analysis	Layer criteria	R	W	S
Age Class	Union	1-9 years	2	1	2
		10-19 years	2	1	2
		20-29 years	3	2	6
		30-39 years	4	3	12
		> 39 years	5	3	15
		Others	1	1	1
River	Reselect	River	5	3	15
Habitat area	Reselect, buffer	River	3	2	6
		400m from River	4	3	12
		Wetland area	5	3	15
Endangered Species	Buffer	Buffer 500m	5	3	15
		500m – 1000m	4	3	12
		1000m – 1500m	3	2	6

** R = Rating, W = weight, S = Score*

Further analysis was done in raster-based format. Layers converted into raster were then reclassified into 5 classes using the 'reclassify' function. For the final output, all sub layers were multiplied with the weightage and added together.

*[ntrlrscrc] = [agecls_clfy] * 0.25 +*
*[river_clfy] * 0.25 +*
*[hbtt_clsfy] * 0.25 +*
*[edngr_clfy] * 0.25*

The final output of this analysis showed the eco-tourism natural resources potential area.

Figure 5: Eco-tourism natural resources Analysis Output

ii. Suitable tourism development area for eco-tourism support

Analysis was done to identify suitable area for tourism development to support eco-tourism industry in the area. Tourism development includes tourism infrastructure and service-oriented facilities such as tourism information center, hotels and cottages. These areas were determined base on the basis of minimum inference to the RAMSAR area.

The analysis was carried out using the same method as the previous one. The output is based on the level of suitability of the areas for tourism development namely *Not suitable for infrastructure (1)*; *Less suitable (2)*; *Moderately suitable (3)*; *Suitable (4)*; and *Most suitable (5)*. In this case, the nearest area are considered the most suitable to support eco-tourism activities. The output are then multiplied with the mask layer, which contain area that could not be developed or not suitable at all for eco-tourism purpose. This step will extract only the suitable area near the Ramsar site and tourism center.

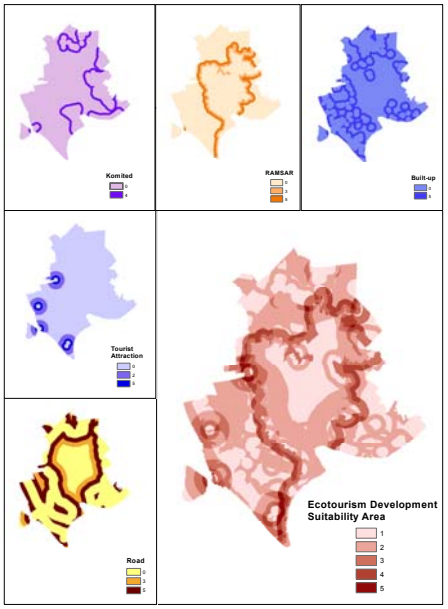

Figure 6 : Eco-tourism Development Suitability

iii. Determination of eco-tourism potential area

The eco-tourism development potential for Sungai Pulai forest reserve was derived through combination of the previous two sub models using the raster calculator. The process had also required for reclassification of the result from the tourism development suitability analysis into a new value range of -1 to -5. The value 1 is for 'Most suitable for eco-tourism development'; 2 for 'Suitable for eco-tourism development'; 3 for 'Not suitable for eco-tourism'; 4 for 'Moderate eco-tourism potential; and 5 for 'High eco-tourism potential'.

Base on the analysis, and eco-tourism requirements, the activity recommended are summarized base on 5 classes. Generally, areas that fall in Class 1 and 2 are suitable for tourism development. Therefore, these areas can accommodate physical structure to support eco-tourism activities such as hotels, resorts, tourist cottages/ rest houses, green hotels and restaurants and public convenience facilities. The Class 4 areas have moderate potential for eco-tourism. These areas are suitable for

passive tourist activities such as camping, trekking, fishing, bird watching, site seeing, and any activities which involved minimum development or inference to the site. Class 5 represents high potential for eco-tourism but these areas need to be preserved or conserved and managed in sustainable way. Its high value of natural resources is suitable for research and education. Thus, it can still be considered for tourism attraction, but with use of certain limitations and guidelines. Example of guideline to be used to limit the number and duration of access to the areas is the code of conduct. Activities suggested for these areas include for the purpose of research and education, site seeing, boating and trekking. This overall result showed that 18% of the total area are suitable for eco-tourism development while another 32% are potential for eco-tourism purpose.

5.0 CONCLUSION

The model for wetland resources management plan can be generated through integration of the typical management's components and categories namely preservation, conservation and development with the consideration of surrounding land use activities, current condition of wetland function manifested by physical performance and key factors of wetland characteristics. The model is derived using a number of factors and assigning weights of importance to the each factor using a spatial multi-criteria analysis approach with incorporation of *What if?* application. The generation of the analysis was successfully being implemented although all the selection criteria have not been taken into account accordingly. The final output could be used for generating alternative scenarios of eco-tourism activities management based upon the wetland's management components. However, further study should be done with the implementation of other related sub models such as the carrying capacity model in establishing a comprehensive wetland resources management plan.

REFERENCES

Jungho Suh & Steve Harrison, 2005. *Management Objectives and Economic Value of National Parks: Preservation, Conservation and Development.* Discussion Paper No. 337, May 2005, School of Economics, The University of Queensland.

Jabatan Perancang Bandar Dan Desa Johor, 2005. *Rancangan Struktur Johor, 2020*

Department of Planning, City of Chesapeake, 2003. *Chesapeake Bay Preservation Area (CBPA) Guidelines,* Chesapeake, Virginia.

Christopher Pettit, David Pullar, 2003. *A way forward for land use planning to achieve policy goals by using spatial Modelling Scenario,* Queensland

Erik Schlenker-Goodrich, *The Bureau of Land Management's Continuing Obligation to Inventory and Protect Wilderness Values : Citizen's Reference Guide*, The Wilderness Society (2002), www.wilderness.org

Freshwater Wetlands in Washington State, 2001 Chapter 4 *Impacts of Human Disturbances on the Functions of Wetlands,* Volume 1 – A Synthesis of the Science

Klaus Dierßen & Silvia Opitz, 2000. *Guidelines for Wetland Management and Reconstruction.* Ecology Centre, Christian Albrecht Universität, Kiel, Germany

Donovan C. Kotze., Breen C M, And Klug J R., 2000. *Wetlands And Water Quality Enhancement,* School Of Applied Environmental Sciences, University Of Natal

U. K. Banerjee, Smriti Kumari, S. K. Paul, S. Sudhakar, 2000, *Remote Sensing and GIS based ecotourism planning: A case study for western Midnapore, West Bengal, India.* http://www.gisdevelopment.net

Virginia Strategy for the Development and Implementation of Wetland Preservation Plans In the Chesapeake Bay Watershed, 2000

T.G. Acott, and H.L. La Trobe, S.H. Howard,1998, *An Evaluation of Deep Ecotourism and Shallow Ecotourism,* Journal Of Sustainable Tourism.

U.S. Department of the Interior, Bureau of Land Management, *Interim Management Policy for Lands Under Wilderness Review* , H-8550-1 (January 1, 1995), http://www.ut.blm.gov/wilderness/wimp.html.

IUCN (International Union for Conservation of Nature and Natural Resources), 1994.Guidelines for Protected Area Management Categories. Cambridge: IUCN.

BLM Manual 1737, 1992. - *Riparian-Wetland Area Management*. Bureau of Land Management, Washington, DC.

Kinch, G. 1989. Riparian Area Management: Grazing Management in Riparian Areas. Bureau of Land Management Service Center, CO.

Freeman, A.M III., 1984. The quasi-option value of irreversible development. *Journal of Environmental Economics and Management*.

http://www.wetland.org.ca