II LITERATURE REVIEW

II.1 Web Geographic Information Systems (WebGIS)

A geographic information system (GIS) integrates hardware, software and data for capturing, managing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationship, patterns, and trends in the form of the maps, globes, reports and charts. A GIS helps you answer question and solve problem by locking at your data in a way that is quickly understood and easily shared (ESRI, 2000).

Much recent attention has focused on developing GIS functionality in the internet, Worldwide Web, and private intranets and is sometimes termed in Web GIS. Internet users will be able to access GIS applications from their browsers without purchasing proprietary GIS software. Web GIS will make it possible to add GIS functionality to a wide range of network-based application in business, government, and education. The challenge of Web GIS lies in creating software systems that are platform independent and run on open TCP/IP-based network, that is on any computer capable of connecting to the internet (or any TCP/IP-based network) and running a web browser (Foote and Kirvan, 1997).

II.2 Decision Support System

Decision support system (DSS) is an interactive, flexible, and adaptable Computer Based Information System (CBIS), specially developed for supporting the solution of a particular management problem for improved decision making. Decision making is a process of choosing among alternative courses of action for the purpose of achieving a goal or goals (Efraim Turban, 1993). A decision support system (DSS) is a computer-based system that helps the decision maker utilizes data and model to solve unstructured problems (Ralph H. Sprague at al., 1982).

The Spatial Decision Support System (SDSS) concept has evolved in parallel with DSS. SDSS is an interactive, computer-based system design to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem. The
development of SDSS has been associated with the need to expand the Geographic Information System (GIS) capabilities for tackling complex, ill-defined, spatial decision problems (Densham et al., 1989).

Similar to DSS, SDSS is composed of several software components which are the Data Base Management System (DBMS) with containing the functions to manage the geographic data base, the Model Base Management System (MBMS) with containing the function to manage the model base and the Dialog Generation and Management System (DGMS) with managing the interface between the user interface with display and report forms and the rest of the system or Graphical User Interface (GUI).

The decision making process adopted to solve semi-structured spatial problems is often perceived as unsatisfactory by decision makers. (Densham, 1991) list the distinguishing capabilities and function of SDSS, which should be capable of providing mechanisms for the input of spatial data, allowing representation of the spatial relations and structures, including the analytical techniques of spatial and geographical analysis and providing output in a variety of spatial forms, including maps.

II.2.1 Multi-criteria Decision Analysis (MCDA)

MCDA is a discipline knowledge that aimed at supporting decision makers who are faced with making numerous and conflicting criteria evaluations. MCDA aims at highlighting these conflicts and deriving a way to come to a compromise in a transparent process. MCDA help the decision makers in the territory management, several actors have shown the adequacy of the association of the geographical information systems (GIS) and the multi criteria decision aid (MCDA) methods.

Multiple criteria decision analysis (MCDA) approaches are major parts of the decision and involve the selection of the best actions from a set of alternatives analysis to evaluate against multiple criteria and also seek to take explicit account of more than one criterion in supporting the decision process. Many existing MCDA methods focus on certainty and uncertainty decision problems. The criteria were evaluated separately as if they were independent of each other which enable evaluation and ranking of many alternatives.
The general objective of MCDA is to assist a decision maker or a group of decision about the problems they face to choose the best alternative from a range of alternatives in an environment of conflicting and competing criteria such in the way the idea of multiple criteria is considered, using computation of weights and scoring with the mathematical algorithm, the model to describe the system of preferences of the individual facing decision-making. The MCDA technique selected will typically need to (Andrea De Monti et al., 2000):

- Deal with complex situations (criteria), consider different scales and aspects (geographical scales, micro-macro-link), social/technical issues and type of data (uncertainties)
- Involve more than one decision maker (stakeholder participation, actors, communication, and transparency)
- Inform stakeholders in order to increase their knowledge and change their opinion and behavior (problem structuring, tool for learning, transparency)

The MCDA component consists of a collection preference structure modeling techniques and associated in multi-criteria decision models. The preference modeling techniques might include with criterion weighting techniques and method as well as the methodology for generating the hierarchical value structure of evaluation criteria, with these MCDA overcomes the limitations of less structured methods, basic methods can be used to reduce complex problems to a singular basis for selection of a preferred alternative. In some methodologies when decide to use MCDA are similar steps of organization and decision matrix construction. In another perspective different methods require diverse types of value information and using some many algorithms. Several techniques use rank options, with indicate some identify and a single maximum alternative, and others differentiate between acceptable and unacceptable alternatives (Malczewski, 1999).

Another points of view that multi-criteria methods categorized as discrete or continuous with calculate upon domain alternatives. In some cases the use of this method does not always use the weights to combine several criteria to generate aggregate score for each alternative. Using the basic approach is simple, very stout in the case, it can be done without using a computer calculation, these
methods is best suited for a one-decision problem with several alternatives and criteria.

In associate with GIS and MCDA method is not only to set the spatial reference information that is required, but also to implement new methods of analysis that allows information to get the most relevant and most appropriate solutions in the search for necessary information. However, most of the MCDA problem does not only consider quantitative criteria, but also qualitative, to make some analysis and the appropriate criteria, which makes the problem becomes complex and difficult to use as decision and analysis.

II.2.2 Ranking and Rating

There are two simple techniques that MCA utilises to identify and select relevant Criteria & Indicator are Ranking and Rating. Ranking involves assigning each decision element a rank that reflects its perceived degree of importance relative to the decision being made. The decision elements can then be ordered according to their rank (first, second etc.). Rating is similar to ranking, except that the decision elements are assigned ‘scores’ between 0 and 100. The scores for all elements being compared must add up to 100. Thus, to score one element high means that a different element must be scored lower (Mendoza, G. A., 1999).

There are three general steps in Criteria and Indicators (C&I) assessment. Multi criteria analysis (MCA) has specific application as a decision making tool in steps 1 and 3.

1. The identification and selection of Criteria and Indicators.
2. The scoring of indicators based on the selected set.
3. The assessment of the system in terms of its overall performance at all levels of the C&I hierarchy.

There are two different ways to rank a set of decision elements, Regular Ranking and Ordinal Ranking. Regular Ranking assigns each element relevant to the decision process a ‘rank’ depending on its perceived importance. Ranks are assigned according to the 9 point scale as shown in Table 1.
Ordinal Ranking is a technique where each expert is asked to put the list of decision elements in order of importance. Unlike regular ranking where different decision elements can be given the same ranking, ordinal ranking forces the experts to put the elements in a hierarchy of importance; each element is deemed more or less important relative to the other elements involved (Mendoza, G. A., 1999).

Table 1  Regular Ranking Value

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<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
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<tbody>
<tr>
<td></td>
<td>Not important</td>
<td>Moderately important</td>
<td>Important</td>
<td>Very important</td>
<td>Extremely important</td>
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</tbody>
</table>

**II.3 Database Management System**

A database is a collection of interrelated data organized in such a way that it corresponds to the needs and structure of an organization and can be used by more than one person for more than one application (Efraim Turban, 1993). The data in
the database are stored together with a minimum of redundancy to serve multiple applications, so the database is independent of the computer program that uses it and the type of hardware where it is stored. A database can be defined from several perspectives (Fathansyah, 1999), such as:

- Collection of data group (archives) that related each other, which is organized in such way so that in the future it can be utilized again quickly and easily.
- Collection of interrelated data kept together in such a way without unnecessary redundancy, to fulfill many kinds of needs.
- Collection of files/tables/archives that related each other, kept in electronic storage medium.

DBMS performs three basic functions. It enables storage of data in the database, retrieval of data from the database, and control of the database.

II.3.1 Storage

DBMS varies the configuration of the stored data. Mainframe systems store many large files, each containing many records, each record containing many data items, and the data items containing many characters. The systems for microcomputer offer more constrained capacities because of limited primary and secondary storage spaces. This limitation is becoming less and less factor.

II.3.2 Retrieval

The feature of DBMS most visible to the user is data retrieval. Current DBMS offer great flexibility in terms of how the information is retrieved and displayed. With a sophisticated DBMS, the user can specify certain processing of data and customize the output (e.g., reports or graphs) in terms of heading and spacing.

II.3.3 Control

Much of the control activity of the DBMS is invisible to users. The users ask for some information and receive it without knowing the process that the DBMS has performed. The DBMS can be designed to screen each request for information and determine that (1) the person making the request is indeed an authorized user, (2) the person has access to requested file, and (3) the person has access to the requested data items in the file. A mainframe DBMS might perform all the control functions very well.
There are some capabilities of DBMS in DSS (Efraim Turban, 1993)
- Captures/extract data for inclusion in a DSS database
- Quickly updates (adds, deletes, changes) data records and files
- Interrelates data from different sources
- Quickly retrieves data from a database for queries and reports
- Provides comprehensive data security (protection from unauthorized access, recovery capabilities, etc.)
- Handles personal and unofficial data so that users can experiment with alternative solutions based on their own judgment
- Performs complex retrieval and data manipulation tasks based on queries
- Tracks usage of data.

II.4 Monitoring Coral reef

Managing the coral reef need to balance between sustainability and conservation of coral reefs, therefore the relations between human behavior and reef ecosystems are critical. Reefs condition is strongly influenced by human activities and environmental conditions in which poverty level contained in the coastal areas and small islands highly dependent on the presence of coastal and marine resources. There are close links how coastal communities in the use of coral reefs and social conditions of its economy.

Due communities are not yet know and understand the importance function of coral reefs. Moreover, many institutions in the national and locally yet have enough data and accurate about the potential and status of coral reefs and other marine resources. Sustainable use and protection of coral reefs, policy makers need to know (GCRMN, 2000):
- Status of coral reefs and changes in the health of coral reef and reef fish.
- Condition of the people that use and affect coral reef include the ability to use, perception of management and characteristics of the people who feel the impact of coral reef.

II.4.1 Monitoring with Remote Sensing Data

Coral reefs monitoring conducted by direct measurement method, field and remote sensing technology and geographic information systems. Use of remote
Sensing technology is one method more practical and efficient because it can cover vast areas and distances (Lehmann et al., 1997, Stoffle et al., 1994).

Satellites collect data from extensive geographical areas in very short periods. These data consist primarily of electronic records of the intensities of electromagnetic radiation reflected or emitted from the earth's surface through the atmosphere to the satellite. Taken repetitively, these data may help identify and monitor changes in the average amount of radiation recorded from analytical units called pixels. However, the satellites can neither interpret what is observed in ecological terms nor explain what has caused the observed changes (Stoffle et al., 1994).

Some combination methods and data analysis model has been carried out to obtain the expected aims using of satellite imagery. This is closely related to the ability of satellite imagery that can provide spatial information in serial and the information contained in coral reefs. Application of the model was performed for determine many marine protected areas and monitoring of coral reefs, and results helpful for management of coral reefs (Scopélitis et al., 2007, Serge Andrefouet, 2006, Wood et al., 2007).

Numerous theoretical studies have been undertaken to obtain a model for extracting bathymetry and substrate information from passive multispectral remotely-sensed data (Jupp D.L.B., 1988, Lyzenga, 1978, Lyzenga, 1981). Simple algorithms have been implemented in an attempt to map the bathymetry, assess water turbidity, and map the type of substrate. Algorithms which have been used successfully in the mapping of the coral reef substrate include band-ratioing and the creation of pseudo-bands from the original spectral bands (Jupp D.L.B., 1988, Jupp, 1985). However, the existence of water turbidity, the effects of the atmosphere on the radiation emerging from the water column, and the mixing of different reef substrates within a given pixel will often limit the effectiveness of many such algorithms.

Some study have been conducted related to water zone study using Landsat Satellite. For example, (Siregar V.P., 1996) conducted the coral reef ecosystem classification using joint algorithmic band 1 and 2 (visible) from landsat-TM data, (Jupp, D.L.B., 1988) developed depth of penetration model for water depth crude
measurement using visible band and close infra red from Landsat-TM, and (Lyzenga, 1978) made water column correction using seichi-disk transparency (SDT) to show the transparency level of the water with visible band ratio.

Remote sensing has been touted to provide information on several parameters that are of importance to reef management. Those are coral reef boundaries, may be used for routing planning requirements and locating the boundaries of management zoning schemes, geomorphologic zone of the reef (e.g. reef flat, reef crest, spur and groove zone), ecological component and determination of live-coral cover. Ecological component may be defined in several ways, such as assemblages of coral species, assemblages of major reef-dwelling organisms, or assemblages of species and substrata (Edmund P. Green et al., 2000).

Figure 2 Cross Section Through a Coral Reef Showing the Major Zones (Jos Hill et al., 2004)

II.4.2 Socio-economic Condition

Socio-economic conditions are a way to identify aspects of social, cultural, economic and political conditions of individuals, groups, communities, and organizations. There is no standard in examining the topic of socio-economic conditions, but is commonly used for identification of topic such as the use of resources, characteristics of stakeholders, gender issues, stakeholder perceptions, organization and administration skills, traditional knowledge, service and public
facilities, components for use in market more broadly, outside the market value and which are not used. Understanding socio-economic conditions are important in the inventory, predict and manage coral reefs.

Information on socio-economic provide guidance to stakeholders for (GCRMN, 2000):

- Determine the relevant stakeholder groups, and concerned in the management process. This will increase the legitimacy of that decision making and adherence to rules and regulations become more stringent.
- Determine the effects of management decisions to the stakeholders, which will improve policy decisions to minimize impacts and maximize benefits to stakeholders.
- Shows the value of coral reef resources and services to the general public, stakeholder groups and policy makers, which will generate greater support for coral reef management programs.

The linkage between human activities and coral reef ecosystem is very important. That is because the corals are not only influenced by human activities, but also the livelihoods and welfare of the people living in coastal areas depend on marine resources including coral reef. How humans use and use of coral reef and related ecosystems and social background of its economy. Knowing the socio-economic background of the stakeholders is important to make a prediction and planning management.

In addition to data from the field, a social assessment also requires the collection of secondary data which includes the existing statistical data, research reports already published, various kinds of documentation, various kinds of maps, data and documentation of historical and existing web data. All secondary data are required, among others; to support field data will be collected. In addition, by first collecting data that already exists, not to repeat the same thing ever done by others. Various kinds of secondary data is compiled, reviewed and evaluated.

Meanwhile, the field of data can be collected through various techniques of data collection, including observation, depth interviews, focus group discussion (FGD) and a survey. Besides collecting data can also be done with various
methods of collecting qualitative data such as maps, historical transect, and Venn diagrams.

Observation is a qualitative description of what researchers see and observe in the study area. Observation is important because by doing observations researchers could quickly find out what community activities related to the utilization of marine resources. Depth interviews were conducted using an interview guide that had been prepared beforehand. By conducting in-depth interviews are the benefits that can be obtained by researchers could delve more deeply into the respondent answers at once to check and re-check the answers in the can. Meanwhile, one of the FGD is a qualitative data collection technique by interviewing approximately four to 10 people who should have the same background. As well as in-depth interviews, FGD is based on interview guides that have been prepared beforehand. Advantages of this technique are able to dig deeper than all of the information also enables the exchange of information through the interaction between them. Survey were conducted with structured questionnaires that had been prepared this questionnaire is usually designed with answers that are already available (choose) or filled with short answers (COREMAP LIPI, 2002).

II.4.3 Coral Reef Condition

The aim of any coral reef ecosystem assessment program is to distinguish relevant biological signals from caused by natural spatial and temporal variations. In choosing biological indicators, one should focus on attributes that are sensitive to the underlying condition of interest (e.g., human influences) but insensitive to extraneous conditions. Faced with the dizzying number of variables, disturbances, endpoints, and processes, marine managers and researchers have periodically failed to choose those attributes that give the clearest signals of human impact (Ruitenbeek at al., 2000).

The first step towards effective biological monitoring and assessment is to realize that the goal is to measure and evaluate the consequences of human actions on biological systems. The relevant measurement endpoint for continue biological monitoring is biological condition. Detecting change at the endpoint, comparing the change with a minimally disturbed baseline condition, identifying the causes
of the change, and communicating these findings to policy makers and citizens are the tasks of biological monitoring programs (Ruitenbeek et al., 2000).

Several ways and methods have been introduced by the experts to conduct an inventory of coral reefs including Line Intercept Transect (LIT) (English et al., 1997), Reef Rapid Assessment (RRA), Manta tow and Reef Check (COREMAP LIPI, 2002, Hodgson et al., 2004).

II.4.4 Decision Support to Monitoring Coral Reefs

As a policy maker, government has an important role in any integrated management process (Figure 3). It is also implemented in an integrated coastal management (ICM). Greater emphasis on performance can help make ICM more oriented toward outcome-based results rather than on input-based accounting. Too often, the performance of ICM initiatives has been based on the level of investments, the number of permits issued for coastal development, or the number of laws and regulations adopted. These “input” measures may or may not be indicative of success. Actual success in both environmental and socio-economic terms can only be judged “on the ground”, as a matter of outcomes and impacts.

Outcomes should be measured in terms of improved water quality, increased public access to beaches, decreased habitat loss, reduced coastal hazards, or increased employment in coastal related activities (Ehler, 2003).

![Figure 3 The ICM Policy Cycle. (Ehler, 2003)](image-url)

In an evaluation of performance management the government requires tools that can be used for understanding of coral reefs management. Tables 2 provide causes and consequences of environmental change on coral reef.

It is essential to re-evaluate the experimental design each year to assess the strength of statistical tests to detect changes. Additional stations need to be added to increase the statistical power needed.
Table 2 Matching Management Problems on Coral Reefs to the Available Toolbox (Jos Hill, 2004).

<table>
<thead>
<tr>
<th>Documented problem and cause</th>
<th>Expected consequences</th>
<th>Management tools</th>
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<tr>
<td><strong>Global</strong></td>
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<tr>
<td>Ocean acidification (rising carbon dioxide concentration)</td>
<td>↑ Disease and fragility in calcifying organism; ↓ reduced rate of calcifying organism; ↓ disease in calcifying organism; ↓ reduced coral-based services; ↑ flooding; ↑ coastal erosion; ↓ land area; ↑ Economic hardship for fisheries; ↓ biodiversity and ecosystem function</td>
<td>No direct, short-term solution (NS); facilitate coral recovery by managing herbivores and water quality (RECOVERY)</td>
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<tr>
<td>Coral bleaching</td>
<td></td>
<td>No; RECOVERY; place MRs in areas of low thermal stress</td>
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<tr>
<td>Sea-level rise (global warming)</td>
<td></td>
<td>NS; RECOVERY; sea defences</td>
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<tr>
<td>Low fisheries yield (overfishing)</td>
<td></td>
<td>↓ Fishing effort (EFFORT); MRs; ↓ loss of mangrove nursery habitats; ↑ alternative livelihoods; ↓ international export of reef fishes</td>
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<tr>
<td><strong>Local</strong></td>
<td></td>
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<tr>
<td>Crown-of-thorns starfish outbreaks (agricultural runoff and/or fishing of predators)</td>
<td>↓ Reduced coral-based services; ↑ land area; ↑ Economic hardship for fisheries; ↓ biodiversity and ecosystem function</td>
<td>Watershed management (WATER); EFFORT</td>
</tr>
<tr>
<td>Algal blooms (fishing of herbivores, eutrophication)</td>
<td>↓ Reduced coral-based services; ↓ public health</td>
<td>WATER; EFFORT; RECOVERY</td>
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<tr>
<td>Rising number and prevalence of diseases (high physiological stress; nutrient runoff)</td>
<td>↓ Reduced coral-based services</td>
<td>NS; WATER; RECOVERY</td>
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<tr>
<td>Tropical cyclone damage (release of ballast; aquarium discharge)</td>
<td>Areas of extensive coral mortality; reduce resilience of reefs locally Disease (e.g. loss of Caribbean Diadema) disrupt trophic pathways (e.g. novel predator Pterois volitans in Bahamas)</td>
<td>NS; RECOVERY</td>
</tr>
<tr>
<td>Invasive species (release of ballast; aquarium discharge)</td>
<td></td>
<td>Enforce and implement controls to ballast water treatment.</td>
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↑ and ↓ denote increasing and decreasing, respectively. Management tools are described once and given a code (in capitals) which is used thereafter. MR = marine reserves.

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The decision support system consists of the following (Ruitenbeek et al., 2000):
- A user interface;
- The computational model in database
- The database of model parameters
- The database of information contain in interactive text and graphic file available to the user.

The steps involved in the analysis for decision support development can be seen in figure 4. The interface helps the user to assess the problems and issues found in coastal zone and define the objectives of the analysis and the criteria or indicators with which to measure the success of each plan. The user definitions include scenario, economic-development and environmental protection option. The user can work through different option, saving each with a name and a description.
The user definitions (scenario, economic development and environmental protection option) drive the socio-economic model, which results in a set of impacts distributed over the area. These used as input into the ecological response model, which estimates changes in the reef health over the impact areas. The change will affect the health of the reef fisheries, which has a feedback effect on commercial fisheries production. The cost of the environmental protection option and the changes in the reef health are considered in the cost effectiveness analysis.

Figure 4 Structure of the Coral Decision Support System (Ruitenbeek et al., 2000)