Social and Ecological Resilience in Coastal Livelihood
(Case Study: Kepulauan Seribu Regency Jakarta Province
and Takalar Regency South Sulawesi Province Indonesia)

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Abstract. Social resilience is the ability of community to cope the external stress that related with ecological/environmental changes. Ecological resilience is how fast environment could recovery from the incoming substance and could support community livelihood in that area. There is a clear link between social resilience and ecological resilience, especially for community that dependent on natural resources for their livelihood. This is preliminary study that will examine how social resilience could affect by ecological changes. Within this context, we explore the shock and adaption in Kepulauan Seribu Regency (DKI Jakarta Province) and Takalar Regency (South Sulawesi Province), Indonesia – a coastal community that using seaweed farming as their livelihood. This study presents a literature review and in-depth interview approach to explain more about how seaweed farmer can survive from the ecological changes and what is the alternative livelihood for their sustainability in that area. Seaweed cultivation is one of the coastal community livelihoods that dependent on natural resources and ecological condition. Seaweed cultivation has given a positive impact to local economic condition of coastal community but the changes of ecological condition could directly affect seaweed productivity. Ecological resilience in coastal area is how fast they could recovery from the incoming substance and always support community livelihood in that area. The quickness of ecological recovery is related to how much; and how long; and extensive the effect of incoming substance. Seaweed cultivation in Panggang Island (one islan in Kepulauan Seribu islands) has started since 1986. The cultivation become booming since there are a high price of seaweed in this area. In 2000, there are Hugh reductions of seaweed production in Kepulauan Seribu. Farmers have tried to replant the seaweed but always failed. The new seed is become damaged and rotten. Since that time, there was no seaweed cultivation in Kepulauan Seribu. In 2013, one of the farmers in Kepulauan Seribu begins to try to grow seaweed. Seaweed seed start to grow well in mid-2014. According to the farmers on Panggang Island, successes and failures of seaweed cultivation is affected by changes in the harvesting season. In Takalar, production of seaweed cultivation constrained by environment factors like monsoon; urban development that causes water pollution; and issues about “land” ownership.
1. Introduction

Topic on social and ecological resilience in coastal areas is interesting because the dynamic of physical and social coastal community. Coastal area is an area between land and sea which means still get influence from land and also from sea. The dynamics that happens on land and sea can affect the condition of coastal areas.

Coastal communities are dynamic communities. They can adapt well and quickly in dynamic environmental conditions. Environmental conditions can change naturally and can caused by human activities.

Aquaculture is an important livelihood for many people living in coastal area in Indonesia. Aquaculture is adaptation activities of society in a dynamic coastal environment. While environmental conditions do not allow coastal communities to catch fish in the middle of the sea, cultivating aquaculture can be an alternative to their livelihood. Aquaculture fishery activities are also influenced by the dynamics of coastal environments. The high dynamics of the coastal environment that affects the aquaculture activities cause coastal communities also need to adapt in order to survive. But coastal communities are more adaptable to cultivation than in catching activities.

Indonesia coastal zones constitute one of the major ecosystems of the area’s biosphere and are important for their biodiversity [1]. Nevertheless, these coastal zones have experienced several stresses that affect their sustainability. These stresses stem from environment degradation and resource depletion in coastal region (e.g., mangrove and coral reef damage), land-based marine pollution, and overfishing, conflicting utilization of marine space, insufficient capacity in local government and a lack of public participation [1].

This is preliminary study that will examine how social resilience could effect by ecological changes. Within this context, we explore the shock and adaption in Kepulauan Seribu (DKI Jakarta Province) and Takalar (South Sulawesi Province) Regency, Indonesia. Kepulauan Seribu and Takalar communities conduct seaweed cultivation as their source of livelihood.

2. Social and Ecological Resilience

The concept of resilience is widely used in ecology but its meaning and measurement are contested [2]. Ecological and social resilience may be linked through the dependence on ecosystems of communities and their economic activities [2]. The resilience of an ecological system relates to the functioning of the system, rather than the stability of its component populations, or even the ability to maintain a steady ecological state [2].

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\text{Resilience} = \text{disturbance which can be absorbed before state change}
\]

[Resilience + Resistance = Stability]

**Figure 1.** Ecological Resilience. There is no precise definition of resilience. Two alternatives appear to be (left) the disturbance which can be absorbed before the dynamic equilibrium is change completely (following Holling) and (right) the rate of recovery from a disturbance [2].
Resilience can be defined in many ways. It is the buffer capacity or the ability of a system to absorb perturbation, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and process that control behavior [1]. Other definitions of resilience emphasize the speed of recovery from a disturbance, highlighting the difference is translated into impact.

Social and ecological systems are themselves linked. The concept of resilience from the ecological sciences and applying it to social systems assumes that there are no essential differences in behavior and structure between socialized institutions and ecological systems [2]. There are two elements in examining the applicability of social resilience in terms of the physical environment. First is the issue of dependency of social systems on the environment itself. The second issues concerns the resilience of institutions [2].

In determining the parallels between social and ecological resilience, potential indicators for the concepts focusing on the links between social stability (of population within social systems) and resources dependency [2]. Resources dependency is defined by the reliance on a narrow range of resources leading to social and economic stresses within livelihood systems [2]. Stresses and variability associated with resources dependency are manifest in instability and increased variance in income and risk of failure of particular sources [2].

3. Coastal Livelihood
This study will used two difference type of regency in Indonesia as a research area. First, Kepulauan Seribu regency at DKI Jakarta Province. The location is at Java Sea and not far from the north coast of Java Island. This area consists of more than a hundred small islands. Second, Takalar regency at South Sulawesi Province in south part of Sulawesi Island. It has a productive coastal area for aquaculture activities.

Kepulauan Seribu regency at DKI Jakarta Province consist of 8,70 km² and not less than 110 islands. The area of Kepulauan Seribu Regency is divided into 2 districts and 6 sub-districts. Sub-districts in this region are North of Kepulauan Seribu and South of Kepulauan Seribu. This region is basically a cluster of coral islands. With these characteristics, the development of the Thousand Islands region is directed primarily to [3]:
(a) tourism activities,
(b) sea aquaculture,
(c) conservation of coral reef ecosystem and mangrove.

The number of population in Kepulauan Seribu regency in 2014 is 23.011 people and in 2015 increased to 23.321 people. And the population growth rate is 1,06 in 2014 but reduced to 1,02 in 2015. Population over the age of 15 years (working age) working on 9 types of main employment is as in the following table.

**Table 1.** Kepulauan Seribu Regency Population of 17 years of Age and Over Who Worked by Main Industry, 2015

| No. | Main Industry                              | Population |
|-----|--------------------------------------------|------------|
| 1.  | Agriculture                                | 2.960      |
| 2.  | Mining                                     | -          |
| 3.  | Manufacturing                              | 107        |
| 4.  | Electricity, Gas, and Water Supply         | 54         |
| 5.  | Construction                               | 303        |
| 6.  | Trade, Hotel, and Restaurant               | 2.602      |
| 7.  | Transportation, Storage, and Communication | 1.264      |
| 8.  | Finance, Banking, and Business Services    | 119        |
| 9.  | Services                                   | 2.001      |
| Total|                                           | 9.410      |

Sources: Statistics of Kepulauan Seribu Regency (2016)

Agriculture is dominant livelihood in Kepulauan Seribu regency. Statistics of Kepulauan Seribu Regency year 2016 said that Agricultural activities undertaken by communities in this region can be distinguished into:
a. marine fishery production
   (1) fishing marine ornamental
   (2) marine fish culture
   (3) sea fishing
   (4) seaweed cultivation
b. planting crops
   (1) productive plants
   (2) cover crops

We can find Seaweed cultivation at South Kepulauan Seribu district. The number of seaweed cultivation production in this region continues to increase. The total production are 26.2 tons in 2011; 10.000 tons in 2012; and in of 167.225 tons in 2013 [3].

Takalar regency consist of 566,51 km2, 9 districts, and 100 sub districts. In 2015, the population of Takalar Regency is 286.906 people. In the past two years, Takalar's growth has slowed from 1,22 percent in 2013 to 1,13 percent in 2014, and then 1,11 percent in 2015 with a sex ratio of 92,6 percent, which means that there are 92 men in 100 women. The population density of Takalar Regency in the period 2014 to 2015 has increased from 500 in 2014 to 506 people per square kilometer in 2015 [4].

Livelihood in Takalar regency is dominated by agriculture. By 2015, the employees in agriculture are 46.547 people who increased compared to the year 2014 which amounted to 43.678 people. The other livelihood is processing industry which in 2014 is 5.024 people and by 2015 conducted by 13.742 people. The populations working in trade are 20.375 people in 2014 and 21.268 people in 2015. Livelihoods in social services have decreased, where in 2014 the number of people working in the field amounted to 34.679 people while in 2015 amounted to 15.588 people. In others livelihood are 21.449 people in 2014 and 17.578 people in 2015[4].

The agricultural production in Takalar Regency consists of Plantation (sugar cane, coconut, cashew nut); animal husbandry (cattle/buffaloes, horses, goats/sheep, domestic poultry, chicken race, ducks); and fisheries (sea, land). One of the mainstays of agriculture sector in this area is fishery because production from this sector always increases (example from year 2014 to 2015) [4].

4. Ecology, Social, and Economic Dimension of Seaweed Cultivation
Since the 1980s, the Indonesia government has implemented a range of policies and projects aimed at sustaining coastal zones. Among this project are efforts to develop various kinds of sustainable, environmentally-friendly aquaculture, such as seaweed cultivation. Seaweed cultivation can play a significant role in nutrient recycling, as well as increase local biodiversity and food security for coastal and island communities [1]. An additional advantage of seaweed cultivation is its beneficial effect on ecology and climate change. By trapping carbon, seaweed cultivation could be a tool in the carbon credit system that is being developed [1].

In the realm of social policy seaweed cultivation is a sustainable form of aquaculture that has particularly benefited woman and has contributed to government-sponsored poverty alleviation program [1]. As an alternative means of livelihood, seaweed cultivation is crucial to the implementation of a system of sustainable ecosystem management [1]. The development of Indonesia seaweed cultivation is affected by various factors, including the availability of socio-economic, resources, public policy, and technology [1].

Seaweed is economically important commodities. Seaweed is widely used as food, medicine, and important materials in the food industry, cosmetics, and pharmaceuticals. Seaweed traditionally mainly used as vegetables, ice mix, and cookies [6]. Some of seaweed that has been used in Indonesia is the genus of Porphyra, Acanthophora, Catenella, Eucheuma, Gelidium, and Gracilaria [5].

Eucheuma cottonii is a seaweed commodity that has a high economic value because it contains compounds used as raw materials for industries. The important chemical constituents of Eucheuma cottonii are agar and carrageenan. Agar is widely used in food, pharmaceutical and cosmetics. Carrageenan is used as a stabilizer, thickener, suspending agent, and a gelling agent in food. Carregeenan is also used in non-food products such as toothpaste, cosmetics, paints, and tactile dyes [6].
Figure 2a Research Area (Kepulauan Seribu DKI Jakarta Province Indonesia)
Figure 2b. Research Area (Takalar Regency South Sulawesi Province Indonesia)
According to FAO statistics (Fish Stat), global production of seaweed increased from less than 4 million wet tones in 1980 to almost 20 million wet tones in 2010 [7]. Not only has production increased but the source has also changed. Increasingly, seaweed is cultivated rather than collected from the wild. National production of seaweed in Indonesia has increased dramatically. According to FAO Statistics (FishStat), cultivated seaweed production in Indonesia was 197,277 tonnes (wet weight) and worth USD21.7 million in 2000; by 2010, production had approached 3.4 million tonnes worth USD1.1 billion [8]. By 2010, Indonesia accounted for more than two-thirds of world tonnage and value [8].

Most seaweed farmers are coastal inhabitants without many assets. They share equipment, such as boats or drying facilities, with other families. As livelihood activity, seaweed cultivation [7]:

a. Could be offer relatively high and continuous income to families. Seaweed cultivation provided a stable annual income USD5000 to a typical nuclear family farm; for a leader farm, the annual income could be more than USD15000.
b. Requires only minimal capital and material inputs.
c. Techniques are relative easy to grasp.
d. Could be conducted most of the year in short production cycles Seaweed cultivation.
e. Could contribute to most of farmer incomes but only half of even less of their time.
f. Helping farmer to meet daily needs including children education.
g. Could make food secured for the farmer.
h. Providing more income to households on an annual basis than fisheries, that relies on depleting natural resources.
i. Not only increasing the physical consumption and wealth of farmers but also facilitated their participation in social function such as social and religious travelling.

Contrary to generally positive views of seaweed cultivation contribution to livelihood, there are some less encouraging aspects of seaweed cultivation. The issues are [7]:

a. Negative health impacts for the farmer. Prominent health problems of seaweed famers are general fatigue, musculoskeletal pains, hunger, eye soreness, asthma and other respiratory problems, injuries by sharp shells or hazardous organisms, skin problems and allergies.
b. The extremely low income because of low productivity of the seaweed or gender inequality.

5. Seaweed Cultivation and Social-Ecology Resilience
Seaweed productivity is influenced by environmental and human factors. The performance of seaweed cultivation is constrained by a number of environmental factors:

a. Seasonally.
   - Seasonality is one of the main causes of production fluctuations. Monthly, seaweed harvest could be 2.8 times of the average in the best season but only 42 percent in the worst season.
   - Season effect on growth was a major handicap.
   - Shifting cultivation sites and changing cultivars have been approaches used by farmers to accommodate seasonality.

b. Disease.
   - “ice-ice” disease a major problem, which not only discourages farmers but also contributes to supply uncertainty for processors.
   - This disease can decline seaweed productivity.

c. Inclement weather.
   - Seaweed cultivation can destroy by hurricane and typhoons.
   - Seasonal weather patterns can prevent production throughout the year.
   - Crop insurance could help farmers to minimize the loss because of inclement weather.

d. Other environmental factors.
   - Grazing by fish or other organisms.
   - Rising sea temperature that could slow seaweed growth.

Other factor that could constrain seaweed cultivation is competition from other sectors like sea cucumber fishery or urban development.

Conditions of seaweed cultivation in Kepulauan Seribu regency are:

a. Seaweed cultivation in Panggang Island (one island in Kepulauan Seribu islands) has started since 1986. The species of the seaweed are *Eucheuma cottonii* [9]. The cultivation become booming since there are a high price of seaweed in this area.
b. In 2000, there are huge reductions of seaweed production in Kepulauan Seribu. Farmers have tried to replant the seaweed but always failed. The new seed is become damaged and rotten. Since that time, there was no seaweed cultivation in Kepulauan Seribu.

c. Production of seaweed cultivation in this area constrained by environment factors like Grazing by fish or other organisms; monsoon; and urban development that causes water pollution.

d. Grazing by fish or other organisms; monsoon; and water pollution make seaweed grow longer and decline the productivity.

e. In 2013, one of the farmers in Kepulauan Seribu begins to try to grow seaweed. Seaweed seed start to grow well in mid-2014. According to the farmers on Panggang Island, successes and failures of seaweed cultivation is affected by changes in the harvesting season. Western monsoon season can caused bad weather in this area. While planting in eastern monsoon season the seed will grow well and the farmer could harvest the seaweed [9].

f. The important factor for seaweed cultivation is the location. The location for seaweed cultivation should consider several things, such as (a) the location must be free from material contaminated, (b) should be away from the current heavy traffic, and (c) a strategic location for marketing the seaweed.

In other side, conditions of seaweed cultivation in Takalar regency are:

a. Seaweed cultivation in Takalar starts in the mid-1980s.

b. Until now, productivity in this area is high and could give good income for farmer.

c. Production of seaweed cultivation in this area constrained by environment factors like monsoon; urban development that causes water pollution; and issues about “land” ownership.

d. Monsoon could affect seaweed growth and quality.

e. Water pollution could affect the cultivation location.

f. “Land” ownership is another issues related to number of seaweed productivity. Seaweed cultivation area mostly already own by the farmer in each village. The ownership could change from parents to their children or by farmers trading.

g. Farmers need to change the seaweed species in term of monsoon changes. It can keep the quality and productivity of the seaweed cultivation. Glacilaria sp can growth well and give high value if planted on dry season. And the other hand, Cotonii can growth well and give high value if planted on wet season.

6. Conclusions

Seaweed cultivation in Panggang Island (one island in Kepulauan Seribu islands) has started since 1986. The cultivation become booming since there are a high price of seaweed in this area. In 2000, there are huge reductions of seaweed production in Kepulauan Seribu. Farmers have tried to replant the seaweed but always failed. The new seed is become damaged and rotten. Since that time, there was no seaweed cultivation in Kepulauan Seribu. In 2013, one of the farmers in Kepulauan Seribu begins to try to grow seaweed. Seaweed seed start to grow well in mid-2014. According to the farmers on Panggang Island, successes and failures of seaweed cultivation is affected by environment changes in the harvesting season. Western monsoon season can cause bad weather in this area. While planting in eastern monsoon season the seed will grow well and the farmer could harvest the seaweed In Takalar, production of seaweed cultivation constrained by environment factors like monsoon; urban development that causes water pollution; and issues about “land” ownership.

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