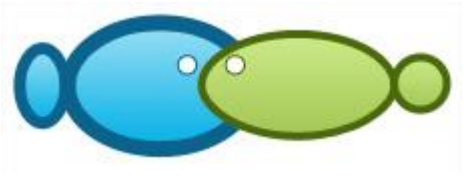

Sustainable development model of small outermost islands in Indonesia: study case of Enggano Island, Bengkulu Province development simulation model

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Abstract. The Republic of Indonesia is known as one of the most significant archipelago countries and it consists of approximately 17500 islands. The development of small islands, especially islands located in the outermost regions of the archipelago, should address three functions - social, economic, and environmental - if the development of a small outermost island is intended to be sustainable. However, the paradigm of small island development is more emphasized mainly on the economic function. This research aims to provide a tool for the policy and management of small islands, using the system dynamics method to assure the sustainable development of small islands based on fishery and/or tourism industries. The use of the dynamics system method is based on its ability to recognize elements and the interaction between components of the system and can be applied using computer simulations. The development model of small islands consists of 5 sub-models, that are fishery industry, tourism industry, population, economy and environment. The simulated scenarios were the business-as-usual scenario, acceleration program of the fishery industry, acceleration program of the tourism industry, economic program, environmental conservation program, and combination of the previous programs as sustainable fishery and tourism industries. The results showed that the acceleration program of the fishery industry or acceleration program of the tourism industry itself could support the growth and become a significant revenue source to increase GDP at the expense of a declining ecosystem. However, the combined programs could be able to increase the value of GDP significantly and developed fishery and tourism industries without damaging the environment, but still being socially acceptable. These two sectors could be expanded and could play an essential role in economic growth activities while maintaining the capacity of environmental services to support human well-being. Moreover, this model could also be able to provide policy options for minimizing the ecological impact.
Key Words: small islands, system dynamics, sustainable development.

Introduction. Sustainable development is a commitment of the world community. Presently, some developed and developing countries, including Indonesia, have embraced the concept of sustainable development. Initially, understanding and accepting the idea only focused on the environmental dimension. Later, the belief that sustainable development is a process of development that integrates the goals of economic development, social, cultural and ecological sustainability was reached. It was also recognized that achieving sustainable development requires policies that involve all sectors of development at all levels. Sustainable development is the responsibility of government, business and society (UNDESA 2002). The development of small islands in Indonesia should also address the three essential functions of sustainable development, which are economic, social and ecological functions (Lestari et al 2003a). Some other roles of a small outer island are defence and security. The paradigm development of small islands used to have more emphasis on the economic function. In the economic role, small islands have a great opportunity to be developed as potential business areas based on natural resources.

The development of the economic sector, which emphasizes fishery and tourism industries in small islands, might be critical (KLH 2003). The paradox is that the development to increase the economic sector is necessary for coastal communities on these islands, but on the other hand, this development may decrease the environment quality required to support human well-being. Croes (2016) stated that tourism development might generate more income for communities, businesses and government; however, the welfare of the residents would not necessarily be improved. (Estrella et al 2015) noted the importance of community access to natural capital, social capital, financial capital, human capital and physical capital on the sustainability of community livelihood and the capability of managing natural resources sustainably. Therefore, the development of small islands should be done carefully and considering the fragile environmental characteristics of small islands and socio-cultural aspects of the residents.

The unique natural features and exotic landscapes of small islands make them a candidate for desirable tourist destinations, offering great experiences to tourists (Boukas & Ziakas 2016). Therefore, one of the development routes for small islands may be the development of the tourism industry in addition to the fishery industry. Nowadays, the development of small islands in Indonesia is still a dilemmatic problem, some issues being represented by the optimization and utilization of natural resources for the welfare of the community, regional and national economic growth and conserving the limited capacity of natural resources to support human well-being. It is essential to balance the need for economic growth to accommodate the increasing human population with the limited natural resources and environmental services in the development of small islands. According to (Katsoni & Stratigea 2015), it is essential to raise awareness regarding the necessity for integrated and long-term perspectives towards the sustainable use of local assets, environment and development of small islands. The small island development affects social, cultural, economic and environmental aspects and should be examined before policies are adopted and implemented.

Given the complexity and the high interrelationship among the ecological, social, cultural and economic aspects in small island development, involving a variety of stakeholders, including private sectors, communities and government, the formulation of policies must be managed through a systematic approach (Eriyatno 2003). Jackson (2006) suggests that systematic thinking can be a guide in using the system theory, methodology, and methods in developing effective policy. Checkland (1999) and Christis (2005) state that the issue is complex and unstructured and can be dealt with by using a soft system methodology. It is expected that the development of small islands can achieve conservation goals, provide social and economic benefits for society, business and government sustainably.

The objective of this study is to provide a reference that could be used as a policy for the management of small islands using a system dynamics approach. Ultimately, this research is expected to give input and understanding of policy related to the development programs of the small outer islands that had been given much attention from the Indonesian government. The development program of the small outer island has the primary goal of increasing economic growth as indicated by the GDP (Gross Regional Domestic Product) (Lestari et al 2003b). The growth of GDP is presumed to be based on two flagship sectors, the fishery industry and maritime tourism (KLH dan FPIK-IPB 2003).

Material and Method

Description of the study site. The study was conducted in Enggano Island, Indonesia (Figure 1). The structure of the outer small island development model was organized based on planning documents and government rules that had been established to regulate the management of the island. This model has causal interactions between environmental factors, flagship development sectors in small islands and socio-economic factors. Furthermore, this model consists of five sub-models, which are: (1) fishery industry, (2) tourism industry (3) population, (4) economy and (5) environment. The structure of the development model described in the causal loop diagram can be seen in Figure 1. The picture describes a model of development of the small outer island,

composed of six components forming nine causal loops, arranged by six positive feedback loops and three negative feedback loops. A negative feedback loop would produce a goal achievement pattern, while a positive feedback loop would result from a growth pattern.

Enggano Island is one of the small outermost islands of Bengkulu Province. Administratively, Enggano Island is a sub-district under the administration of the North Bengkulu Regency. Enggano Island is located in the Indian Ocean, at 05°31'13'' South latitude and 102°16'00'' East longitude. This research was conducted for 2 years, 2016 to 2017.

Data manipulation and analysis. The information was determined from secondary and primary data. Secondary data were obtained from various literature and databases (BAPPEDA 2002; BALITBANGDA 2004). The collection of primary data was done using the interview method.

According to (Tasrif 2005), steps for building a system dynamics model are:

1. Identifying variables that might influence the evolution of the system. The variables included social, economic, and environmental aspects. Based on this finding, a mental model of small island development was constructed.

2. After having mental models, causal influences of variables based on expert judgment were used to build a causal loop diagram of the model (Figure 1). Experts were requested to examine the influence direction of each variable on the other variables. This causal loop diagram showed the relation between the variables of the model. The fundamental principle of constructing the model was that the cause would affect the level condition, as the cause would produce the process. The dynamic model consisted of levels, rates, auxiliaries, and constants.

3. A causal loop diagram (CLD) is used to understand and analyze complex systems. It helps identify key variables in a system and shows the cause and effect relationships between the variables. There are four basic elements in a causal loop diagram: the variables, the links between them, the sign on the links, and the sign of the loop, which is a type of behavior the system produces. After translating the causal loop diagram into a computer model, the behaviour of the model is validated using the existing data. When the model could generate data that was not significantly different from the existing data, computer modeling could be used to simulate the scenario of the small island development.

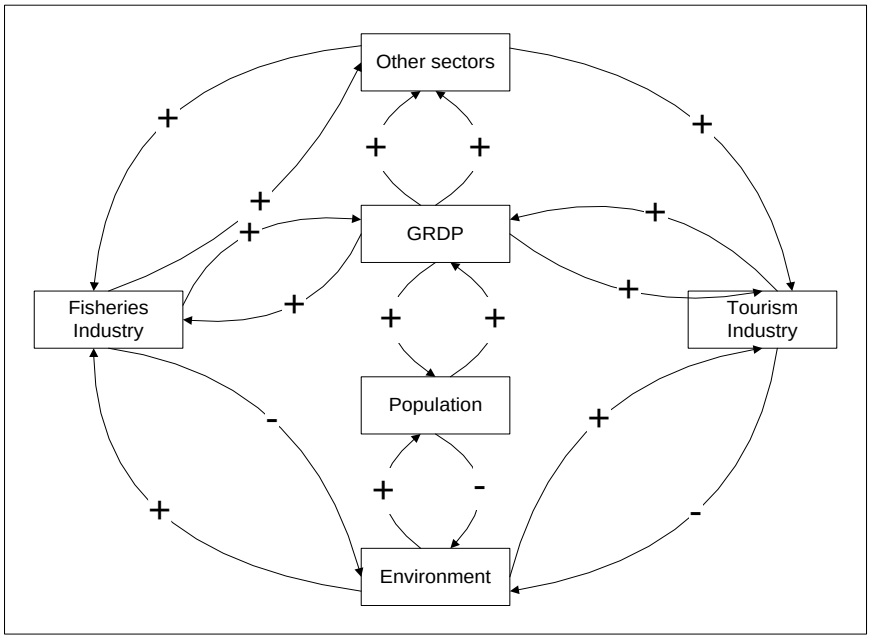

Figure 1. Causal loop diagram of the outermost small island development model structure.

4. Implementation of the model to simulate six scenarios were carried out to observe the response of the system. Five scenarios were performed by changing the essential variables with the assumption that they were considered to represent policy intervention on the model structure, in the hope that these changes would improve the behavior of the basic model. The initial vision of the concept of Enggano Island Development, namely the achievement of economic development without damaging environmental assets, was considered when compiling various alternative policy scenarios. Scenarios used to simulate the model were:

1. The base scenario consists in a "business as usual" policy.
2. Acceleration program of the fishery industry. The 2nd scenario describes the Fishery Industry Improvement Program. The increased fishing industry is done by increasing the initial vessel unit from 30 units to 50 units and by the addition of fishing gear aids for improving the catch.
3. Acceleration program of the tourism industry. The 3rd scenario describes the Tourism Industry Improvement Program. This scenario increases the number of tourists from 50 tourists per week to 100 tourists per week by reducing the lower limit of tourist expenditures from 100 USD to 80 USD.
4. Economic program. The 4th scenario describes the Economic Policy Acceleration Program. This scenario illustrates the economic policy that would increase the linkage ratio of two leading industrial sectors. The linkage ratio of the fishery industry to other sectors is increased from 2% to 4%. The linkage ratio of the tourism industry to other sectors is also increased from 1% to 5%.
5. Environmental conservation program. The 5th scenario describes the Environmental Awareness Improvement Program. Economic development always has an impact on environmental damage. The adverse effects of economic development programs minimize by raising public awareness regarding the importance of ecological roles. This environmental program is aimed to reduce damage to two essential ecosystems, mangrove forests and coral reefs. The scenarios involve increasing mangrove forests and decreasing the degree of coral reef exploitation from 0.5 to 0.1.
6. Sustainable fishery and tourism industries. The 6th scenario is a combination of policy changes that are used in scenarios two to five.

Results and Discussion. Six policy scenarios were tested by making changes on essential variables with the presumption that changes could represent the intervention policies of the model structure. The base scenario was run to simulate business as usual policy. Intervention policy, as implemented in the 2nd to 6th scenarios, affected the behavior of the business as usual model essentially. The alternative 2nd scenario illustrated an accelerated program of fishery industry. The alternative 3rd scenario illustrated the improvement of the tourism industry. The 4th scenario represented the change in economic policy. This scenario described the economic policies that could improve the linkage ratio of the two superior industries, which were the fishery and tourism industries. The 5th scenario illustrated an increasing of the environmental awareness program. The 6th scenario combined the changes of policies in all other scenarios simultaneously. The simulation of the development model showed that the behavior of the baseline scenario (1st scenario) regarding the two superior sectors could support the growth moderately and become a significant revenue source, increasing the GDP. Furthermore, the application of alternative policy simulationsin the 2nd and 6th scenarios improved the performance of the GDP indicator, while conserving environment factors.

The simulation results of all scenarios regarding the fishing industry are presented in Figure 2. The 3rd, 4th, and 5th policy scenarios do not change the development because of the acceleration program of the fishery industry, while the 2nd and 6th scenarios had a development of the fishery industry higher than in other scenarios. It is precisely demonstrated that the policy for the fishery sector program in the 2nd scenario and 6th scenario had been successfully able to promote the development of the fishery industry, while other scenarios did not have a significant impact.

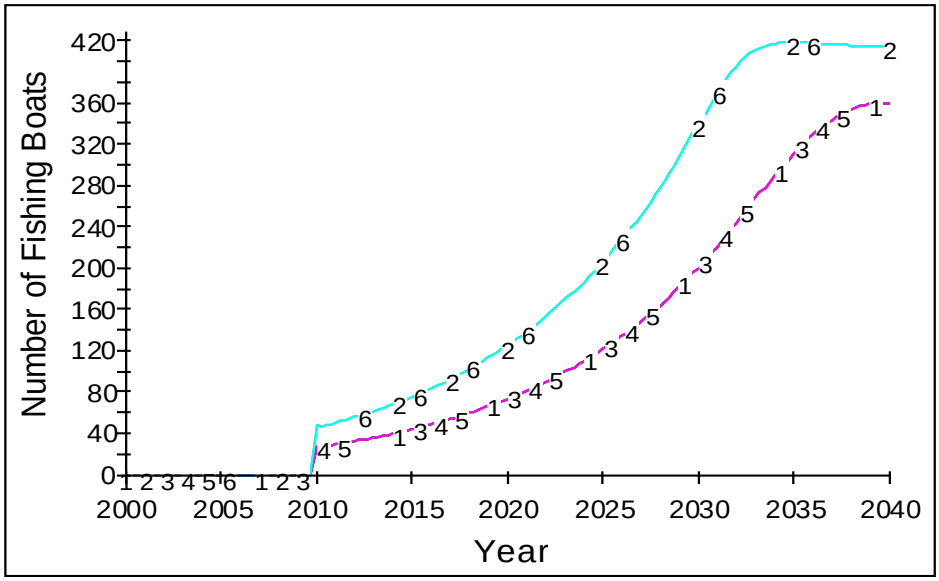

Figure 2. Dynamics of the fishing industry from the 1st to 6th scenario.

The policy improvement program of the tourism industry in the 3rd scenario has been successfully able to increase the number of tourists yearly, while the combination of policies in the 6th scenario presents the highest growth. The dynamics of the tourism industry in each scenario is presented in Figure 3. The development of the tourism industry can also support the growth of the GDP. This simulation result was similar with the results from other studies (Fauzel 2016). The tourism industry development triggered economic growth and investment in the tourism sector.

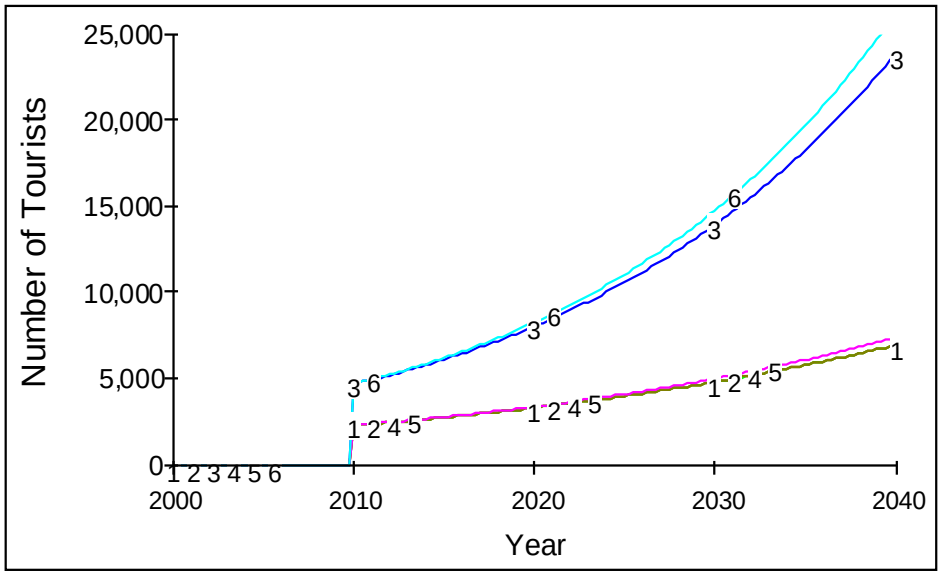

Figure 3. Dynamics of the tourism industry from the 1st to 6th scenario.

The simulation results of the population in various policy scenarios are presented in Figure 4. Only the 3rd and 6th scenarios can increase the growth of the population. The 2nd, 4th and 5th scenarios exhibit similar behavior as the base scenario. In the economic development of small islands, labor demand-driven migration may occur, as economic activities increase on the island. The migration of the people to the island caused the increase of population, and it seems that it slows the growth of GDP per capita. According to Alberts (2016), a more educated workforce and effective government administration to regulate the migration of the people may increase productivity and real GDP per capita.

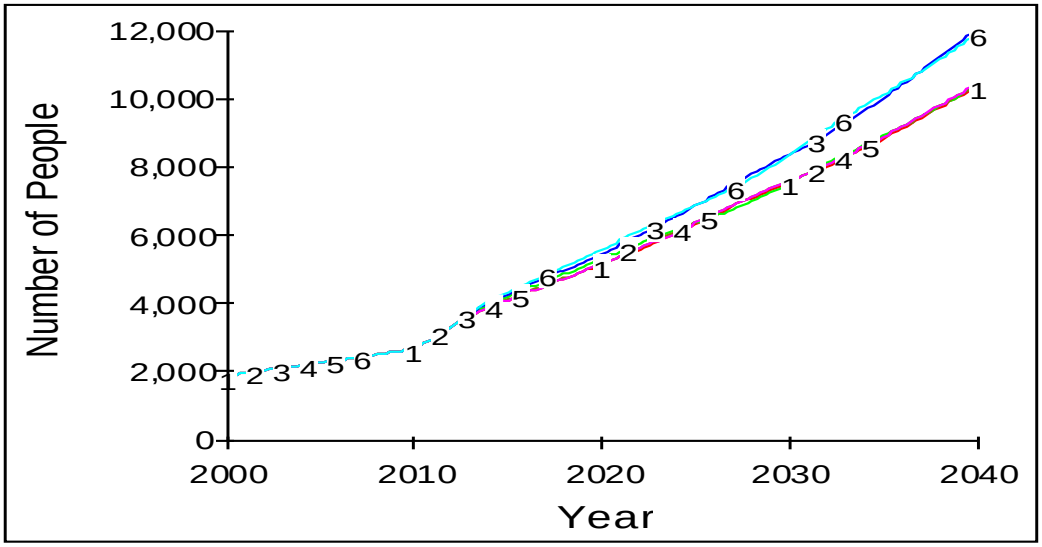

Figure 4. Population dynamics from the 1st to 6th scenario.

The simulation results of the economic program showed that the development of sectoral promotion programs increased the value of GDP; however, the increase of development programs for the tourism sector increase higher the GDP compared with others. The policies from the 6th scenario have been able to increase the value of the GDP compared with the other scenarios (Figure 5). The 6th scenario shows that the GDP value increased twice in less than ten years. In contrast, the increase in GDP value, which was consistent, did not occur for the GDP per capita, which was relatively small and slow (Figure 6). It was caused by population growth, which was higher when compared with the increase rate of the GDP. The slow growth of GDP/capita may trigger the negative perception of residents on the benefit of tourism development for them. When the attitude of the residents towards tourism development decreases, it may affect the sustainability of the island development (Figueroa & Rotarou 2016).

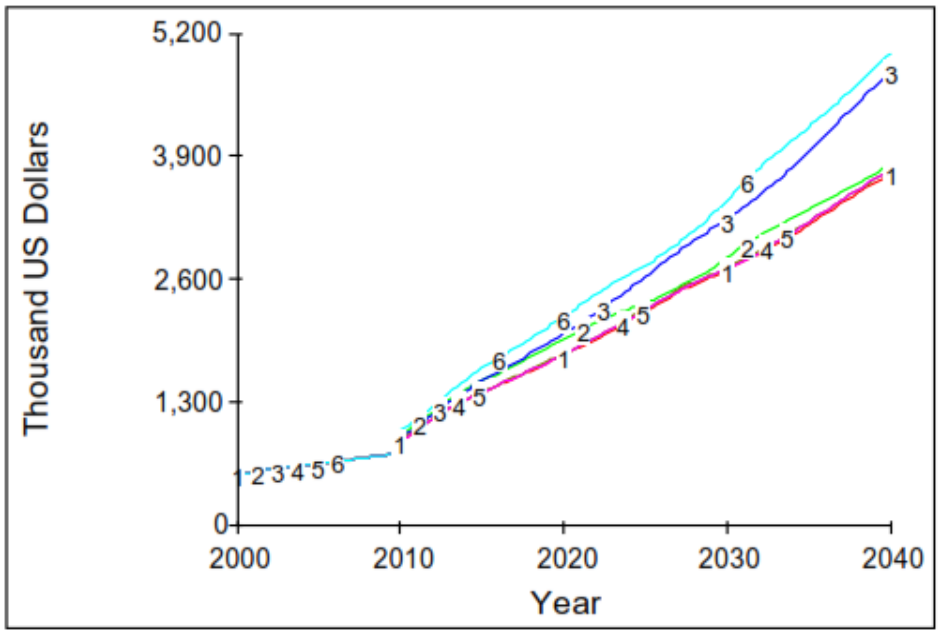

Figure 5. Economic dynamics regarding the GDP from the 1st to 6th scenario.

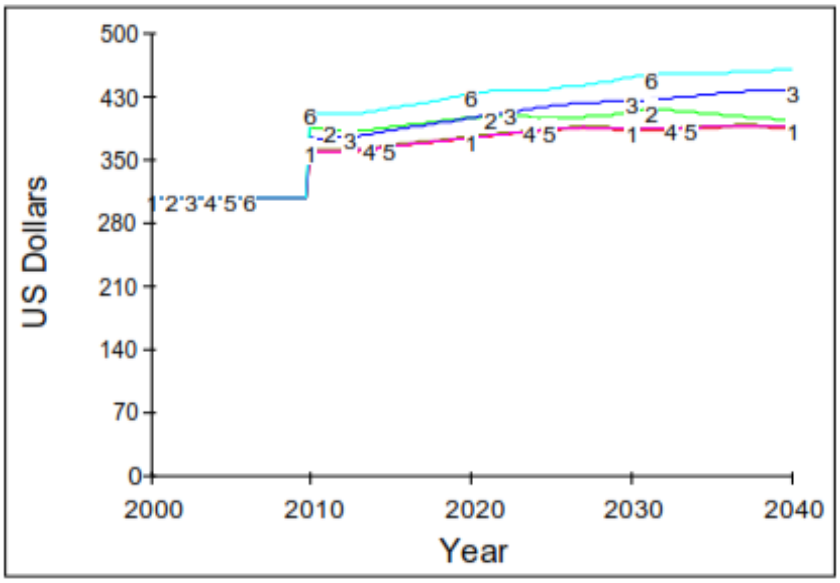

Figure 6. Economic dynamics regarding the GDP/capita from the 1st to 6th scenario.

The environmental awareness program from the 5th scenario and the combination program from the 6th scenario have managed to reduce the level of ecological damage. Conversion of the mangrove ecosystem and the damage to coral reefs decrease in the case of the 2 scenarios (Figure 7; Figure 8).

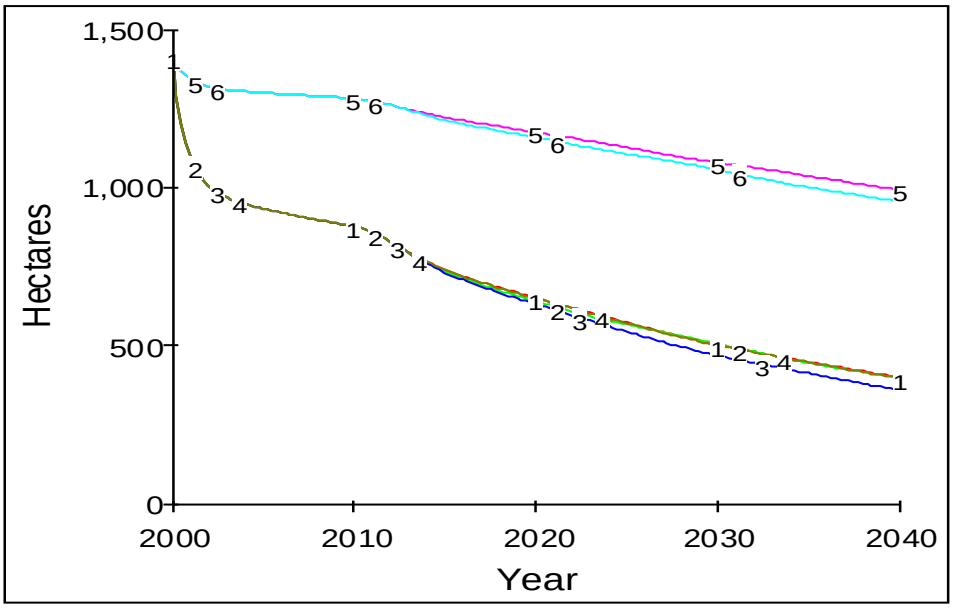

Figure 7. Dynamics of mangrove ecosystem from the 1st to 6th scenario.

The number of simulated tourists increased in the 5th scenario. This result indicates the positive linkage between environmental improvement and tourism industry. The ecological attractiveness of tourism industry in the 5th scenario could increase the number of tourists compared to the base scenario. Similarly, the 6th scenario can increase the number of tourists.

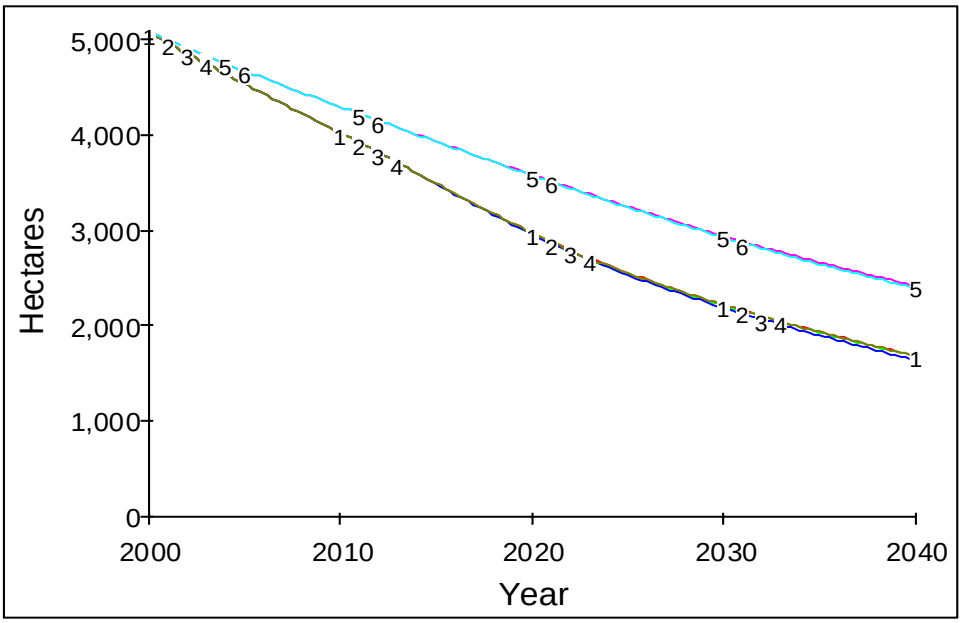

Figure 8. Dynamics of coral reef ecosystem from the 1st to 6th scenario.

Overall, the 6th scenario, which consisted in the sustainable development of the fishery and tourism industries, showed the best possible results. The simulation model could also be able to provide policy options for maximizing economic growth, while minimizing the environmental impact. The 6th scenario also accommodated the increase in population. However, as stated by (Kazakov & Kunc 2016), even if a dynamic strategic configuration has been developed based on anticipating future possible states, the performance of small island development strongly depends on the managerial capabilities of the development actors.

Conclusions. The development model of small outer islands was able to simulate the fishery industry and tourism industry for the sustainable development of a small island. These sectors can develop and play an important role in supporting economic growth, accommodating population growth and conserving the environment. Overall, the development of the two key sectors can increase the value of the GDP significantly. However, the increased GDP is still not able to improve the welfare of the local community. GDP per capita is still relatively low. It was affected by the increased migration rate, because of the improvement in the economic attractiveness of the area.

Evaluation and revitalization of the programs are still needed to increase the commitment of stakeholders to aligning and sustaining the development programs. The Enggano Island development simulation model can help government programs to realize the development of the small outermost islands that have now been prioritized. Concerning this model, it is evident that the very high potential incidence of migration needs to be studied to add a model structure that can limit it. In addition, the development of the two industries, fishery and tourism, harms environmental sustainability. For that reason, it is necessary to add a model structure that can describe the implications of environmental rehabilitation. The structure of this environmental rehabilitation model can refer to efforts of empowering coastal communities or through corporate social responsibility models of established industries.

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