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A Comprehensive Review in Applied GIS-Based Spatial Decision Support System (SDSS) in Water Quality Modeling in the Malacca River

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ABSTRACT

A spatial decision support system is a solution for spatial issues and problems applying a computer system and providing results for decision making. This comprehensive review study has been carried out to determine GIS and RS in SDSS towards water quality modeling in Malacca River. Rapid development in land use for human activities include agricultural and livestock activities, industrial activities, residential activities, commercial activities, municipal activities, open space activities, and so on, leads to environmental issues, especially water quality in the river, which affecting the physical parameters, chemical parameters, biological parameters, and heavy metal parameters. In analysis, water quality data, land use data, map-based data, and satellite data will be grouped together to provide new information. As a result, modeling will be provided, such as water quality data overlap with RS data, water quality data overlap with land use data, map-based data overlap with water quality data and land use data, and map-based together with satellite data overlap with water quality data and land use data. In conclusion, applied GIS and RS in the SDSS model will solve the issues and problems of concentrated human activities in a particular area, as well as issues of uncontrolled land use, contamination of rivers, negative impact on human life quality and ecosystems, and destruction of the natural environment.

Keywords: SDSS, GIS, RS, Land Used, Water Quality.

I. INTRODUCTION

Spatial Decision Support System or SDSS is a decision making apparatus supported by computerized information based on geographical or spatial components to reach a decision [17]. In other words, computer support for spatial application is provided by systems based geographical information system (GIS) [18]. There are various definitions used in GIS based according to different fields and expertise. However, generally speaking, GIS can be described as a system to capture, store, check, interpret, manipulate, analyze and displaying spatial data to understandings, patterns, and trends that relating to the Earth surface [10]; or an information system related to geographical data that can be referred to. GIS is a computer-based information systems that enables the capture, modeling, storage, searching, sharing, manipulating, analysis and presenting the spatial-geographical data [27]. Due to the advantages of GIS, the benefits have contributed to decision making lies in the ability of these systems to store and manipulate data based on spatial location. According to the history of GIS, it is applied in industries such as forestry and mining; and the development is progressive in the transportation field which is involved in the design of transport infrastructure and the routing of vehicles that use such infrastructure. Until today, GIS is still used for location analysis and related problems, such as a variety of business and government applications like siting public facilities [21], accessibility by mobile telephone [20], and so on. Therefore, GIS and SDSS are tools widely used in almost all fields to solve spatial problems, especially in decision making.

In the 1970s, a decision support system (DSS) was developed by the information systems (IS) community at the Massachusetts Institute of Technology [12] [19]. DSS is continuing to develop, especially from an academic perspective, such as books and published papers [1] [25] [4], where DSS becomes one part of IS in the early 1980's. Due to rapid development in DSS, it starts to evolve from traditional business data processing into financial and operating data associated with business use, and also towards GIS, for examples

Geodata Analysis and Display System (GADS) [13] used for routing applications. However, application of GIS had limitation in graphics and lacking in data processing toward the full usage of spatial applications. So, a research done by Nagy and Wagle [24] stated that there is development concentrated particularly on GIS in geographic data processing applications by IS community. In the mid-1980's, spatial decision support system (SDSS) evolved [2] and the model can be fully applied in the GIS field [8]. In 1990, US National Center for Geographic Information and Analysis launched research more advanced for SDSS [11]. Nevertheless, SDSS was accepted by the IS community in the early of 1990s [23], but was not accepted by other fields in GIS as a whole. This can be proven in GIS textbooks as no mentioned SDSS at all [3] [6]. There was less attention paid to SDSS until the mid-1990s, where some research work involve with SDSS [26] showing the effectiveness of SDSS technology [7] are appropriate for application, and the benefits of SDSS have been discussed by decision makers until today [20].

Decision support system or DSS can be described as any combination of database, interface and model components directed at a specific problem [25]. However, the definition is being critics by majority of academics and practitioners. Result from surveys have shown that DSS can only be applied in certain systems [9]. In an informal definition, Keen [15] stated that a trend use of any computer system to make any decision can be defined as DSS. Since GIS is a technology involve with a computer system, it is eligible for the definition, but limited in geography user and related fields for decision-making. Various academic approaches are needed to seek for GIS in DSS to meet the definition of DSS. Therefore, GIS contains an interface, a database, and some spatial modeling components which already meet the requirements of DSS. According to Alter [1], GIS can consider as an Analysis Information System rather than modeling component, which already have in GIS software. Meanwhile, Mennecke [22] described SDSS as a subset of GIS used for manipulating and analyzing spatial data. Nevertheless, SDSS should be an intersection of GIS and other techniques, where it becomes flexible as a form of DSS generator [25] and acts as model in specific DSS [16]. Therefore, this review paper has been conducted to assess SDSS in apply GIS towards water quality modeling in Malacca River.

II. METHODS AND MATERIAL

Since the water quality modeling is based on Malacca River, the sample area for this research will be concentrated in Malacca State. The tools involved in generating modeling are geographic information system (GIS) and remote sensing (RS), and the data required for analysis are map-based, satellite data, water quality data, and land use data as shown in figure 1.

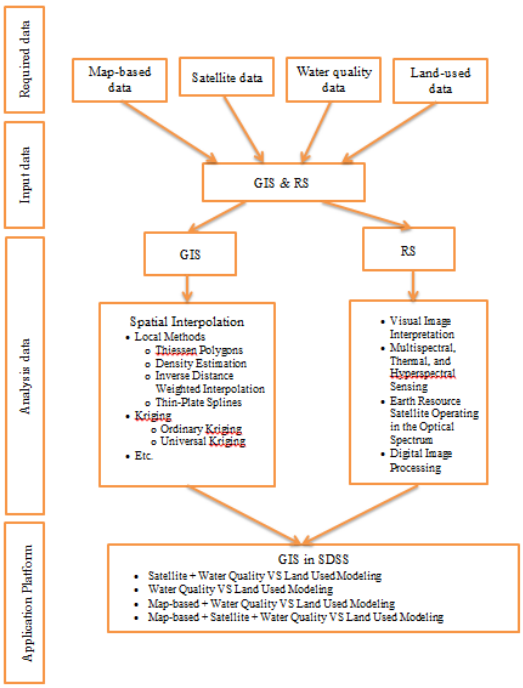

Figure1: GIS and RS in SDSS

III. RESULTS AND DISCUSSION

According to figure 1, GIS data will require map-based data that exists in vector data and raster data format. Basically, the vector data analysis can involve buffering, overlay, distance measurement, pattern analysis, and map manipulation; meanwhile, raster data analysis can include local operations, neighborhood operations, zonal operations, physical distance measure operations, and other operations [5]. Both data formats are important in helping to carry out the analysis and provides result in modeling. At the same time, RS can operate as a tool in modeling water quality and land use to generate SDSS. However, there are slightly weaknesses in RS due to the information that provided is only based on satellite image. In other words, the results from the satellite can only be proven accurate when there is other data analyzed together. For example, statistical analysis of water quality data will strongly prove together with RS data when there is river pollution exists. Nevertheless, RS still has various advantages and benefits, especially in land use design and

protection towards water quality in the river. This is because satellite data have the ability to view Earth's surface in overall and large scale, which mean the information provided can be evaluated and determine all issues and problems regarding to water perspective, plant's perspective, Earth perspective, and land cover perspective. On the other hand, RS results can become input data for GIS in updating the map-based and other information. Therefore, GIS and RS are tools that can be applied to develop an SDSS model and help to protect the water quality from continue polluted in river.

Water quality data and land use data can be classified into several categories, which can be shown in figure 2 and figure 3.

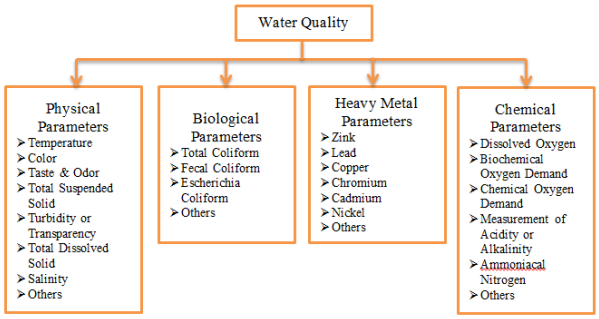

Figure 2: Categories of water quality

Figure 3: Categories of land use

Information about water quality can be affected by various factors, and these factors can be determined through human and natural activities that contribute to point source or nonpoint source pollution. If contamination occurs due to natural activities, the pollution will not happen for long periods of time. For example, erosion of riverbanks may cause contamination such as turbidity, and the pollution will be stopped when water velocity is decreasing and there is no energy to transport the sediment. Nevertheless, conditions are different when human activities take part and listed as a factor to cause river pollution. When there is human intervention, then it will be large and huge changes happen in particular matter, for example, development of land use. Many areas are explored and developed to undergo for certain and appropriate activities. Since human population is increasing daily, the development of the area will be tripled just to fulfill societal demands. This can be shown through chemical factories, as population increase will cause demand for plastic materials (e.g. chair, water bottle, Tupperware) to increase, and also increase the wastewater which can cause pollution to occur. Increasing demand toward plastic material will also cause increasing in construction of factories. So, researchers should carry out laboratory analysis for water parameter (physical, chemical, biological, and heavy metal) to assess and evaluate the condition of water quality in river. On the other hand, water quality results can overlap with satellite image data to prove that water pollution occurs or is in good condition. Therefore, a research study as a comprehensive review is important, especially for SDSS concerning water quality modeling in Malacca River, so that there are other methods and solutions that can be applied to reduce water pollution and protect the river from destruction.

Land use development can be considered among the most effective in reducing river pollution to occurs, because the river can act as a source of water supply and also receive all the water flow from all direction of areas (including raining, surface and ground water). Referring to figure 3, there are several human activities that may cause water pollution in river, namely agricultural and livestock activities, industrial activities, residential activities, commercial activities, municipal activities, open space activities, and others. These activities will require water and at the same time, contribute wastewater that can cause pollution of river water. As a result, the water quality data that has previously undergone laboratory analysis can be used to cross over with land use data to determine the percentage of river pollution, which is based on statistical analysis but not yet involve with GIS and RS. Instead, a proper land use to carry out human activities should be designed and managed, which can apply GIS and RS tools in this condition. At this moment, the modeling for SDSS can be

archived as third and fourth in the application platform.

In GIS, when water quality and land use data overlap, information will be provided to model the factors of water pollution in Malacca River. Once the model is complete, the proper land use can be determine, for example, if factories activities, agricultural and livestock activities, commercial activities, and residential activities are contribute the highest pollution in river at a particular area, then the best suggestion to reduce river pollution is to move out the factories activities from further than 100 km from the river, agricultural and livestock activities outside 50 km, and commercial and residential activities should outside 20 km from the river. This is because when human activities are nearer to the river, then water will be faster to get polluted in the river. Although the decision to move out the human activities from the sensitivity area of the river will not stop contamination drastically, but the pollution of the river can be progressively reduced and continuously improve the water quality back to the original. At the same time, RS analysis can also serve as a minor contribution in modeling the factors of contamination and help to place the human activity in particular and suitable area. Therefore, when the model is completed and suggestions are applied, the SDSS in GIS towards water quality modeling in Malacca River will be an important contribution not only for the environmental field, but also for urban and tourism planning, health management, business, sustainable education through research platforms, and so on.

IV. CONCLUSION

Last but not least, SDSS refers to decision making supported by computerized based on geographical or spatial components of decisions. The ability of GIS as a computer system will contribute various benefits and advantages for solutions of spatial issues in decision-making. Meanwhile, RS is another computer tool to support the GIS especially in detection, solution, modeling, and so on. In general, the issue and problem that has begun to concern the population is water pollution in Malacca River. These problems have occurred due to the rapid development in land use for human activities without control. Therefore, this situation has created problems such as too concentrate of human activities at particular area, uncontrolled land use, contamination in the river, negative impact on human life quality and ecosystems, and destruction towards natural environment. Hence, applying GIS and RS to model SDSS is important to solve the issues and problems of land use, river pollution, and protect the environment. At the same time, research by Hua and Kusin [14] will become a starting point to further develop the field of environmentalism, built environment and architectural, health, educational, and etc. So, applied GIS-based Spatial Decision Support System (SDSS) in water quality modeling in Malacca River as a comprehensive review will be evaluated as a platform for a research study in 'Applied GIS in assessment water quality modeling in the Malacca River. Case study: Introduction to research study'.

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