

# Integrated Vulnerability Assessment on Small Island Regions towards Integrated Coastal Zone Management (ICZM): A Case Study of Thousand Islands, Indonesia

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## Abstract

*Centralized development, population growth and pollution are contributing factors to ocean and coastal management problems in Indonesia, particularly in the small island regions. Indonesia, consisting of more than 17,504 small islands, has been adopting and implementing the Integrated Coastal Zone Management program in order to achieve sustainable development. However, many disputes between local communities and governments are observed since Kepulauan Seribu, also known as Thousand Islands, became a Marine National Park in the early 1980s. For a century, the islands located in the northern part of Indonesia's Capital have experienced severe anthropogenic pressures from the surrounding environment, which caused a loss of some islands and the degradation of regional ecosystems. This study aims to assess the social, economic and environmental impacts on Thousand Islands as influenced by anthropogenic factors, using vulnerability indices and Geographic Information Systems. The assessment is based on a qualitative analysis and a survey of decision-makers, aiming to evaluate the policy that has been involved within ocean and coastal management in the region. From the data analysis results, it can be summarized that the region has the sustainability in a social and economic perspective; however, it is the environment that is severely deteriorated. It is found that the policies to maintain the balance of social, economic and environmental impacts have failed in order to overcome the changes. In addition, the ambiguity and powerlessness of law enforcement has caused damage to the environment to some extent. Therefore, coordination between the central government and local governments, as well as public participation is recommended, in order to monitor, evaluate and (if possible) redevelop the region.*

## 1. Introduction

As stated by the European Commission (1996),<sup>1</sup> Integrated Coastal Zone Management (ICZM) is "a continuous process with the general aim of implementing sustainable development in coastal zones and maintaining their diversity". ICZM resulted from the World Summit in 1992 under Agenda 21, Chapter 17, with an intention that "Coastal States commit themselves to integrated management and sustainable development of coastal areas and the marine environment under national jurisdiction" (Johnson, 1993). ICZM was also defined by Cicin-Sain (1993b), Turner and Bower (1999), Vallega (1993) and Vallega (1999) who shared the common aim to achieve this sustainability. In addition, Young (1992) described sustainability as "the integrity of the ecosystems, the efficiency of the economy and the social equity" that needs to be implemented in ICZM. The Earth Summit of 1992, followed by UNCED in 1996, was

the benchmark in ocean and coastal management in terms of sustainability. Based on the results of the Earth Summit meeting, sustainability is a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Vallega, 1999). Despite the wide implementation of this concept in several nations, some problems began to arise in developing countries, as mentioned by Burbridge and Humphrey (1999), Farhan and Lim (2010), Milne et al., (2004), Christie (2005), Pollnac and Pomeroy (2005) and Shipman and Stojanovic (2007). Based on the studies by Cicin-Sain (1993a), Olsen (1993), Lévy (1993), Griffith and Ashe (1993), Turner and Bower (1999) and Westmacott (2002); it can be concluded that at least in developing countries, sustainability for coastal and island management requires the right balance of ecological, social and economic demands under

<sup>1</sup><http://ec.europa.eu/environment/iczm/overview.htm>



sufficient guiding principles. However, in developing countries the economy is one of the most important factors regarding coastal management and also one of the most difficult requirements to be met for sustainability (Daly, 1990, Ollikainen, 1997, Mertz et al., 2009, Somanathan and Sterner, 2006 and Gilpin, 2000). This is because of a government's ambition to increase the nation's economy and gross domestic product (GDP) through infrastructure investment. During the 1970s, Indonesia, being one of the richest providers of natural resources in Southeast Asia for oil, gas, mining and forestry was exploited without regard for environmental concerns and the concept of sustainability. Hence the United Nations Convention on the Law of the Sea (UNCLOS) in 1982 recommended that the Indonesian government act in favor of the protection of marine environments. Despite this, economic development remained the nation's utmost priority. In 1992, the Ministry for Population and the Environment indicated that most Indonesian coral reefs in Weh Island (Aceh), Riau Island (Riau), Thousand Islands (Jakarta), Karimunjawa (Central Java), Karimata Island (Kalimantan), Nusa Tenggara Barat and Western Bali; were decreasing due to coral bombing. The same was occurring in the regions of Maumere Strait (Flores), Bunaken (Sulawesi), Togian (Sulawesi), Tukang Besi (Sulawesi), Taka Bona Rate (Sulawesi), Pombo (Maluku), Kasa (Maluku), Kei (Maluku), Banda (Maluku), Cendrawasih Strait (West Papua), and Raja Ampat (West Papua). Despite the efforts of the government – the 1982 environmental law enactment; the establishment of the Ministry of Environment in 1983, and the Environmental Impact Management Agency in 1990; environmental tax in Indonesia was not strong enough to manage environmental deterioration. Since the 1980s, several Environmental Programs in Indonesia had been solely dependent on non-profit donor agencies, and currently most programs remain discontinued because of insufficient financial support (Tridoyo, 2008, White et al., 2005 and World Bank, 1994). Indonesia had instituted environmental regulations after the Indonesian Cooperation Law No. 23 of 1997 (Purnama, 2003); however, the degradation was unavoidable. The World Bank (1994) reported that 55% of industry on Java Island was located in urban areas, and annual production of manufacturing industry has increased from 1.34% to 4.45% (Indonesia-BPS, 2011). This would simultaneously increase land, water and air pollution. Additional World Bank data (1994) also indicated that pollutants from urban areas in Java had increased exponentially, having

been measured up to 20,000 tons in 1980; 40,000 tons in 1990, and then 100,000 tons in 2000. Alarming, pollutants produced in rural areas amounted to twice that of urban areas, where most of the manufacturing industry is located. In Indonesia, the centralization policy that lasted for 32 years (from 1966 until 1998), had created a large gap between rural and urban areas. The government's sole focus on the development of Java Island and DKI Jakarta (the capital city of Indonesia), led to dense urbanization. Recently, environmental degradation due to the increased population on Java Island became of major concern. Poor water quality due to economic activities is especially of concern, as untreated industrial waste directly pollutes the air and water bodies. Small islands, particularly those near the larger cities, are severely affected by such problems. In addition, geographical isolation and the remoteness of small islands (especially those in the outer island regions of Indonesia), creates difficulty in terms of management and development. In order to overcome this problem, Indonesia thus adopted the Integrated Coastal Zone Management (ICZM) initiative in 1997, as noted by Dutton (1997). Chapter 18 of Agenda 21 has similarities with the *Indonesian Action Plan for Sustainable Development of Marine and Coastal Resources*; namely in Government Management, Resource Protection and Management, Regional Planning and Development, Coastal Community Development, Business Involvement, Training and Education and Information and Research, with total investment of over 600 million US dollars. However, in 1999 the ICZM could not be carried on due to the budget shortfall (Farhan and Lim, 2010). One of the methods to understand the balance between socio-economic development and environmental protection is to assess vulnerability. Vulnerability is a widely accepted concept that can be summarized as "the tendency of something to be damaged" and the opposite of this is resilience, which means "the ability to resist and/or recover from the damage" (Pratt et al., 2004). The vulnerability concept has been a useful measure to describe the relationship among physical, biological, social, economic and political systems, and to assist decision-makers with reducing the risks or hazards (Adger, 2006). A comparison method on how to measure global vulnerability known as *seven stages*, was developed by the Intergovernmental Panel on Climate Change through their third assessment report in 2001, which specifically mentioned that "vulnerability is defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change".<sup>2</sup>

<sup>2</sup>IPCC: <http://ipcc.ch/index.htm>



Three IPCC working groups were formed to assess a) the physical aspects (Working Group 1); b) the vulnerability of socio-economic and natural systems (Working Group 2) and c) adaptive solutions (Working Group 3). However, the methodology is specifically used to overcome the climate change impact as mentioned by Harvey et al., (1999). Another method was mentioned by the South Asia Pacific Applied Geosciences Commission (SOPAC)<sup>3</sup>; which, working under the United Nations Environment Program (UNEP), focused on Small Island Developing States (SIDS), and was calculated using a composite of 50 indicators and 10 sub-indices. This environmental vulnerability index (EVI) program already measured and produced vulnerability values of all small-island developing states. Because of national and local data limitation, EVI only measured and assessed the vulnerability based on the impact and perspective of the global network data. From a SOPAC technical report in 2004, there are three aspects that must be considered in terms of vulnerability: resilience, the occurrence of hazards and damage. Based on the different geological and geographical formations in the world, vulnerability could be classified into several different pressures, changes and mitigations. Each element of vulnerability indicator will be different to the other, and there are various equations that have been used, as represented by Goklany (2007), Gornitz, (1991), Gornitz et al., (2001), Harvey and Woodroffe, (2008), Meur-Férec et al., (2008), Nicholls et al., (2008), Pethick and Crooks, (2000), Villa and McLeod, (2002), and Szlafsztein and Sterr, (2007). At this present time, there are no definite vulnerability indicators that can be applied widely to every country, as this depends on the availability of national data (Turvey, 2007). This paper aims to assess the small island environment in Thousand Islands, Indonesia by describing historical conditions in conjunction with using Geographic Information Systems (GIS) to identify environmental pressures. This assessment will be done together with qualitative analysis of socio-economic and governance factors, in reviewing ocean and coastal policies within Indonesia; in order to overcome the problems within small island regions in archipelagic states.

## 2. Study Area: Thousand Islands

Thousand Islands are inner islands in the Java Sea, located only 6km from the capital city of Indonesia (Jakarta Province) and 2km from Banten Province. With a total area of approximately 7,200 square kilometers, more than 22,700 people live in the region.

<sup>3</sup>SOPAC: [www.vulnerabilityindex.net](http://www.vulnerabilityindex.net)

Administratively, Thousand Islands are divided into 4 districts and 6 villages. Most residents live on the main 12 islands including Pramuka Island, which is the centre of local government on Thousand Islands (see Figure 1). Pre-historical geology, as described by Kuenen (1950), Tomascik et al., (1997) and Umbgrove, (1949), of the Thousand Islands region, suggests it was exceptional. Firstly, Thousand Islands were located in 'sheltered intra-archipelagic seas' as part of a 'stable geo-syncline', where natural disturbances were rare, and secondly; the sheltered position of the islands prevented the excessive influence of winds and currents. Based on the geological facts, Thousand Islands were part of the Sunda Shelf which had submerged after the Pleistocene glacial period (Umbgrove, 1949 and Van Bemmelen, 1949) and some of the island reef clusters that formed Thousand Islands were the remainder of older Pleistocene reefs. From the sea bottom profile of the region, the depth of the neighboring sea of Thousand Islands ranged from approximately 25 to 55 meters (MGI, 1990) and there was no indication of tidal fluctuations in the region except in Jakarta Bay (Umbgrove, 1949). The development of Thousand Islands started in 1965 as part of the Conference of the New Emerging Forces (CONEFO); that was initiated by Soekarno, the first president of the Indonesian Republic. At that time, transportation, electricity and resort developments were typically finished within one year. However, during the power transition from Soekarno to Soeharto in 1966, the CONEFO project was left behind and the development of Thousand Islands became delayed. Between 1965 and 1970, the corals of Thousand Islands were significantly destroyed because of fish bombing and coral exploitation for infrastructure development, and in both Jakarta and Thousand Islands; these activities still existed until the 1990s (Umbgrove, 1949 and Verstappen, 1988). In order to prevent further damage, the governor of Jakarta declared Thousand Islands a tourist district in 1969, furthermore passing an act in 1970 that required anyone entering the area to do so by permit only. In 1971 a marine research station was announced by the governor, under the auspicious Institute of Marine Science, with a focus on marine biology and marine inventory. Between 1972 and 1975, Thousand Islands had a tourist boom from both domestic and international regions. The development of Thousand Islands began in 1973 as part of the Pacific Asia Travel Association (PATA) event of 1974.

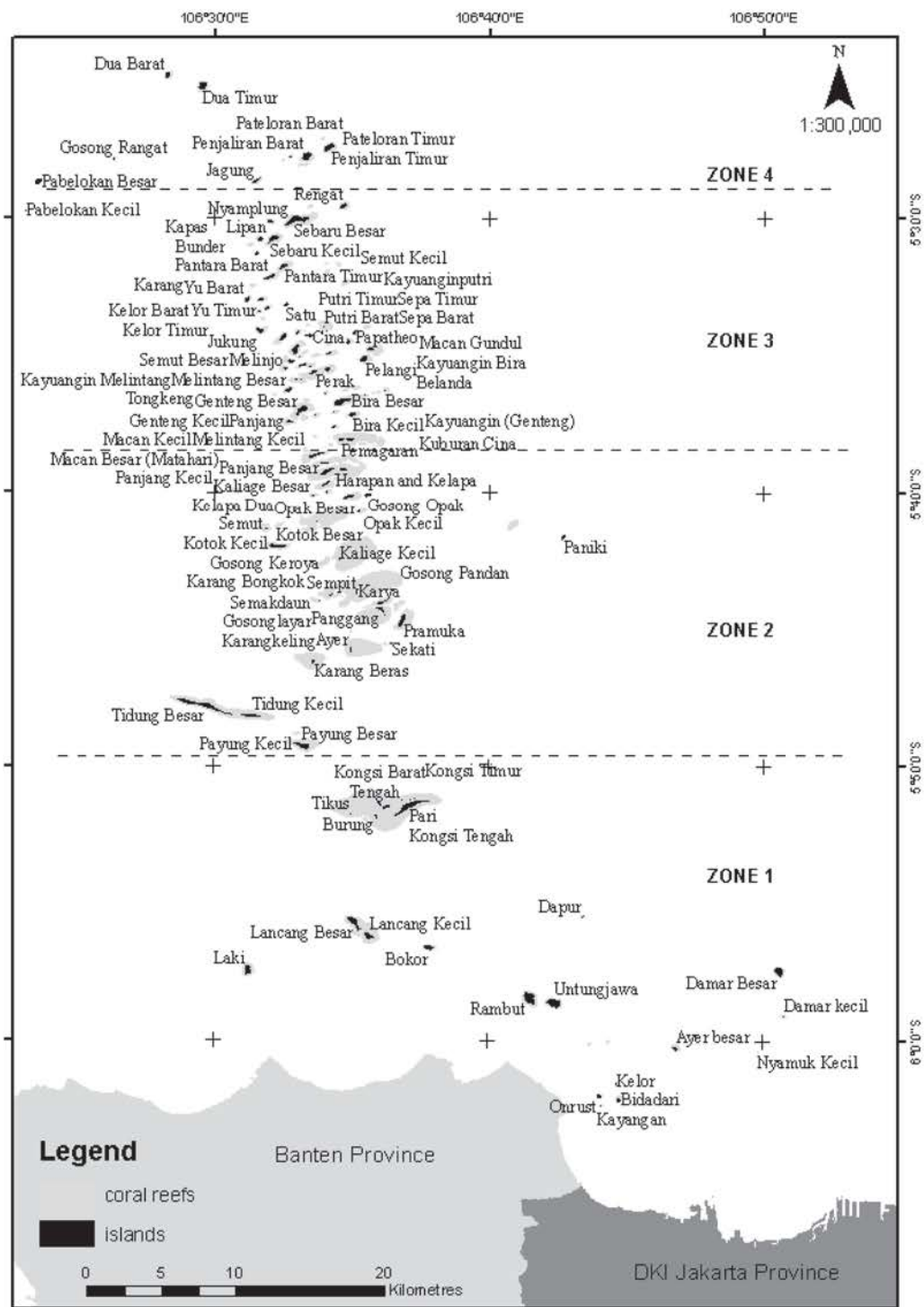


Figure 1: The national marine park zones, Thousand Islands

The government initiated the development on Panjang Besar Island. At that time, two islands were nominated as tourism districts based on their geographical location; the closest to Jakarta was Nirwana Island (known as Nyamuk Besar Island in recent times), and the other island was located in the

middle of the region; namely Putri Island. Despite Thousand Islands having been declared a Marine National Park (MNP) in 1982 by the Ministry of Forestry, the rapid developments in Jakarta Bay have made the region unsafe for marine biodiversity. Researches by Farhan and Lim, (2010 and 2012),



Verstappen, (1988), Brown and Suharsono, (1990), Tomascik et al., (1994), Edinger et al., (1998), Yates, (1994), Fauzi and Buchary, (2002), Cleary et al., (2006), Crawford et al., (2006), Rachello-Dolmen and Cleary, (2007), De Vantier et al., (1995) and Williams et al., (2000) have shown that the MNP stands only as an environmental representation, there having been no improvements in terms of management as well as the environment for decades.

### 3. Methodology

In order to determine the vulnerability indicators and calculate the vulnerability within the study area, relevant datasets have been acquired and analyzed using Geographic Information Systems and NIVO Software 10. The datasets include both spatial and a spatial data:

#### A. Spatial Data:

- Topographic maps in 1999 with 1:50,000 scale from the Indonesian National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL, Indonesia).
- FORMOSAT 2 satellite imagery in 2007 from the Agency for Assessment and Application of Technology (BPPT/Indonesia).
- Aerial photographs taken in 1989 from the Marine and Agriculture Office of Thousand Island Government Administration (Indonesia).
- Spatial analysis data by Farhan and Lim (2012) based on topographic maps in 1913 with 1:50,000 scale from Royal Tropical Institute, Amsterdam.

#### B. A Spatial Data:

- Coral reef evaluation data on Thousand Islands (1985-1999) from UNESCO, Jakarta (Indonesia).
- Coral reef observation data (2003-2007) from the Indonesian Coral Reef Foundation, Marine and Agriculture Office of Thousand Island Government Administration and the David and Lucile Packard Foundation.
- Demographic data and statistics of Thousand Islands (1980-2009) from the Centre of Indonesia Statistics (BPS, Indonesia).
- Geological survey data from Centre of Marine Geology Institute (MGI, Indonesia).
- Indonesian newspapers, namely Kompas from 1965-2012 (Kompas Gramedia Group, Indonesia).

Firstly, the hard copy maps are converted into a digital format by scanning and geo-referencing with Indonesia Ground Control Points, maintained by the National Coordinating Agency for Surveys and

Mapping. Aerial and satellite images are also geo-referenced, followed by a consecutive spatial analysis using file sampling (based on topographic data and aerial photographs), and re-classification. The raster classification needed careful examination due to thin cloud in some areas of the Formosat 2 images. Then the raster data was converted into vector data to obtain the coastlines on each island. The field sampling of the pixel value of FORMOSAT 2 images was generated and validated based on aerial photographs in 1989; field survey data and analysis results of Estradivari et al., (2009), Miwardja and Pranowo, (2001), Rachello-Dolmen and Cleary, (2007), Uneputti and Evans, (1997), van der Meij and Suharsono et al., (2010) and Williams et al., (2000). Stage 1 involved a qualitative analysis utilizing two sets of data: literature reviews of Indonesian newspapers from 1965 to 2012 and the interview data from decision-makers of Thousand Islands in 2011. After both sets of data were imported to NVIVO software, an in-depth document analysis on the history of Thousand Islands was conducted. In Stage 2, spatial themes were generated and each theme was assigned as a vulnerability indicator based on qualitative assessment of attribute data and their impact area within the study area. Also at this stage, the qualitative analysis was generated into three themes: environment, which was used to have a better understanding of pressure on the region; governance, and economic and social aspects; in order to enhance and strengthen the GIS capability that will be used in Stage 3. Stage 3 aims to superimpose the six themes on a map of Thousand Islands. A model builder with spatial joint analysis and an intersection tool were used to compute the vulnerability level. Each theme of Thousand Islands will be highlighted individually to find any specific changes. To strengthen and enrich the information on the region, the GIS results from Stage 3 will be converted and combined with all information that derived from a spatial data using NVIVO software. Stages 1-3 are illustrated in Figure 2.

### 4. Results and Discussions

Spatial analysis indicates that Thousand Islands had lost 6 islands by 2012: Dapoer Island known as Dapur Island in 1999; Schiedam Island known as Ubi Kecil Island in 1999; Rotterdam Island known as Ubi Besar Island in 1999; Haarlem Island known as Ayer Kecil Island in 1999; Enkuizen Island known as Nyamuk Kecil Island in 1999, and Leiden Island known as Nyamuk Besar Island in 1999. It is accepted that the loss is due to coral mining and fish bombing (Umbgrove, 1949 and Van der Meij et al., 2010). The geological change maps show that most

of the unpopulated islands were significantly eroded; Gosong Keroya Island had more than 80% erosion, followed by Kelor (66%) and Kapas, Gosonglayar and Sempit with more than 35%. On the contrary, most of the resort islands such as Payung Kecil, Satu and Ayer experienced major changes with more than 90% increment because of their resort developments. Based on the pressures in the region and the qualitative analysis, Thousand Islands could be divided into four zones (see Figure 1).

The first zone is located within 15 km from Jakarta Bay, and this has been highly affected by the pollution from Jakarta. The second zone is dominated by the populated islanders and the third zone by the private sectors (individuals or private companies). The fourth zone is located far north where most of the islands are unpopulated. Combined GIS results from Stage 2 together with field data from Estradivari et al., (2009) and De Vantier et al., (1995), and the vulnerability indicators on Thousand Islands, were identified and classified into three sets (Table 1); main indicators that directly affect the region, seasonal indicators

that depend on monsoons, and supplementary indicators.

**Land Use:** Population and land use has influenced the environment of Thousand Islands. Despite environmental problems such as waste and littering (Uneputty and Evans, 1997), populated islands are less vulnerable than uninhabitable islands. Populated islands can be divided into three management classes: populated, government and private islands. Private islands are usually more concerned with environmental protection, hence private islands are considered to be less vulnerable. Government islands are classified as moderately vulnerable because of the government protection. Populated and unpopulated islands are classified as highly vulnerable and very highly vulnerable respectively, due to the aforementioned analysis results.

**Coastline Changes:** Coastline changes represent the amount of changes from 1913 to 1999, and the condition of coral reefs is computed by using the in-situ data from 1920 to 2005.

Table 1: Vulnerability Indicators

	INDICATORS		
	Main	Secondary	Supplementary
Zone 1	Land used	Climate changes	Oil spill
	Coastline changes		
	Islands Location		
	Islands remoteness		
	Coral reef changes		
	Pollutant areas		
Zone 2	Land use	Climate changes	Oil spill
	Coastline changes	Tourism activities	
	Islands remoteness		
	Coral reef changes		
Zone 3	Land used	Climate changes	Oil spill
	Coastline changes	Tourism activities	
	Coral reef changes		
Zone 4	Land used	Climate changes	Oil spill
	Coastline changes		
	Islands Location		
	Coral reef changes		



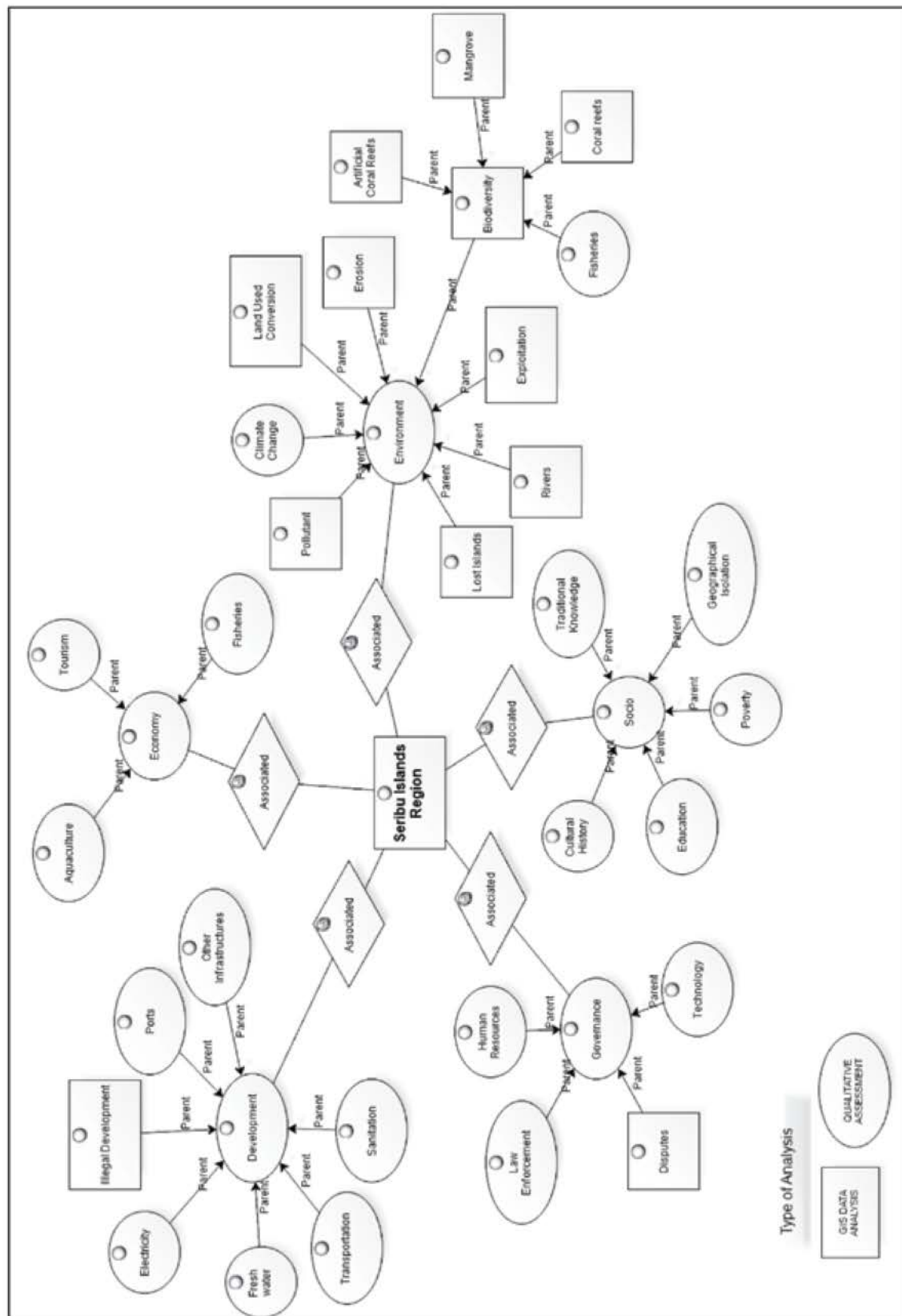


Figure 2: Qualitative data Analysis based on development, economy, environment, socio- and governance issues derived from Indonesia newspapers from 1965 and 2011

**Island Location:** The distance from Jakarta Bay is included as one of the factors because of the strong anthropogenic influence from Jakarta Bay. This applied only to islands that were located approximately 20 km from Jakarta Bay.

**Island Isolation:** Island remoteness is an indicator of whether or not the island is surrounded by other islands. Islands that are surrounded by other islands are less vulnerable (Farhan and Lim, 2010).

**Coral Reef Changes:** Coral reef changes are similarly computed as coastline changes. Coral reef changes represent the amount of changes in Thousand Islands from 1913 to 1999.

**Polluted Areas:** There are two rivers that contribute to the high pollution in Jakarta Bay: Ciliwung River in Jakarta Province and Cisadane River in Banten Province. In addition to pollution from the two rivers, container and oil vessels in the parking area of Jakarta Bay and the aquaculture area of Banten Province, also contribute to contamination of the coastal area. Polluted areas become worse in wet seasons and could expand far from Thousand Islands (Uneputty and Evans, 1997 and Willoughby et al., 1995).

**Geological Conditions:** Sedimentation of Thousand Islands can be considered one of the contributing factors of coral reef development. Coral developments in Thousand Islands are well noticed in sandy mud, silt, muddy sediment and pebble mud areas (Farhan and Lim, 2012 and MGI, 1990)

**Climate Changes:** As described by Brown and Suharsono, (1990) and Estradivari et al., (2009); climate changes happened in the region in 1983 and 1998, however a lack of supporting evidence that this happened in each of these years means that climate change is regarded as a secondary indicator in computing the vulnerability.

**Tourism Activities:** Tourist activities e.g. snorkeling, diving and boating can affect tourism districts. Islands in the tourism districts are Putri Island, Sepa Barat, Pramuka and Macan Besar.

**Oil Spills:** Oil spill accidents on Thousand Islands occurred for the first time in 1972, then in 2003, followed by four incidences occurring in 2004.

The coastal vulnerability indexes (CVI) were calculated by including the above factors, based on Farhan and Lim (2012):

$$CVI = (w_1 * VI_1 + w_2 * VI_2 + \dots + w_n * VI_n) / n \quad (1)$$

where VI's represent vulnerability indicators,  $w$ 's are weights of the indicators, and  $n$  is the number of vulnerability indicators. We developed qualitative analysis models using NVIVO as illustrated in Figure 2. After the CVI was generated under classification on Table 2 and weighting on Table 3, the second analysis was conducted on the basis of the qualitative analysis models. The results show that from 1965 to 2002, electricity and fresh water were the two major problems for the livelihood of the islanders. The electricity on populated islands solely relied on diesel generators that only operated between 6pm to 6am. To cope with the problem, the local government initiated submarine electricity connection in 2007, however the power was often unstable and the coverage limited. In terms of fresh water, the islanders still relied on water wells, which depended on rainfall. The long drought of 2002 forced the islanders to buy fresh water from Jakarta Province, making their livelihood difficult. After the first Indonesian Environmental legislation was enacted; namely Indonesian Cooperation Law Act No. 4, Thousand Islands was classified by the Ministry of Forestry as Marine National Park (MNP), and divided into four different zones of utilization in 1986 (Radjamandalu, 1987).

Table 2: Vulnerability calculation

Vulnerability Indicator	Vulnerability classification				
	Very low	Low	Moderate	High	Very high
Land use	None	Private	Government	Native	Unpopulated
Coastline changes	≤10%	11%-20%	21%-30%	31%-50%	>50%
Island location	>16 km	12-16 km	8-12 km	4-8 km	≤4 km
Coral changes	≤8%	9%-16%	17%-24%	25-32%	>32%
Dead coral reefs	≤5%	5-10%	11-15%	16-20%	>20%



Table 3: Weighting indicators

Weighting Indicator	Dry Season Weight	Wet Season Weight
coral reef coverage	5	5
Dead coral reefs	4	4
coastline changes	3	3
land use	2	2
pollution	1	3

These were the Conservation Zone, Protection Zone, Tourism Zone and Settlement Zone. This ministerial decree was ambiguous because 28 islands were left behind - 25 islands near Jakarta Bay; Pabelokan Island, namely, Pabelokan Besar Island dan Pabelokan Kecil Island, and Sebira Island which is the most remote island in the north (approximately 23 km from Dua Barat Island). Surprisingly, in the following year, the governor of Jakarta declared anew tourism project; namely Pulau Seribu Marine Project on two islands (Pantara Barat Island and Pantara Timur Island), which are located in the middle area between the Protection Zone and Conservation Zone of the MNP. The plan was to develop 38 hectares into 220 cottages and tourist attractions. It can be concluded that the MNP focused on only two zones (the Conservation and Protection Zone), and did not take surrounding islands into consideration. This was the major weakness of the MNP. Unfortunately, the financial burden in managing the whole region forced the government of Jakarta to privatize 15 islands in 1982, and several tourist islands became private islands. These actions accounted for almost 50 percent of islands becoming private islands by the 1990s. Unexpectedly, the government of Jakarta converted another 30 islands to tourist islands, and by 2012, the government of Jakarta was managing only 54 islands; 12 as populated islands and the other 42 as private islands. In addition, land disputes in terms of ownership and management occurred over 22 islands (located in front of Jakarta Bay and Banten Province), between the governments of Jakarta and Banten in 2000, and were still an ongoing issue in 2011. In the Thousand Islands region itself, the population growth and density of the study area given by Indonesia-BPS (2009), indicates that the number of people living in Kelapa Villages is higher (with 2,355 people/km<sup>2</sup>); compared with other villages. However, the population growth impacted both negatively and positively on the resilience of the islands. Positively, population in the region made the islands more rigid or sustained in terms of erosion, and since the 1990s, some of the islands have been extended by islanders using a 'cut and fill method' from the coral reefs, in

order to create more settlement zones. For instance, Harapan Island and Kelapa Island are currently being extended, as well as other populated islands; as described by Farhan and Lim (2011). These settlement zones did not have water sanitation and therefore made coral; mangrove and ecological systems degrade every year of the study period, making the coral restoration process slower than that on non-populated islands (Farhan and Lim, 2012). Surprisingly, the coral reefs in non-populated islands were restored after 30 years, as mentioned by (van der Meij et al., 2010). Each Zone of the Thousand Islands region could be summarized below:

**Zone 1:** As analyzed comprehensively by Farhan and Lim (2012) is the closest zone to Jakarta Bay. As described by De Vantier et al., (1995), Farhan and Lim (2012), Romimocharto, (1976) and Williams et al., (2000); this zone is severely affected by pollution flowing from unmanaged rivers in Jakarta and Banten provinces. Most of the islands in this zone have been categorized as highly vulnerable to very highly vulnerable. In addition, the abundance of crown-of-thorns-starfish was identified in Tikus, Lancang Besar, Bokor and Untungjawa (De Vantier et al., 1995). Dead coral covers approximately 20% of this region whilst coral reefs cover only 10% in the islands such as Ayer Besar, Kelor, Kayangan and Damar Kecil (De Vantier et al., 1995 and Estradivari et al., 2009).

**Zone 2:** Figure 3 is the populated zone in the region. Since the populated islands such as Harapan, Kelapa, Panggang and Pramuka, had significant increment, it can be concluded that the vulnerability of these islands is moderate. However, the severe erosion on Tidung Besar and Tidung Kecil has made the Tidung region highly vulnerable. This is possibly because of the geographical location of Tidung Besar and Tidung Kecil, which indicates that they were not protected by other islands. The abundance of crown-of-thorns-starfish was also identified in Panjang Kecil, Kelapa, Kotok Besar, Semak Daun, Ayer, and Tidung Besar. Most of the coral reefs on the populated islands e.g. Harapan, Kelapa,

Panggang and Pramuka were dominated by the dead coral measuring up to 3m in depth (De Vantier et al., 1995 and Estradivari et al., 2009). Another intriguing fact was that Ayer Island (See Figure 3A), was found to have low vulnerability. However, past historical analysis using the map from 1913 shows that the owner has excavated the island in order to build bungalows. Thus Ayer Island could be assigned as a region of high vulnerability.

**Zone 3:** Figure 4 is the region occupied by private sectors (individuals) or private companies. Generally, most of the islands showed moderate vulnerability except for Bunder Island, Jukung Island and Pemagaran Island, where lower vulnerability was observed. However, the abundance of crown-of-thorns-starfish had been identified in Pantara Barat, Pantara Timur, Jukung, Sepa Barat, Putri Barat and Belanda (De Vantier et al., 1995).

## Vulnerability Index Zone 2

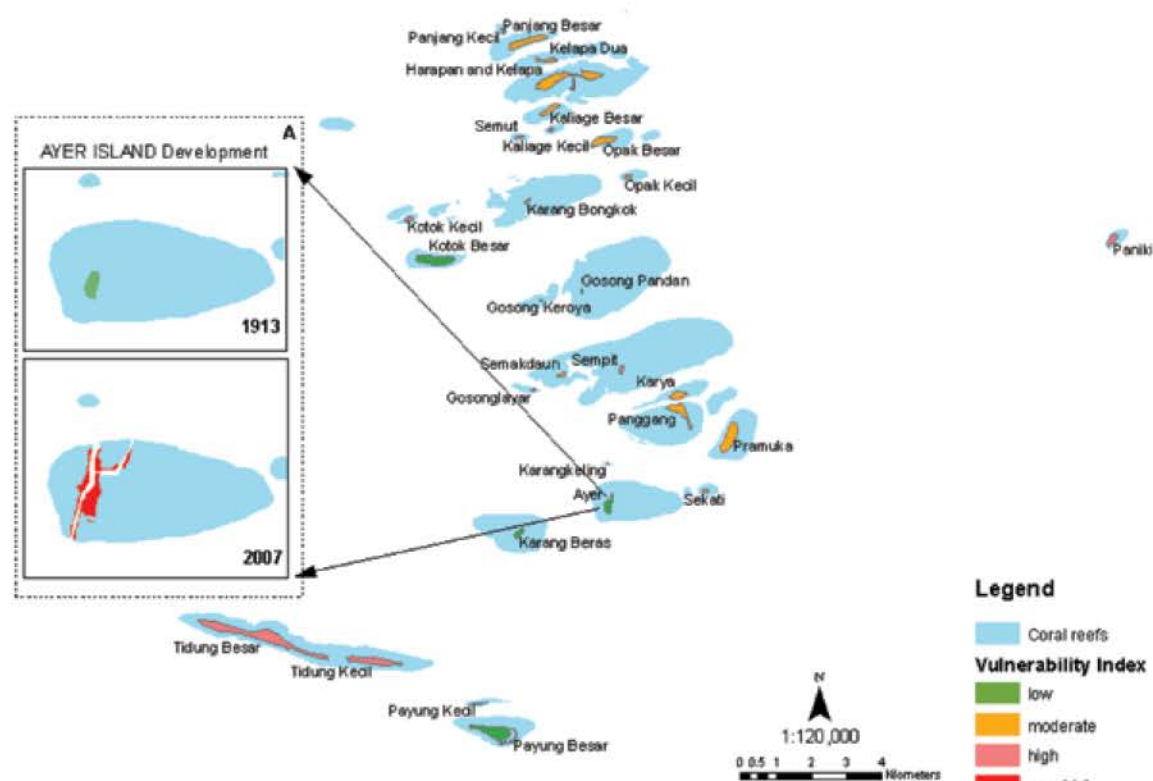


Figure 3: Vulnerability Zone 2

**Zone 4:** Figure 4 comprises mostly unpopulated islands managed by local governments, except for Sebira Island that is located approximately 23 km to the north of Dua Barat Island. The vulnerability indexes showed that Penjaliran Timur, Penjaliran Barat and Gosong Rengat are highly vulnerable compared to other zones. Unfortunately, Sebira Island could not be analyzed as this region was excluded from the National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL), and the Formosat 2 images. However, it can be concluded that Sebira Island solely depends on the islanders, and its geographical location is possibly the biggest barrier for the local government to conduct evaluation and maintenance. In the final

stages, the results were re-evaluated with the data obtained from interviewing the decision-makers of Thousand Islands, to show that the following issues were acknowledged.

### 4.1 Governance

At present, the dispute on governance still exists. The National Marine Park decree has caused confusion and made the local government powerless in terms of management. This has resulted in the local government only having jurisdiction over the populated islands, whilst the management of other islands falls under the Ministry of Forestry. This situation has put the local government into a difficult position with monitoring and evaluation



because the revenue from the National Marine Park is used by the Ministry of Forestry. There are five Indonesian government agencies (Ministry of Forestry, Ministry of Marine Affairs and Fisheries, Ministry of Transportation, Central Government of DKI Jakarta and Local Government of Thousand Islands) involved in Thousand Islands, and the regional coordination to overcome the

forementioned problems is difficult. It is also problematic to finance environmental rehabilitation. Because of the Status of Special Capital Territory of Jakarta (DKI Jakarta), which is fully controlled by the provincial government; the head of the local government of Thousand Islands was appointed directly by the governor of Jakarta, accounting for constant regulation changes.

## Vulnerability Index Zone 3 & 4

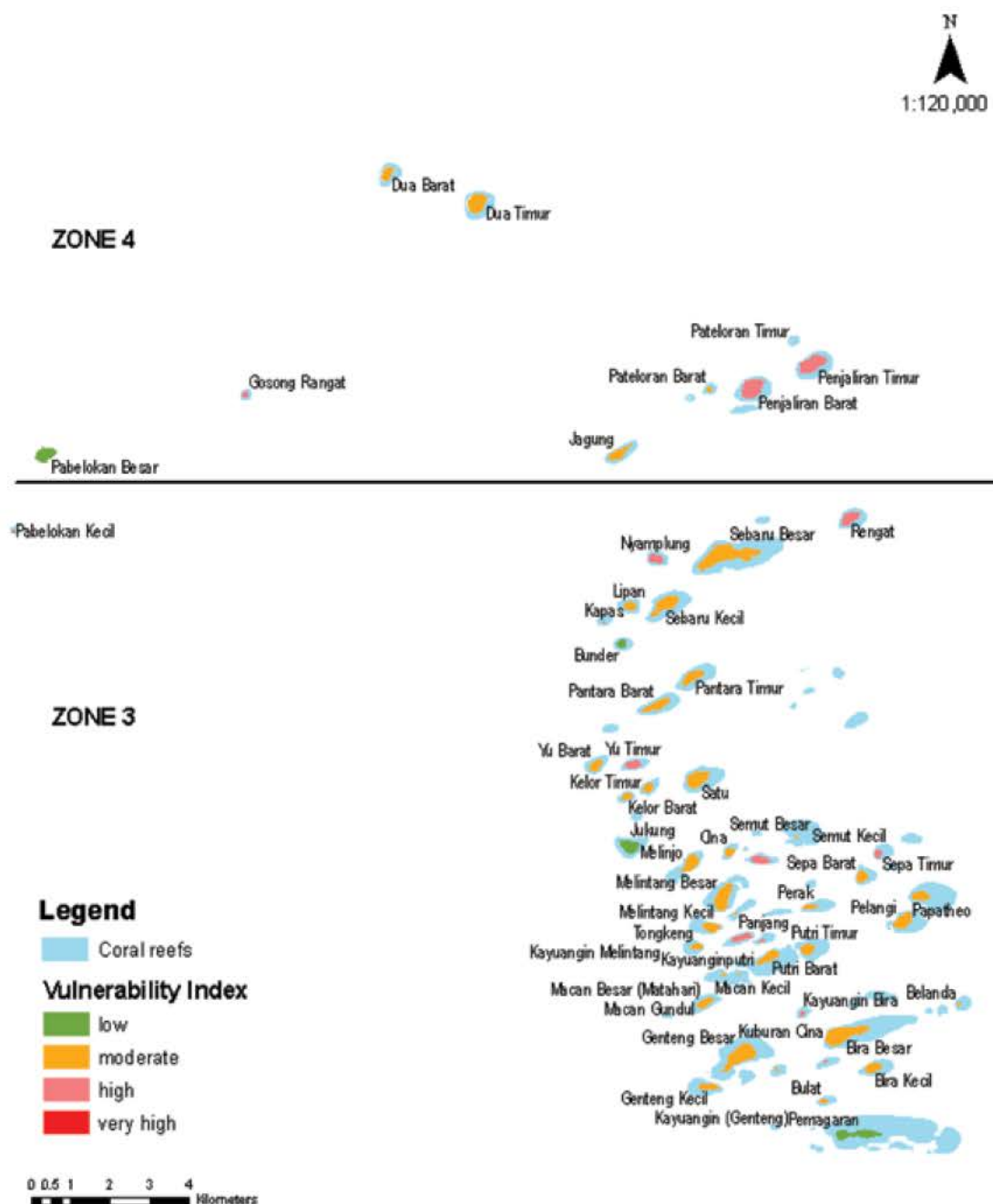


Figure 4: Vulnerability Zones 3 and 4

Since there were no firms policy guidelines and regulations in place, jurisdiction problems occurred, and consequently some of the oil spill cases were solved outside of court. This situation also happened with the case of the National Marine Park boundary. Meanwhile, revenues from resorts and oil exploration in Pabelokan Island (northern part of the region) are directly used by the central government (DKI Jakarta Province), and are mostly used for infrastructure development in Jakarta Province. Local government must build at least two offices or monitoring stations in order to overcome geographical barriers, especially as with those islands in Zones 3 and 4. By doing this, evaluation and monitoring as important processes of coastal management can be performed with greater success.

#### *4.2 Social Issues*

At present, the development within the education sector was represented by 14 primary schools on populated islands, 4 junior high schools and one senior high school on Pramuka Island. However, most school infrastructures were underprivileged, with a lack of laboratory and technology equipment, and more importantly, adequate school transportation for both students and teachers. Furthermore, public transportation between islands and Jakarta Province involves mostly boats that are not standardized, with any safety regulations. The overloading of passengers and the absence of buoys are common problems to mention a few. Since the local government of Thousand Islands was formed in 2002, attempts were made to change the fishermen to marine aquaculture farmers for grouper fish and seaweed. At first these programs were successful but soon afterwards finding fish seeds became difficult. Another issue is the 'cut and fill' method for settlement zones, along with the growing population. The islanders have excavated the corals and used them to expand the islands for their settlement zones. At the present time, the local government surprisingly uses the same method to expand the islands with justification that they use the dead corals. Relocation of the islanders from one densely populated island to another in order to manage island capacity, is very difficult due to tribal issues i.e. one tribe inhabits each island and does not want to be mixed with other tribes.

#### *4.3 Economy*

The local government claimed in early 2005 that poverty was reduced and marine aquaculture programs were resolved. However, at the present time, with aquaculture difficulties and expensive fuel for fishing boats, together with public

transportation issues; the poverty level rises. Problems with fuel and electricity have also contributed to the decline of the tourism industry in the region. Based on interviews, the local revenue was not enough to provide electricity for the whole region, and forced the islanders to have to provide electricity for themselves. Financial revenue from 1980 to 2009 showed that the tourist boom started in 1972, then declined significantly since 1995 and then slowly increased since 2003. This is probably because of the newly formed municipality of Thousand Islands in 2002, and the development of infrastructure such as electricity that started in 2010. This has made the region flourish and could be described as a boost to the tourism industry. The ownership of private islands must be evaluated to ensure that island developments are in accordance with environmental soundness, and that developments like Ayer Island do not happen again. The best possible solution is the return of those private islands to local governments so that they can be used as tourist islands to enhance local revenue. The inequity between environmental, social and economic factors in the area has made the Thousand Islands region fail in coping with bio-physical changes. The density of population on islands such as Harapan, Kelapa, Pramuka, Karya, and Pangang, must be resolved by moving the islanders to new locations in order to provide better islander livelihood. In addition, public services such as electricity, island transportation, fresh water and sanitation are problems that continue over time and marginalize the islanders. Local governments must build at least two offices or monitoring stations in order to overcome geographical barriers, especially for the islands in Zones 3 and 4. By doing this, ocean and coastal management processes in term of evaluation and monitoring, can be performed efficiently and effectively. The ownership of private islands must be evaluated in order to ensure that island development is in accordance with environmental soundness; so that developments like Ayer Island do not occur again. Since there are 44 private islands and only a few islands dedicated as tourist islands, this has caused difficulty in terms of monitoring and evaluation accessibility. The best possible solution is to return those private islands to local governments, so that they may be used as tourist islands to enhance local revenue. Based on the results, it can be concluded that the further the small islands in Indonesia are from the central government area, the more vulnerable they are. This can be explained by inequity of development, islander poverty and quality of life, poor accessibility and lack of planning; as well as island



management. For instance, Sebir Island (in the study area), did not exist on any national map, even though it is located only 23km from the capital city, which suggests that this could happen to any outer islands that are located in Indonesian territory. The case of Sipadan Island and Legitan Island that were located at the northern part of Eastern Kalimantan Province (a province that was well known as the largest natural gas and coal mining area in Indonesia); and was lost to Malaysia in 2002, is possibly one of a number of international incidents that could happen again in the future. Historical spatial changes in small island regions were crucial in identifying the vulnerability indicators and qualitatively assessing them in terms of socio-economy; while governance factors added valuable information in order to enhance the accuracy and validity of the results. Vulnerability indicators in this region might be applied to other small islands in Indonesia, especially those in the inner small island region (Farhan and Lim, 2011). However, the outer small island region requires more indicators such as oceanographic, natural disaster (tsunamis, earthquakes, etc.); while some islands in Indonesia boast strong cultural history (tribal issue, traditional knowledge, etc.) indicators. Further research on micro economy and investment is needed to have suitable economy sustainability in the region.

### 5. Concluding Remarks

The spatial analysis using GIS is very useful to cover a wide area and to estimate accurate vulnerability measures, especially the physical changes in the region. In addition, historical spatial changes in the small island region were influential in improving the vulnerability indicators of the region, and a qualitative assessment in terms of socio-economic and governance factors added valuable information that enhanced the accuracy and validity of the results. By using the vulnerability index, decision-makers can easily identify which part of the region needs to be protected or developed. Each region in Thousand Islands has different characteristic pressures, and consequently, the vulnerability indicators must be carefully selected to provide a better understanding of the changes over the region. Policy enforcement and coordination among island managers has recently created disputes in management and also weakened public participation, which will eventually lead to an inability to meet future generational needs. A lack of coordination between agencies and stakeholders and the lack of spatial planning and public participation guidelines are the main causes of underperforming coastal management in Indonesia. New regulations and guidelines must be placed into

a collaborative framework between inter-agencies, in order to have sustainable development in the region. The Indonesian Cooperation Law needs to be revised and must have principal guidelines in terms of administrative jurisdiction. Administrative boundaries and jurisdictions among decision-makers must be defined and placed into a set of regulations in order to minimize disputes and optimize effective management. This must be followed by an acknowledgement and enhancement of public/local community participation, in order to create better coastal community-based management in the region. A recommendation is to enhance the community-based management on each island, with islanders given proper training to adapt to the changes. Then the National Marine Park (NMP) must be broadened to cover the entire region, in order to ease the pressures in terms of ecological protection and management.

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