GIS APPLICATION IN COASTAL MANAGEMENT: THE PERSPECTIVES OF GOVERNMENT AGENCIES IN SELANGOR

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Abstract

The coastal area is highly considered as one of the most complex areas to be handled by the traditional planning system. In managing coastal areas, there must be integrated coastal management between various related agencies, technically and physically. The management of the coastal area depends on the coastal manager's ability to recognize and comprehend the complexity of natural coastal processes. Thus, this paper addresses how GIS tool is embedded in the coastal management system from the perspectives of government agencies in Selangor. The objectives of this research are: to identify the present integration between coastal management and GIS at government agencies in Selangor coastal districts; and to study the application of GIS and related spatial information technologies to local government officials. Data were gathered through survey. The findings show positive relationship between coastal management and GIS in Selangor. Government agencies indeed has actively been using GIS as part of the management tool of the coastal area in Selangor This may eventually lead to GIS application being recognised as a significant tool to be used in coastal management.

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INTRODUCTION

The coastal area is considered one of the most complex areas to be handled through traditional planning system. In managing coastal areas, there must be integrated coastal management between various related agencies, technically and physically (Sousa et al., 2016). Nowadays, Geographic Information System (GIS) is becoming a utility for analysing the dynamics of the coastal areas. Among the frequent users of GIS whose works relate to the coastal areas are town planners, engineers and land managers, who are concerned with the spatial and time distribution of coastal changes like landslides and sediment drift, whilst identifying possible causes and consequences.

To record coastal behaviour, a multi-temporal study where large quantity of data in various types and from various sources are collected for a better description of the coastal behaviour. Therefore, a reliable inventory describing the type of activities in coastal area is needed before any analysis takes place (Martínez-Harms & Balvanera, 2012). What needs to be noted is that management of coastal area depends on the coastal manager's ability to acknowledge and comprehend the complexity of natural coastal processes.

Modelling natural coastal processes requires the ability to combine both spatial and non-spatial information from multiple datasets. GIS could integrate physical, ecological, socio-economic and hazards information, which makes it among the best assessment tools to support management efforts in coastal area. Through GIS' practises, coastal managers are able to model vulnerability to coastal erosion, sea-level rise and other threats so that decision makers have the necessary information to protect local communities and effectively manage coastal natural resources (Templer et al., 2016). Thus, this study explore the application of GIS in coastal management in Selangor coastal districts.

GEOGRAPHICAL INFORMATION SYSTEM (GIS) IN COASTAL MANAGEMENT

Globally, coastlines are undergoing rapid development, and therefore firm management policies have to be established. However, for any coastal management to be effective, the policies need to be based on informed decision-making. This in turn requires ready access to appropriate, reliable and timely data and information in a suitable form for the task at hand.

Since much of these information and data is likely to have spatial components, GIS can contribute significantly to coastal management in a number of ways: it can handle much larger databases, and integrate and synthesize data from a much wider range of relevant criteria than might be achieved through manual methods. GIS encourages the development and use of standards for coastal data definition, collection and storage, which promotes compatibility of data and processing techniques between projects and between departments, as

well as ensuring consistency of approach at any one site over time (Bartlett & Celliers, 2016).

The coastal area is highly dynamic, and scientists or managers increasingly require access to technologies that can represent these dynamics, particularly to evaluate and deal appropriately with changes in the geometry of the shore. Two main divisions of coastal change analysis may be recognized: monitoring and simulation modelling. GIS has been applied to coastlines planning, management and monitoring in order to keep track of a wide range of natural and human-induced changes. While monitoring can help to identify and evaluate changes that are taking place on the shore, effective management of the coastal area occasionally requires intervention and manipulation of the processes, controls, feedback and inter-relationships at work along, within and across the shore, in order to arrive at more desirable results (Islam & Sugianto, 2007).

Modelling and simulation of coastal phenomena are extremely valuable techniques for assessing the effectiveness and likely impacts of such intervention. By combining rapid data retrieval with analytical and modelling functions, GIS can respond rapidly and flexibly to ad hoc "what if" questions. Thus, a well-designed coastal area information system could be a significant decision support tool to aid the development of integrated and sustainable coastal resource management strategies (Eldrandaly & Naguib. 2013). The use of maps and spatial information in natural resource management and land-use planning is essential to improving the sustainable and equitable use of land and natural resources through participatory community and local level planning and investment.

GIS can be used for any number of coastal management applications, like improving the administration and enforcement of zoning ordinances. It can measure distances and areas, and thus determine a minimum lot width of 100 ft. and minimum lot size of 20,000 sq. ft. as often mandated in subdivision regulations. Alternatively, GIS can also be used to generate buffers around lines or designated areas.

The benefits of application of GIS approach to coastal management include:

1. The ability to model, test and compare alternative scenarios - before the proposed strategy is imposed on the real world;
2. The ability to handle much larger databases, and to integrate and synthesize data. This leads to a more holistic and coordinated management strategies; and
3. Enhanced capacity for data exchange.

There are few successful GIS tools that have been used in managing coastal area. These are listed in Table 1.

Table 1 Example of GIS application used in coastal management

Component of coastal management	Application/Tools	Country
Huge databases and models	Geographical Information Infrastructure (GII) Monitoring the Netherlands' coastal zone. Risk management 'Eagle Suite.'	Rijkswaterstaat (RWS) / Ministry of Transport, Public Works and Water Management, Netherland
Management strategies	The COSMO (Coastal zone Simulation Model) Coastal Zone Management Centre, the Netherlands.	(SAMPAK – Thailand) (COMA – West Africa) (CORAL – Maldives) (DSMOZ – Mozambique)
Policy alternatives	RamCo (Rapid Assessment Module for Coastal Zones) Policymakers: climate change, demographic growth or changing economic demand.	Research Institute for Knowledge Systems (RIKS), the Netherlands
Coastline Management	SHO-MAN (the SHOreline MANagement tool): assessing the impact of management actions on the development of the coastline.	National Institute for Coastal and Marine Management, The Netherlands

Research Methodology

This study employed multi-methods for data collection. These include questionnaire survey, interviews and literature review. Thus, these data were triangulated to establish the findings (Thurmond, 2001; Olsen, 2004).

The selected respondents for the questionnaire survey and interviews were those who were well-versed in the field and have experience on the implementation and practice of planning and coastal initiatives. They were selected as respondents because:

i.   they are the officers involved in coastal management in Selangor;
ii. they are aware of the current scenario of coastal management planning; and
iii. the questionnaire requires professional perspective of those who have dealt with coastal management planning.

Data were analysed for mean and standard deviation in order to observe the central tendency of the variables and also to measure the average score for the participants on the given study. Individual and average values for mean and standard deviation were also shown in order to demonstrate the consistency of the data.

The Kruskal-Wallis test was also employed for multivariate analysis. It is a nonparametric (distribution free) test, and is used when the assumptions of ANOVA are not met. The test is used to identify significant differences on a continuous dependent variable by grouping independent variables (with three or more groups) (Kruskal & Wallis, 1952). The test is represented by the following formula:

$$H = \frac{12}{n\,(n+1)} \sum_{i-1}^{\kappa} R_{i}^{2} - 3\,(n+1)$$

Where,
H = Kruskal-Wallis Test statistic
N = total number of observations in ail samples
T_i = Sum of the ranks assigned

The Kruskal-Wallis test statistic is approximately a chi-square distribution, where k-1 should be greater than 5. If the degree of freedom where the m calculated value of the Kruskal-Wallis test is less than the critical chi-square value, then the null hypothesis cannot be rejected. If the calculated value of the Kruskal-Wallis test is greater than the critical chi-square value, then the null hypothesis can be rejected and it can be concluded that the sample comes from a different population.

Assessing the significance of H depends on the number of participants and the number of groups. If there are more than three groups with more than five participants per group, then H shall be treated as Chi-Square. H is statistically significant if it is equal to or larger than the critical value of Chi-Square for a particular degree of freedom. Therefore, Kruskall-Wallis test was chosen because there were more than 3 samples of population for this research that need to be analysed.

THE PERSPECTIVES OF GOVERNMENT AGENCIES IN SELANGOR
In determining whether GIS application in coastal management has impacted agencies' variation in the benefits of GIS, the mean difference between the benefits reaped by agencies was tested for One-Way ANOVA Kruskal Wallis analysis measurement. Based on Table 2 below, at 9 degree of freedom, with a calculation where χ2 (9) = 16.919, p = 0. 000 < 0.05, has led to the rejection of difference in means for perception on the usage of GIS application in coastal management. This is supported by the significant value 0.000 which is less than 0.05.

Table 2 GIS Application

Department/Agencies	YES	NO
Lembaga Urus Air Selangor (LUAS)	49.21	50.54
Department of Drainage and Irrigation (DID)	62.18	56.11
Malaysia Geospatial Data Infrastructure (MyGDI)	11.00	11.00
PLANMalaysia	11.00	11.00
Department of Forestry	56.60	51.10
Majlis Daerah Kuala Langat (MDKL)	39.50	51.00
Majlis Perbandaran Sepang (MPSp)	39.50	43.95
Majlis Perbandaran Klang (MPK)	39.50	45.13
Majlis Daerah Kuala Selangor (MDKS)	39.50	63.00
Majlis Daerah Sabak Bernam (MDSB)	49.00	43.17
Test Statistics[a,b]		
Chi-Square	56.887	13.593
df	9	9
Asymp. Sig.	.000	.138
a. Kruskal Wallis Test		
b. Grouping Variable: Department/Agencies		

Generally, coastal management is well-known in Selangor but this may not be the case for GIS. However, GIS application has nevertheless become a medium of information widely used in planning related sectors nowadays. Official websites of government offices such as PLANMalaysia and local authorities use GIS application for local communities, developers and others to seek and find information related to their land using the GIS tool which are embedded into the websites.

Officer from MyGDI also affirmed that their department is working hard in providing information directly and allowing it to be easily accessed by various parties using GIS tools. MyGDI has launched MyGDI programme, which is an initiative by the federal government to develop Geospatial Data Infrastructure sharing platform. The program was developed to raise the awareness of government agencies and local people about the availability of data. Planner from Majlis Daerah Kuala Selangor also revealed that GIS can be accessed by local people. The Kuala Selangor municipal council have prepared GIS counters and portable computer-operated machines that can be found at the entrance of the municipal building. Local people have two choices: either to ask for assistance with GIS at the counter or personally check it using the provided machines.

Usage of GIS in Coastal Management
Kruskal Wallis is a one way ANOVA test, ascertaining the differences of any means value between any groups is influenced by any intervention χ factor. It was assumed that the dependent variable had an ordinal scaled data and selective sampling group. For this study, the hypothesis to be tested was the significant

differences of mean of coastal management issues should be resolved using GIS application between different agencies and departments.

Table 3 Kruskal Wallis Descriptive for Mean Differences of Resolving coastal management issues by using GIS application

Department	Integrated management and sustainable development of coastal and marine areas	Marine environment	Sustainable use and conservation of marine living resources	Addressing critical uncertainties for the management of the coastal area
LUAS	51.50	37.00	37.61	63.71
DID	39.14	44.55	48.95	35.41
MyGDI	39.14	44.55	48.95	31.05
PLANMalaysia	32.38	47.38	41.88	37.25
Forestry	31.50	45.30	36.70	33.60
MDKL	77.00	37.00	16.00	55.50
MPSp	38.50	41.15	48.80	35.90
MPK	19.25	37.00	31.13	46.38
MDKS	28.00	37.00	50.50	37.25
MDSB	77.00	37.00	16.00	55.50
Test Statistics[a,b]				
Chi-Square	31.523	6.397	15.884	23.234
df	9	9	9	9
Asymp. Sig.	.000	.700	0.69	.006
a. Kruskal Wallis Test				
b. Grouping Variable: Department/Agencies				

In determining whether GIS application in coastal management has impacted agencies' variation in benefiting GIS, the means difference between the benefits reaped by agencies have been tested for One-Way ANOVA Kruskal Wallis analysis measurement. Based on Table 3 above, at 9 degree of freedom, with a calculation where $\chi 2\ (9) = 16.919$, $p = 0.\ 006 < 0.05$, the mean rank of 31.523 (integrated management and sustainable development of coastal and marine areas) and 23.234 (addressing critical uncertainties for the management of the coastal area) has led to the rejection of difference in means for whether agencies in areas of GIS application is useful in coastal management. This is supported by the significant value 0.000 which is less than 0.05. Hence, human activities involving various land use activities sometimes place demands on coastal ecosystems that often results in resource-use conflicts. Hence, a proper balance between the different demands must be achieved and resolved by informed decision making. Integrated management and the sustainable

development of coastal and marine areas enables these decisions to be made, implemented and monitored using GIS in order to promote sustainable coastal development.

The engineer from the Department of Irrigation and Drainage has addressed the issue on the maintenance of coastal physical development, especially where erosion of the beach has worsened due to human activities such as tourist and recreational activities. Addressing critical uncertainties for the management of the coastal area has been pointed out since there are various legislation and policies related to coastal areas. NGO worker from Malaysian Nature Society has pointed out that local authorities normally control coastal areas using local plans or special area plans. However, respondents are concerned with the effectiveness of the implementation of local plans and special area plans in managing the coastal area and its surrounding eco system. Respondents hope that the usage of GIS can increase the effectiveness of local plan implementation in Selangor.

Weaknesses in the application of GIS application
An "H" score assumed as a Chi-Square value is calculated using the sums of the ranks of each group. The test statistic for a Kruskal-Wallis test is given below.

Table 4 Kruskal Wallis Descriptive for Mean Differences of Reason on GIS Tools is not been used

Department	Lack of manpower	No GIS expertise	Financial constraint	Poor level of awareness of GIS application
LUAS	19.71	42.61	56.93	58.82
DID	52.09	36.91	30.41	31.00
MyGDI	44.05	38.86	39.41	31.50
PLANMalaysia	55.38	48.06	38.06	46.00
Forestry	46.30	36.10	47.70	42.70
MDKL	26.50	53.50	70.50	62.50
MPSp	49.10	47.65	26.90	35.00
MPK	21.75	42.63	61.00	48.75
MDKS	70.75	31.75	18.50	35.00
MDSB	26.50	53.50	70.00	62.50
Test Statistics[a,b]				
Chi-Square	33.220	6.305	38.880	23.199
df	9	9	9	9
Asymp. Sig.	.000	.709	.000	.006
a. Kruskal Wallis Test				
b. Grouping Variable: Department/Agencies				

Where N is the total amount of participants so N = 83 and n is the amount of participants in each group so n1 = n2 = n3 = n4 = 83. The H value of 1.384 is lower compared to the critical value of 16.919. This critical value is calculated by selecting the appropriate size of group's value and p value. In this case there are 83 participants in each group and the appropriate p value is 0.05, as a 5%

significance level is required. It can be concluded that each department has a similar opinion on the weaknesses of GIS application in managing coastal areas in Selangor. Subsequently, treating this result as though it were a value of chi-square, distribution of chi-square with df = 9, 16.919. The means rank of 38.880 (Financial constraint), 33.220 (Lack of manpower) and 23.199 (Poor level of awareness of GIS application) is higher than 6.305 (No GIS expertise) and the difference is significant. This highlights that participants considered financial constraint and lack of man power as the highest concern with regards to using GIS application in coastal management for Selangor coastal districts. It suggests that GIS application is important in coastal management. However, due to several factors, the capability of GIS application is not being fully utilised. This is in line with the findings by Bhatta (2013) on GIS limitation, which are:

  i.   GIS data are relatively expensive than traditional data;
  ii.   Learning time on GIS software and systems can be long, because it easily becomes the objective of the study rather than just a tools; and
  iii. Privacy and security issues can sometimes limit distribution of data.

Engineer from Lembaga Urus Air Selangor and Planner from Majlis Daerah Kuala Selangor had agreed that financial constraint is the main reason why GIS application has not been used in their departments and agencies. According to the respondents, allocation for GIS management and improvement is being specifically provided in the agencies' budget.

The poor level of awareness on the GIS application is also connected with the issue of financial constraint. Despite the agencies sending their staff for training on GIS application, the agencies did not procure GIS software due to limited budget.

Ironically, lack of manpower is also associated with financial constraint. According to Planner from Majlis Daerah Kuala Selangor. Typically, every staff in local authority performs multiple functions. Local authorities that were involved in this study have yet to have staff specially assigned to GIS. Aside from this, IT Officer from MyGDI also mentioned that even though the GIS application is available, some of the agencies did not fully utilise the programme. Moreover, it is possible that there are also agencies that do not realise and are not aware of the existence of MyGDI (or MacGDI).

FINDINGS

Government agencies has actively used GIS as part of the coastal management

From the above finding, there is a relationship between coastal management and GIS application. This may eventually lead to the GIS application being recognised as a significant tool to be used in coastal management. MyGDI is formed with the connexions of several components, which are clearinghouse/geoportal, metadata, geodata, framework and standard by partnership and collaboration between numerous agencies. Partnership is the main key in MyGDI components since partnership holds all components together. Coastal management is included within the Built Environment framework. Therefore, other MyGDI frameworks are also applicable in coastal management of Selangor coastal districts. In this respect, the use of GIS application is significant in the coastal management of Selangor's coastal districts.

Coastal management implementation has considered GIS as tools of development for coastal area in Selangor

This undoubtedly strengthens the GIS application's capability, and shows that it can be used by any sectors and studies. GIS application allowing on-line access to geospatial data is pertinent in the planning and development of coastal areas in Selangor. Using GIS may circumvent the duplication of geospatial data during data collection processes, which supported by a variety of GIS value-added products can increase the levels of operation and awareness of geospatial data. GIS application can help to spur coastal management in Selangor. At the same time, it may increase the awareness of local geospatial data industry in Selangor. All these prove that GIS is an important tool for coastal management implementation in Selangor.

Use of spatial information in coastal management

Uncontrolled/unplanned land use is taking place throughout developing countries and the tsunami-affected coastal areas are no different; rather, it is worse in some places where accelerated development has been taking place. Thus, forest or land clearing and degradation is an ongoing process and the speed of clearing is increasing. For example, there is a strong link between road improvement, waterways and forest clearance. Such development has an enormous impact on the quality of the remaining natural resources (land, forest, fishery, agriculture), particularly where these resources are related to each other. Therefore, such conditions also affect the livelihoods of many communities; their dependencies on these resources remain strong. Secure and sufficient access to land and resources is crucial to raise income and provide livelihood options for those who depend on them on a daily basis, especially where alternative options are very

limited or do not exist. When adopting the multilevel stakeholder approach to sustainable land management, the various dimensions of sustainability have to be weighed against one another in a negotiated, i.e. participatory, approach that does not discriminate against or favour particular actor categories. For example, scientific information must be coupled with indigenous knowledge to offer a better basis for decision-making in the negotiation processes. Here, GIS and maps may serve as appropriate tools to facilitate communication in the negotiation processes. It can also be noted that besides the use of participatory rural appraisal data/information, created and available maps are a valuable source of information.

CONCLUSION

This study has found that GIS has the potential to be used widely in coastal management in Selangor. However, existing constraints like limited budget, has to, firstly, be overcome. The usage of GIS in coastal management can be increased by accelerating the execution of electronic government and knowledge economy, especially at the local authority level. Other GIS associated applications such as remote sensing and other imagery resources can be used in order to increase the quality and usage of GIS application in coastal management. In order to increase the performance of coastal management and GIS application, there should be a clear division of work between coastal management and GIS should be emphasized by experts on Coastal management & GIS, who should be present in every department. Additionally, the solidification of the agencies and the departments' capability in producing knowledge-strong workers through human resource development programs especially related with GIS and coastal management in Selangor is also important.

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