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Social adaptation and resilience on disaster, *the case of Sidoarjo mudflow*

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Abstract. Sidoarjo Mudflow disaster has been happen since 2006. It changed landscape, natural resources, and also the land use. It developed social problems such as difficulties of catching fish and lack of water quality. This research aims to observe social adaptation and resilience as an effect from Sidoarjo Mudflow disaster. This research used spatial information as tools to describe and analyze major environmental problems. It examined data Landsat 7 and 8 Imagery between 2005-2018 to explore spatial information regarding changes from Sidoarjo Mudflow to social adaptation. This research also used in-depth interview to calculate social impact from Sidoarjo Mudflow and to produce social adaptation and resilience map on Sidoarjo Mudflow. This research analyzed the impact of mudflow distribution pattern and social adaptation in the way of retrospective view. The results of this research were social adaptation and resilience maps shows that The community of fishermen change their area of fishing and fishing intensity regarding Sidoarjo Mudflow disaster. The society could adapt to the environmental changes impacted by Sidoarjo Mudflow.

1. Introduction

Sidoarjo Mudflow disaster occurred in District Porong, Sidoarjo regency, and has been going on since 2006. The disaster was caused by drilling Sidoarjo Brantas Inc. Mitigation that has been done by the government was only flowing the mud into the water bodies. The unavailability information about Mud Sidoarjo impact is the concern of this research as a reference for further measurement of mitigation. This research used qualitative and quantitative approach with time series method. The aims of this study is to examine the distribution of spatio-temporal of Sidoarjo Mudflow distribution and its relation to social adaptation of local community, especially fisherman. The study of sediment transport sediment spatio was conducted using spatial analysis.

Sidoarjo Mudflow Disaster occurred when PT Lapindo Brantas Inc. as a contractor for BP Migas, explored gas resources at the Banjarpanji-1 Well in the Brantas Block in Renokenongo Village,



Porong District, Sidoarjo Regency. Mudflow appeared around 150-200 m from the exploration area. At first, the burst discharge was only around 5,000 m³ / day, then grew to 170,000 m³ / day in 2006[1].

Mudflow prevention has been carried out in several ways, such as blockage using concrete balls and burst localization using a mud barrier embankment around the burst centre. However, some of these efforts have not yielded results due to large volumes of mudflow, and were expected to continue to increase[1].

Humans and the environment are an inseparable unity. The welfare of people who are on it will also depend on the conditions of their environment. Environmental damage will have an impact on the quality of community welfare. Along with the mudflow bursts, in areas outside the embankment retaining mudflows, other geological phenomena occurred, and environmental pollution, including: land subsidence, cracks, gas bursts, air pollution containing H₂S gas, and water pollution[1].

The social impact that raised from the Sidoarjo Mudflow was due to the loss of access to the facilities of daily living. The decline in the level of social welfare of the community was caused by among others[1]:(a) Difficulty getting clean water, (b) Difficulty in performing religious activity, (c) Transportation are interrupted, (d) The peace of life is disturbed by an unsafe environment, and (e) Increased psychosocial disorders.

Different things in handling the Sidoarjo mud disaster, according to information from PPLS is the behavior of victims which is far different from other disaster victims. Affected communities demand ways of handling that are tailored to their will. Therefore, conventional disaster management standards in the existing legislation cannot be applied[1].

Sidoarjo Regency, Bangkalan Regency, and Surabaya City are area that are affected by the Sidoarjo Mudflow. These areas are located on the east coast of East Java Province. Based on this research supported by Atmodjoresearch[2], The Coastal is the most affected area from Sidoarjo mudflow. It flows from Porong River to the North towards the Madura Strait. The area of the sea and coastal are bordering the landscape. Some people live on the coast. The decreasing water quality due to the Sidoarjo mudflow over the past few years affected the social life of the people who depend on the resources of coastal area.

Surabaya City has the highest population compared to other regions. It because Surabaya city is the center of government and economy of East Java Province. Urban areas are generally the center of the economy, innovation, and employment opportunities, so it will increase more significant in its demographic level than other regions[3]. The city of Surabaya has developed into one of the most densely populated cities in Indonesia, one of the reasons why it can be a high populated area because it has natural advantages in its environment such as access to transportation and coastal resources[3].

This natural advantage causes social dependence on natural resources and has been going on since before modern times to date[3][4]. The number of people who lives depending on natural resources or work depending on natural resources according to BPS historical data[5] shows in Figure 1. This information is the number of employment related to natural resources such as activity in agriculture, plantation, forestry, hunting, and fisheries.

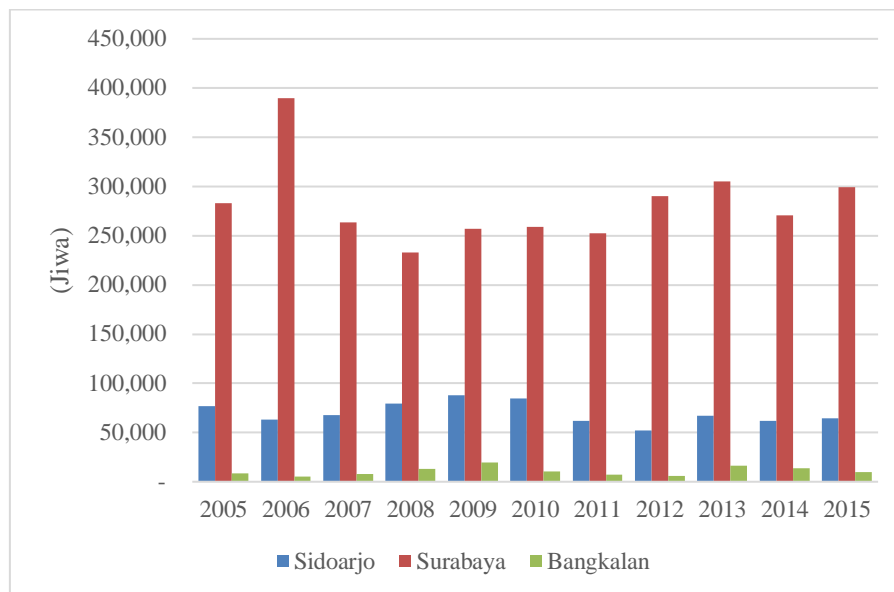


Figure 1. Historical Histogram of the number of workers in the field of natural resources.

Based on the results of the description above, the social community is very rely on the quality of its natural resources. In 2015, according to the table above, the percentage of workers engaged in natural resources reached 37% of the total other major employment. Therefore, the quality of natural resources will affect the social structure of society, including occupation of people. The declining quality of the Madura Strait due to the direct disposal of Sidoarjo mudflow affects the social adaptation of the community. It affects the efforts of community especially fisherman communities to overcome the low water quality [6].

In environmental science theory, there are connection between 3 aspects: Natural Environment, Artificial Environment, and Social aspects[4]. In the previous research[2], it was suggested that the natural environment affected by Sidoarjo Mudflow became an artificial environment. Researchers argue that other impacted area is effected as directly and indirectly ,especially the Madura Strait, where the characteristics both in water quality and landscape was changed. Researchers also arguethat there are human-made modifications[7] in the form of mitigation carried out by the government by dumping mud into water bodies.

2. Methods

With the massive impact of the Sidoarjo mudflow on the environment, it certainly has a high impact to humans who dependent on it, in this case coastal communities that depend on coastal ecosystems. In this research, In-depth interviews and secondary data were used as an analysis of social adaptation and community resilience to spatio temporal patterns of Sidoarjo Mudflow.

In-depth interviewing is a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on particular idea, program, or situation[11]. At this research, the sample needed in an in-depth interview was used to analyze the social adaptation of the Sidoarjo mudflow. Social adaptation is related to the ability to adapt to environmental changes due to the spread of Sidoarjo mudflow.

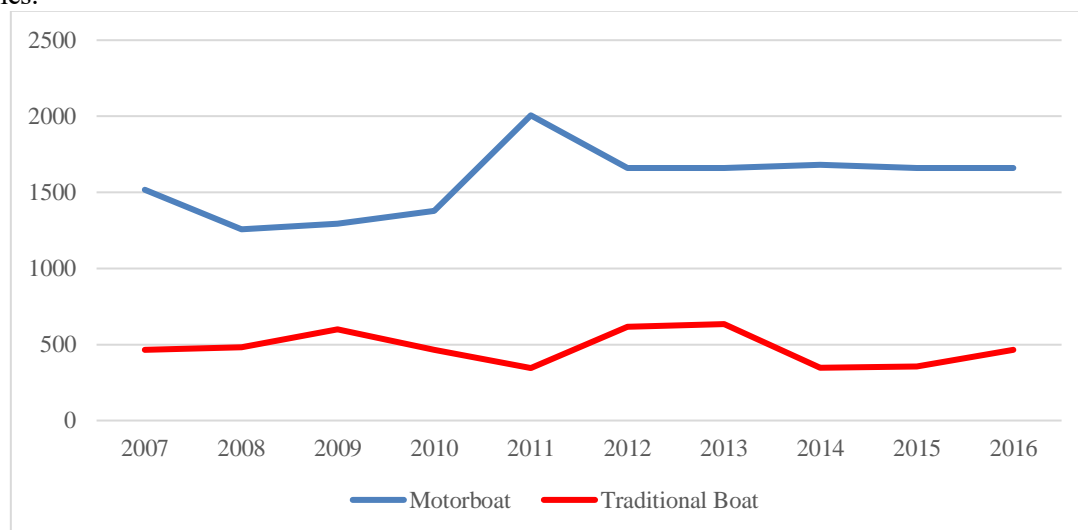
The selected informants consist of stakeholders or the government who have responsibility for the impact of the Sidoarjo Mudflow and directly affected communities. The technique used to determine the informant was purposive sampling. Specifically the informant criteria are explained in the following table. The criteria for informants for fishermen in this case served as community leaders of Kenjeran Fishermen and their members and families, whereas PPLS served as government social guidance.

Table 1. Informant criteria table

Criteria	Institution/Profession	Quantity
Stakeholders who have direct responsibility for the impact of the Sidoarjo Mudflow	BPLS (Badan Pengelola Lumpur Sidoarjo)	2
People who work as fishers in the Kenjeran Fishermen Community	Kenjeran Fisherman	4

3. Results and Discussion

Information was obtained from the Kenjeran Fishermen Community, Surabaya. The Kenjeran community is located in the location of Sidoarjo mudflow in the Madura Strait. Based on BPS Surabaya data (2017), there are dynamics of the number of fishing fleets, as in Figure 2. Motorboats increased fleet in 2011 but continued to decline until 2016. Fishing boats decreased in 2011 and increased again in the following year. The dynamics in this study were associated with the increasing sediment from Sidoarjo Mud in 2011 and above, which affected the pattern and intensity of fish catches.

**Figure 2.** Fishing Fleet Chart.

Based on information from the community of the fishing community, especially the Kenjeran community, there were changes in fishing locations which was caused by an increase in the flow of sedimentation in the Madura Strait waters.

Scarcity of fishing catches was caused by loss of natural habitat due to increasing sedimentation in waters[8]. The loss of natural habitat in the waters very impacted to fishermen, which for most of the Kenjeran people to be the main livelihood are negatively affected. Disruption of catching fish habitat around the residence causes a decrease of fishermen's income. Adaptation for this problem can be solved with looking for a new fishing area.

Altering fishing area is one of adaptations which can be done by fishermen in adjusting to decreasing water quality that affect catches[8][9]. It could be the option because the lack of availability of fishing target in the coastal area which is still abundant when the sedimentation is massive. Habitat adaptation is a biological mechanism that is carried out by aquatic biota to find more viable locations for life[8]. Habitat adaptation causes people who are seeking income from capturing,

automatically taking part in moving their fishing area. These changes include the fishing area up to: the northern part of the Madura Strait, the northern part of Madura Island, the southern part of Madura Island, and the Pasuruan – Probolinggo Waters as in Figure 3.

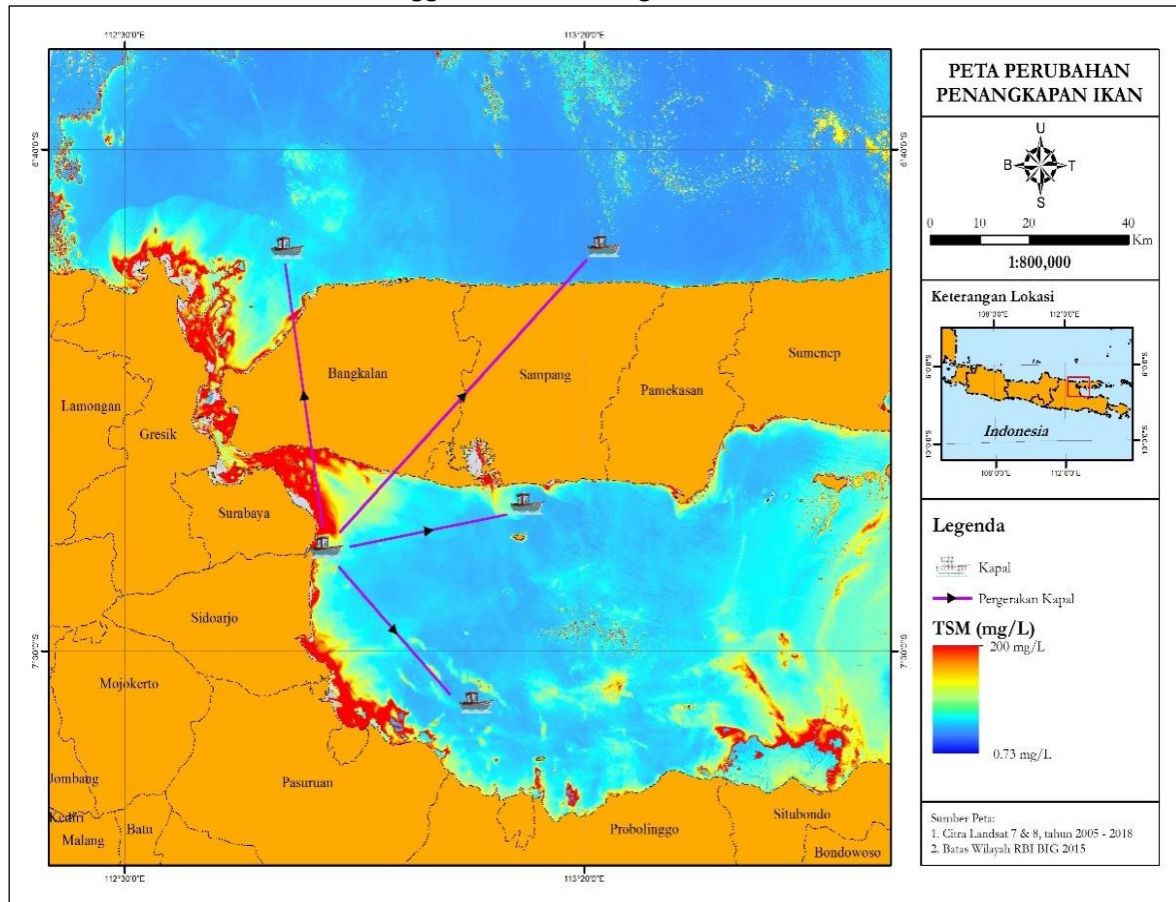


Figure 3. Fishing Adaptation Map.

Changes in fishing areas clearly increase the burden or fishing cost by the fisherman. The distance of the catch area changes up to 40–140 km. The increasing of catch target also affects the intensity of catchment, because they require higher costs than before. It happens because it is not supported by the quality of the catch, many fishermen tend to lose, and affect the micro-economy of fishermen. Based on additional information, the size of the fish caught was also reduced in the study area, from previously around 2 kg to around 500 gr.

Based on CCME[10] the size of fish is also influenced by water quality, including aquatic sedimentation. The decrease of catch related to research by Scrivener et al.[8] fish experience growth inhibition caused by stress by sedimentation which inhibits growth during the juvenile period. Based on fishing data, there was a downward trend in fish catches in 2011 in Figure 4. The decline in sea fish catches has decreased significantly. The researcher argues that the accumulation of Sidoarjo Mud sediments began to affect the quality of the waters, which resulted in a decrease in fishing production. Based on previous data, it can also be assumed that the decline in fisheries production affects the number of fishing fleets due to the increased costs caused by the decline in water quality.

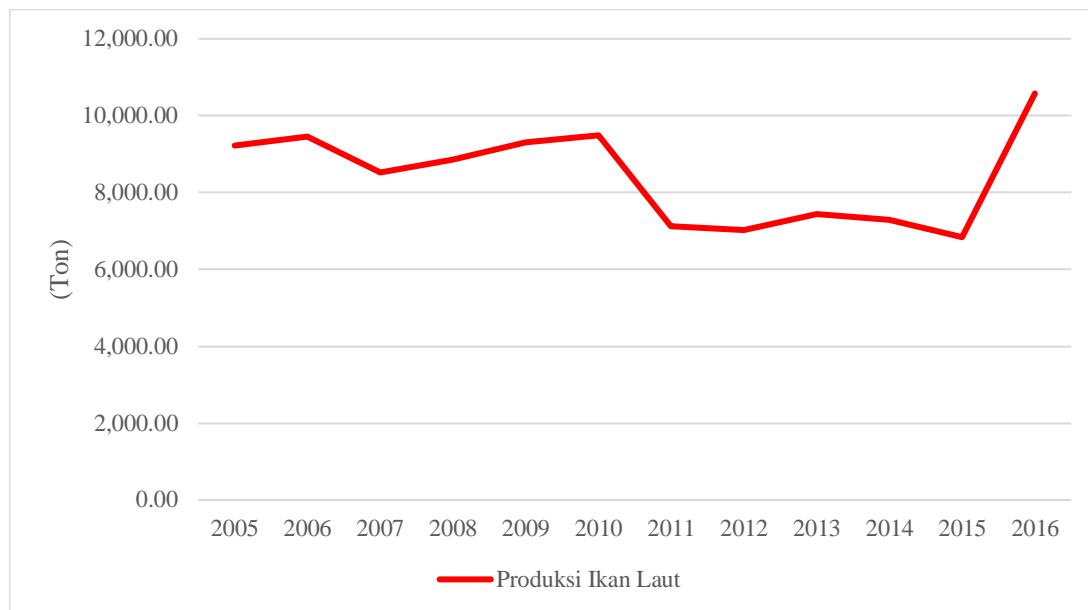


Figure 4. Marine Fish Production Graph.

Based on BPS data[11], catches declined from 2010, but increased again in 2016. Based on BPS data, the increase was in the form of biota: White Shrimp (*Vanamiae*), Rajungan, Kepiting, and Belanak[11]. The production of biota increased by more than 100% compared to the previous year, thus contributing to an increase in overall marine fisheries production. The biota lives in mangrove and estuarine habitats, not naturally living in the Madura Strait which is affected by the Sidoarjo Mudflow. Therefore, the increase in 2016 production is outside the Madura Strait. The decline in marine fisheries production includes the Manyung Fish, Sumping and Pari biota.

Based on the results of the Indepth interview, Sidoarjo Mud, which polluted the Madura Strait, affected the economic level of the community. The decline in catches due to Sidoarjo Mudflow affects daily income levels which tend to suffer losses due to fishing costs that are not covered by catches.

High operating costs compared to fish catches cause low economic growth of Kenjeran fishermen. The low growth of economic due to reduced catch, causing fishermen to borrow money from middlemen with interest that the researchers did not inform. This phenomenon caused the low level of economic growth of the fishing community as a whole. Community adaptation to the decrease in catches and increased operational costs is by reducing the intensity of fishing. Community adaptation is needed to raise the community's economy with strategy in catch. The catches should be decreased but the operational cost should be increased by reducing the intensity of fishing. It can be more valuable and sustainable for sustainability of economic of Kenjeran fisherman to catch in those area.

The intensity of the catch is set to be one of the solutions in the adaptation carried out by the Kenjeran fishing community. Adaptation is done to adjust to the scarcity of biota with chronic or slow pollution. Other information from the results of the in-depth interview is that most fishermen have high school and vocational education and a small percentage have a diploma. However, the fishing profession is still the main profession and side profession of the surrounding community.

4. Conclusion

Based on this information, Fishermen are not only a source of livelihood for the local community, because the observations of many researchers also become traders in the area. The fishing profession has also become special characteristics of community and as an activity in a spare time. So when the

impact of Sidoarjo Mudflow reached the Kenjeran area, the majority of local fishermen tended to adapt in finding fish compared to other professions. Social adaptation which can be done by the community among others are finding new catch areas and reducing the intensity of fishing. The government's abstention on the rehabilitation of the impact of Sidoarjo mud contributed to the community taking the initiative in overcoming the pollution load. The lack of education and reporting mechanisms that are unknown to Kenjeran fishermen are some factors of the government's role in the study area, especially the Madura Strait.

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