II. LITERATURE REVIEW

2.1. Mangrove

2.1.1. Mangrove Ecosystem

Mangroves are located in the brackish water margin between land and sea in tropical and subtropical areas. Mangroves are found to grow on a variety of substrates such as mud, sand, reef flat and even on relatively solid rock. They are well developed on protected muddy coastal plains having adequate fresh river water discharge. Mangroves are highly productive ecosystems, provide critical habitat for a diverse marine and terrestrial flora and fauna, provide valuable habitat for fisheries and shorebirds (Choudhury and Junaid, 2002).

Mangrove forests are unique natural ecosystems and have high ecological and economical values. Mangrove forest as sources of energy material are used for private home or industry (fuel wood, charcoal, paper material or rayon) which have high economic value, and also have very important ecological functions (sources of nutrient, spawning ground, nursery ground, and feeding grounds) some of marine and brackish biota. Aside from this, mangrove forest plays a role as abrasion defense of land area behind this ecosystem. These rich ecosystems provide a variety of economic and environmental services and products. In addition to their direct values, mangroves also support other ecosystems such as coastal fisheries, thereby indirectly sustaining a wide range of social and economic activities (Suthawan, S., 1997).
2.1. 2. Functions and Values of Mangroves

The values of mangroves are recognized as tangible and intangible benefits (Choudhury and Junaid, 2002). The forest of the mangrove ecosystem is capable to yield the following tangible or direct benefits:

- Lumber or similar construction wood;
- Poles, fuel wood, fishing gear, etc.;
- Raw materials for the wood-based industry of various nature and including board mills, rayon mills, match factories and charcoal products, etc.;
- Non-timber products including tannin (mostly from bark) to supply raw materials for leather tanning industries, fishing net processing units, thatching material for roofing and raw materials for indigenous medicine;
- Edible products including honey and wax, meat and fish, fruits, drinks and sugar.

The mangrove ecosystem can yield the following intangible or indirect benefits:

- Natural spawning ground for fish and crustaceans, especially for shrimps and prawns, protection and conservation of wildlife habitats of a rare nature, control and regulation of the food chain in stores;
- Contribution to mud flat formation and control of erosion;
- Capability to check inland salinity intrusion;
- Enhanced capability to combat the impact of cyclone and tidal surge;
- Enhanced capability to function as a shelterbelt during storms, hurricane and cyclones.
Dahuri (2001) reported on the functions and values of mangroves as shown in Figure 1.

- Mangroves are highly productive forests growing along tropical tidal mudflats and coastal shallow water areas extending inland along rivers.
- As an ecosystem, mangrove forms a unique association of plants dominated by the mangrove forests as primary producers interacting with associated fauna and the physical environment.
- Mangrove plants are unique for being able to get established and survive in a waterlogged and saline soil.
- Mangrove ecosystems have extremely high biological productivity in terms of plant growth and all the associated organisms.
- This productivity is translated into useful products for people in the form of wood, fish, crustacean, and other ecological and economic benefits.

**Figure 1. Type of mangrove value (Dahuri, 2001)**

Decreasing “tangibility” of value to individual is related to increasing difficulty of measuring accurate values and finding reliable methods of measurements.
2.1.3. Mangrove Degradation

Mangrove is one of the renewable resources, its condition is affected by regenerating as inflow and loss as outflow. The degradation of mangrove is usually caused by two main factors, natural factors and human factors. Yet, on the mangrove resources, the main factors of degradation are caused by human, such as production activity, exploitation, or caused by non-production activity such as pollution from domestic or industrial waste (Fauzi, 2004).

The major factors that caused mangrove degradation in general, may be enumerated as follows (Choudhury and Junaid, 2002):

a. Population expansion.

Increase of population, coupled with economic growth, inevitably caused the use of mangrove lands for various purposes such as construction of roads, ports and harbors, industries, urbanization, etc.


Alternative uses of mangrove lands, especially for the production of fish and prawns, succeeded in fetching higher monetary gains over a short period and led to the conversion of mangroves to fish ponds. At the same time, the conversion of mangrove lands to salt beds and rice fields brought in higher monetary returns within a short period.

c. Lack of government attention and overall awareness.

Most of the mangrove lands all over the world were left unattended by governments. In most countries, government agencies, until very recently, did not take up the management of mangrove lands and that caused their indiscriminate use leading to serious depletion.
d. **Obscure regulations.**

Government regulations with respect to mangrove lands are often either too complicated or inadequate to ensure the required conservation. This situation led to illegal encroachment of many mangrove lands all over the world.

e. **Inefficient reforestation techniques.**

The reforestation and restoration of degraded mangrove areas and forestation techniques were almost unknown in the recent past. These techniques are yet to be well understood and standardized for most of the mangrove countries in the world, though some progress has been achieved in this respect in a few countries.

f. **Inadequate manpower and logistics:**

The mangrove management agencies, mostly the local forestry departments, very often do not have the adequate manpower and logistics required for the implementation of effective management.

### 2.2. System Dynamics

#### 2.2.1. Terms and Definition

System dynamics is a methodology used to understand how systems change over time (Martin. 1997). The way in which the elements or variables composing a system vary over time is referred to as the behavior of the system. In the field of system dynamics, a system is defined as a collection of elements that continually interact over time to form a unified whole. The underlying relationships and connections between the components of a system are called the **structure** of the system. The term **dynamics** refers to change over time.
System dynamics links the behavior of a system to its underlying structure. Figure 2 shows how the underlying structure of a system determines the system’s behavior. The upward-pointing arrow on the left symbolizes the relationship. The downward-pointing arrow on the right indicates the deeper understanding that is gained from analyzing a system structure. Full understanding can only come when one dives beneath the behavior to understand the structure causing the behavior.

![Diagram showing the link between structure and behavior](Figure 2. The link between structure and behavior (Martin., 1997))

### 2.2.2 The System Dynamics Process

System dynamics is growing at an impressive exponential rate. Interest in system dynamics is spreading as people appreciate its unique ability to represent the real world. It can accept the complexity, nonlinearity, and feedback loop structures that are inherent in social and physical systems. On the other hand, several difficult steps in moving from problem to solution hamper system dynamics. First, and probably most elusive, little guidance exists for converting a real-life situation into a simulation model. At later stages, many system dynamics projects have fallen short of their potential because of failure to gain the understanding and support necessary for implementation. Figure 3 illustrates the system dynamics steps (Forrester, 1992).
STEP 1. Describe the system

An investigation starts at Step 1 motivated by undesirable system behavior that is to be understood and corrected. Understanding comes first, but the goal is improvement. System dynamics appeals to activists, it is undertaken for a purpose. At the first step, the relevant system must be described and a hypothesis (theory) generated for how the system is creating the troubling behavior.

STEP 2. Convert description to level and rate equations

This step is to begin formulation of a simulation model. The system description is translated into the level and rate equations of a system dynamics model. Creating the simulation model requires that the rather general and incomplete description of Step 1 be made explicit. As with every step, active recycling occurs back to prior steps. In Step 2, writing equations reveals gaps and inconsistencies that must be remedied in the prior description.
STEP 3. Simulate the model

Simulation of the model can start after the equations of Step 2 pass the logical criteria of an operable model, such as all variables being defined, none defined more than once, no simultaneous equations, and consistent units of measure. System dynamics software packages provide such logical checks. Simulation may at first exhibit unrealistic behavior. As a result, simulation leads back to the problem description and to refinement of the equations. Step 3 should conform to an important element of good system dynamics practice; the simulation should show how the difficulty under consideration is being generated in the real system. Unlike methodologies that focus only on an ideal future condition for a system, system dynamics should reveal the way we arrived at the present and then, in a later step, the path that leads to improvement. The first simulations at Step 3 will raise questions that cause repeated returns to Steps 1 and 2 until the model becomes adequate for the purpose under consideration. There is no way to prove validity of a theory that purports to represent behavior in the real world. One can achieve only a degree of confidence in a model that is a compromise between adequacy and the time and cost of further improvement. The proper basis of comparison lies between the simulation model and the model that would otherwise be used.

STEP 4. Design alternative policies and structures

This step identifies policy alternatives for testing. Simulation tests determine which policies show the greatest promise. The alternatives
may come from intuitive insights generated during the first three stages, from experience of the analyst, from proposals advanced by people in the operating system, or by an exhaustive automatic testing of parameter changes. The system dynamics will continue to rest on experience, art, and skill for imagining the most creative and powerful policy alternatives. Automatic parameter searching will be of limited usefulness. In the more complex systems, there will be many competing criteria for defining success; also, there will be many peaks in the multi-dimensional behavior map so that the most favorable performance may depend on several simultaneous changes in the model. In addition, the best alternative behaviors will often come from changing the system structure.

STEP 5. Educate and debate

Step 5 presents the greatest challenge to leadership and coordinating skills. The model will show how the system is causing the troubles that are being encountered. Implementation often involves reversing deeply embedded policies and strongly held emotional beliefs. Even with widespread intellectual agreement with a system dynamics model and with the recommended improved policies, there may still be great discomfort with the prospect of changing from traditional actions. To overcome both active and passive resistance requires sufficient duration and intensity of education and debate to reverse traditional practices.

STEP 6. Implement changes in policies and structure
This step is implements the new policies. Difficulties at Step 6 will arise mostly from deficiencies in one of the prior steps. If the model is relevant and persuasive, and if education in Step 5 has been sufficient, then Step 6 can progress smoothly. Even so, implementation may take a very long time. Old policies must be rooted out. New policies will require creation of new information sources and training. Evaluation of the policy changes comes after implementation. As with determining model adequacy, evaluation has no clear procedures, nor can one expect a conclusive outcome. While the new policies are being implemented and used, a process that can take several years, many other changes will have occurred in the system and its environment. Even when performance is unambiguously better, some people will claim that credit should go to changes, other than the new policies, that occurred during the system dynamics project. The evaluation may even rest on results other than those for which the project was undertaken.

2.2.3. Simulation Model

The purpose of a simulation is to simulate (or to imitate or to mimic) the real system so that its behavior can be studied. The model is a laboratory replica of the real system, a microworld (Sterman., 1991). By creating a representation of the system in the laboratory, a modeler can perform experiments that are impossible, unethical, or prohibitively expensive in the real world.

Simulations of physical systems are commonplace and range. There are many different simulation techniques, including stochastic modeling, system
dynamics, discrete simulation, and role-playing games. Despite the differences among them, all simulation techniques share a common approach to modeling. A Simulation models are descriptive, does not calculate what should be done to reach a particular goal, but clarifies what would happen in a given situation. The purpose of simulations may be foresight (predicting how systems might behave in the future under assumed conditions) or policy design (designing new decision-making strategies or organizational structures and evaluating their effects on the behavior of the system).

Given the physical structure of the system and the decision-making rules, the simulation model then plays the role of the decision makers, mimicking their decisions. In the model, as in the real world, the nature and quality of the information available to decision makers will depend on the state of the system. The output of the model will be a description of expected decisions. Comparing the output with the decisions made in the real system can check the validity of the model’s assumptions.

The steps of the simulation as the following below (Muhammadi, et al, 1991):

1. **Concept Arrangement.**

Important to understand about an indication or a process which will be simulating, what are the parameters and the role of them? One and another of the parameters are interaction, related to something, dependence, and allied to activity. Based on the parameters and it’s related, the idea or concept of the indication which will be simulated can be arrange.
2. **Model Building.**

The idea or the concept about an indication or a process is simulated as model with descriptions, figures, or formulas. Model means any form or shape that make for imitate of an indication or a process. Model can be divided into quantitative model, qualitative, and iconic. Quantitative model is the model performed as figures, diagrams, or metrics that is relation of each parameter. Qualitative model does not use mathematical formula, statistic, or computer. Iconic model has the physical shape is equal with the original was simulated, although the scale can be adjusted bigger or smaller.

3. **Simulation.**

The next step after building of the model is to make the simulation. On quantitative model, the simulation by putting of the data into model, where calculate to use the behavior of indication or process. On qualitative models, the ways of simulation are to trace and putting of data or information collected analysis of the causal correlation of each parameter by putting of data or information to know behavior of the indication or process. On the iconic models, the simulation be used physical trial of the model to know how the model behaviors on different conditions.

4. **Validation.**

Validation means to know how the suitability between simulation result and indication or process was simulated. The model is good if the error of simulation result concerning the indication or process is small.
Simplification of the model simulation steps (Muhammad, et al, 1991) can be looking on the Figure 4 below:

Figure 4. Steps of model simulation (Muhammad, et al, 1991)