Understanding and adaptation to climate change of fishermen in the northern coastal of Central Java, Indonesia

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Abstract. The negative effects of climate change forcing coastal communities to adapt. Fishermen's understanding of climate change is very important because it shapes the fishermen's readiness to adapt. This research explores fishermen's understanding of climate change, fishermen's adaptation in response to the perceived impacts of climate change, and the relationship between fishermen's understanding and climate change adaptation. A survey by interviewing randomly selected 120 fishermen was conducted on the northern coastal of Central Java from March to June 2018. The results showed that fishermen had a good understanding of climate change. Most fishermen prefer to looking for detailed information about climate change, change fishing ground, and fishing time adjustment. There is a positive correlation between fishermen's understanding of the sea-level rise and adaptation to climate change. This is because the northern coastal of Central Java is prone to tidal disasters due to rising sea levels.

1. Introduction
Climate change is the effect of global warming, which has a negative impact on coastal areas, include rising sea surface temperatures, extreme weather intensity, changes in rainfall patterns, and high waves. This negative impact has a sustainable impact on the life pattern of the fishing community in meeting their daily needs. Fulfillment of the necessities of life-related to their socio-economic life which depends on their basic livelihoods as fishermen, so that the fishing community must have a survival strategy to meet their daily needs with their social capital.

Fishing communities have an economic life related to marine resources. The existence of global warming and erratic weather changes make fishermen unable to determine the fishing season. The high rate of global warming affects unpredictable weather changes. The fourth IPCC report [1] and the fifth IPCC report [2] place Indonesia as one of the vulnerable countries to climate change. IPCC [2] states that coastal areas throughout Southeast Asia will experience sea-level rise 10-15% higher than the average global sea-level rise. The disasters that occur due to climate change make fishing vulnerable due to rising sea levels, increasing intensity of tropical tornadoes, and seawater intrusion.

An alternative way to find out how the climate is changing is to look for various climate change information that fishermen understand. Fishermen are the main stakeholders in the climate change debate. However, fishermen's knowledge about climate change is still very limited. Concern and understanding of a problem, for example, climate change, will shape action or inaction on the problem...
[3]. Thus, fishermen's understanding of climate change is very important because it shapes fishermen's readiness to adapt. According to Murdiyarso [4], adaptation to climate change is one way of adjusting spontaneously or planned to react to climate change.

The Northern Coastal of Central Java Province is a coastal area in Indonesia that is vulnerable to climate change. According to the results of the monitoring of the Deputy Research team for the Utilization and Correction of Science and Technology of the State Ministry of Research and Technology of the Republic of Indonesia in 2009, in identifying the vulnerability of coastal areas to the impact of climate change (Coastal Dynamics Due to Climate Change) and controlling the impact of climate change (PDPI) explained that Central Java Province has a specific problem as a coastal area. The results of observations by the State Ministry for Research and Technology include, first, that the impact of climate change in Central Java Province is tidal inundation (rob) which disrupts industrial activities, infrastructure, settlements, and fisheries. In Central Java, Bedono Village, like other areas, sank because of the tidal wave. Senik Hamlet sank in 2007, and Tambaksari Hamlet sank between 1999-2000. Second, the impact of climate change on the socio-economic sector, the impact of climate change on fisheries and fishermen's livelihoods, namely a decrease in fisheries productivity.

Climate change also has a significant economic loss impact related to the loss of productivity of primary sectors such as fish ponds and agriculture. Although the Meteorology, Climatology and Geophysics Agency (BMKG) has provided information to the local Department of Marine Affairs and Fisheries, coastal life still has low access to this information. The climate change that is felt by fishermen, such as rainfall, high waves, accompanied by strong winds, makes fishermen can't have fishing time or if they have the fishing time they will get minimal catches. High waves and prolonged storms have proven to have paralyzed the economy of fishermen in the Northern Coastal of Central Java. Fishermen are forced to earn income by selling ships or pawning their belongings to buy basic daily needs. The fishing population spreads from Pekalongan, Demak, to Jepara in Central Java [5]. This study focuses on the understanding of fishermen and adaptation held by fishermen to reduce the various impacts of climate change.

2. Methodology

2.1 Study area
In this study, data were collected from coastal areas of Central Java Province, including Kendal Regency, Butang Regency, Pekalongan Regency, and Pemalang Regency. Determination of the location is done deliberately considering that the northern coastal of Central Java has a high fishing population and areas that are vulnerable to tides. The Central Java Province has a coastline of 971 kilometers consisting of 645 kilometers of the northern coastline and 326 kilometers of the southern coastline. The richness of marine natural resources in the Northern Coastal of Central Java has the potential to improve the people's economy (Figure 1).

2.2 Sampling and questionnaire
In this research, the analysis unit is to capture fishermen who have their ships and participate in fishing activities as the key informant. The method used in determining the respondents is purposive random sampling with a total of 120 fishermen were selected. The questionnaire was carefully designed to get information on socio-economic characteristics, fishermen's understanding of climate change, and climate change adaptation selected by fishermen based on their knowledge, understanding, and experience.

2.3 Data analysis
Fishermen's understanding of climate change is measured by a Likert scale with a range of scores ranging from 1 to 5. To get fishermen's understanding of climate change, categorization is carried out based on the score obtained by the Strugess formula [6]. Climate change adaptation is examined from
the number of adaptation strategies that have been implemented by fishermen. To analyze the correlation between understanding of climate change and adaptation is used Product Moment Pearson.

3. Characteristics of fishermen
The characteristics of fishermen are typical characteristics of fishermen in believing, acting, and feeling, which include: age, years of schooling, household size, experience, ship weight, fishing time, and fishing distance (Table 1).

| Characteristics          | Min  | Max  | Mean  | SD   |
|--------------------------|------|------|-------|------|
| Age                      | 21.00| 74.00| 43.09 | 10.99|
| Years of schooling       | 0.00 | 16.00| 5.84  | 2.98 |
| Fishing experience       | 5.00 | 50.00| 29.33 | 11.94|
| Household size           | 1.00 | 7.00 | 3.07  | 1.29 |
| Ship weight              | 1.00 | 15.00| 4.59  | 2.47 |
| Fishing time             | 3.00 | 20.00| 8.48  | 3.15 |
| Fishing distance         | 0.50 | 50.00| 7.08  | 9.61 |

Source: Primary Data, 2018.

Age is an important variable because it is related to physically strong which is an important requirement in working as a fisherman and is also related to work productivity. In the Northern Coastal of Central Java, fishermen have an average productive age that supports their working who require strong physical strength because dealing with unpredictable natural environmental conditions. Most of the fishermen have a low level of years of schooling, and not a few of them don’t have formal education. Overall, the average years of schooling of fishermen have not reached the nine-year education target set by the Indonesian government. The low education level of fishermen is a reflection of the fishermen’s’ poverty in Indonesia.
In the Northern Coastal of Central Java, fishermen have a high average experience. This shows that fishermen have never switched jobs as fishermen. The low level of education means that fishermen do not have the opportunity to get other jobs except as a fisherman. Based on the results, most fishermen have fishing experience ranging from 12 - 20 years. Capture fisheries business has been started for a long time, the geographical conditions which are coastal areas make most of the people dependent on their livelihoods as fishermen.

Based on Table 1, most fishermen are environmentally friendly fishermen because they have ships weight ≤ 10 GT. The circular from the Minister of Marine Affairs and Fisheries stated in 2014 that ship weight ≤ 10 GT no longer need to make permits, but must be registered. The catch must also enter the Fish Auction Place (TPI) so that the local government also has information on catch capacity and the marketing channel because ship weight ≤ 10 GT are not allowed to sell their catch to foreign ship.

The fishing time starts from preparing supplies for fishing operations, operating at sea, and selling the catch from fishing with a limit of up to eight hours of fishing time work at sea and equivalent to one working day. Table 1 shows that fishermen have fishing time ranging from 3 - 20 hours with an average of 8.5 hours. During the shrimp and squid season, fishermen carry out fishing time in two shifts. First, fishermen leave at 2 - 10 a.m and the second shift at 4 - 10 p.m. However, under normal conditions, fishermen usually go to sea at around 5 a.m and return at 12 or most around 2 p.m. The fishing distance is required for fishermen to reach the fishing target, this is greatly influenced by how long it will take for fishermen to find the ideal fishing ground. The longer and farther in the sea, it can be assumed that they will get high catch capacity. Fishermen usually have low fishing distance if there is a high enough tide. Most fishermen have fishing distances between 0.5 - 10 miles (Table 1) because they have a small capacity ship and not possible to carry too much fuel.

4. Results and discussions

4.1 Understanding of climate change

Measurement of understanding is seen through statements containing cognitive components about fishermen's experiences and knowledge of climate change. The distribution of fishermen's understanding of climate change in the Northern Coastal of Central Java can be seen in the following Table 2.

| Climate change indicators       | Kendal regency | Batang regency | Pekalongan regency | Pemalang Regency | Northern Coastal of Central Java |
|---------------------------------|----------------|----------------|--------------------|------------------|----------------------------------|
| Changes in rainfall            | 60.00          | 60.00          | 76.67              | 40.00            | 59.17                            |
| Increase in temperature        | 56.67          | 80.00          | 86.67              | 40.00            | 65.83                            |
| Sea level rise                 | 46.67          | 86.67          | 83.33              | 30.00            | 61.67                            |
| Northern Coastal of Central Java | **54.45**      | **75.56**      | **82.22**          | **20.00**        | **62.22**                        |

Source: Primary Data, 2018.

The results showed that most fishermen have a good understanding of climate change (Table 2). Fishermen understand that there are changes in rainfall, an increase in temperature, and sea-level rise. The northern coastal of Central Java is very vulnerable to natural problems such as flooding, tidal flooding, and abrasion, so fishermen are relatively aware of sea-level rise. For example, in Pemalang Regency, the location of fishing settlements close to the edge of the sea and rivers makes it prone to disasters such as floods, robs, and abrasion. Due to tidal waves and abrasion, the distance between the sea and fishing settlements is getting closer. The length of the damaged and collapsed roads ranges from 50 - 120 m. Apart from damaging the paved road, the huge sea waves also destroyed the 8 m wide
shoulder of the road. Big waves and tides that occurred in Tanjungsari Village usually appeared between 2 and 6 p.m [7].

Fishermen also have local knowledge that can be used to deal with conditions at sea [8]. But the problem is that some of the local knowledge does not always match the current conditions which are very uncertain and are anomalies of the commonly encountered climatic conditions. This local knowledge needs to be balanced with knowledge based on data based on global science, namely knowledge of climate change. Sunblad [9] explained that the knowledge about climate change among the community, especially fishing communities, is still not very clear. The level of knowledge and public trust will increase if each studies climate change and understands the risks of climate change impacts.

4.2 Climate change adaptation
Most fishermen in the Northern Coastal of Central Java choose to look for detailed information on climate change, and changes fishing ground is the most widely used adaptation option to reduce the impact of climate change (Figure 2). To reduce the impact of climate change fishermen must understand well about climate change and most of the fishermen have a good understanding of climate change. Furthermore, the choice of climate change adaptation that is also mostly used by fishermen is time fishing adjustment. One of the impacts of climate change on marine ecosystems is the increasing frequency of extreme waves and storms. This is also a derivative impact of the sea-level rise [10]. Climate change that occurs causing extreme waves and strong winds also often occurs in the east wind season and during peak fishing activities. This is of course very detrimental, where ships and fishing facilities are still traditional and not yet in the capacity to face storms or big waves. So, fishermen need to adjust their fishing and fishing activities to reduce risks due to climate change.

4.3 The correlation between understanding and climate change adaptation
Fishermen's understanding of climate change is very important because it shapes the adaptations and various other adjustments that fishermen must make to reduce the impacts of climate change. The results of the analysis show that there is a positive relationship between fishermen's understanding of sea-level rise and adaptations (Table 3). In the Northern Coastal of Central Java, fishermen understood about sea-level rise. This is because the location of fishing settlements around the Northern Coastal of Central Java is very close to the seafront and an increase in sea level of 8 mm per year is due to climate change. The sea-level rise is predicted to shift the coastline in the northern region of Central Java. In 100 years, sea-level rise reached 80 cm and submerged part of the area [11].

![Figure 2. Climate change adaptation by fishermen.](image-url)

Badan koordinasi survei dan pemetaan nasional (Bakosuratnal) [12] also stated that the condition in the Northern Coastal of Central Java was very worrying. This is due to rising sea levels and exacerbated by land subsidence in big cities such as Jakarta, Semarang, and Surabaya. This makes areas vulnerable
to tidal flooding caused by sea-level rise and coastal erosion. For example, in Pekalongan Regency, almost all areas in North Pekalongan and some areas in West Pekalongan are prone to tidal flooding. In some subscribed areas, the water level can reach 1 – 1.5 m. The occurrence of rob takes place in about eight months of the year, around April to December. This incident has occurred for decades and has become a part of daily life for residents in the northern coastal of Central Java.

The importance of knowing climate change is stated by Leary and Adejuwon [13] that failure to adapt is due to a lack of awareness, information, and knowledge about climate change. Understanding and knowledge of fishermen can contribute to climate change adaptation policies and development in the capture fisheries sector to reduce the vulnerability of fishermen [14]. The level of knowledge and understanding of the coastal community is very effective in reducing the risk of climate change. By sharing knowledge such as environmental changes, regional status, and frequency of disasters with communities who have previously felt they can reduce the risk of climate change [15].

### Table 3. Correlation between understanding and climate change adaptation.

|     | P1          | P2          | P3          | P4          |
|-----|-------------|-------------|-------------|-------------|
| P1  | Pearson     | 1           | .357**      | .477**      | -.031       |
|     | correlation |             | .000        | .000        | .367        |
|     | Sig. (1-tailed) |          | 120         | 120         | 120         |
| N   |             |             |             |             |             |
| P2  | Pearson     | .357**      | 1           | .589**      | .112        |
|     | correlation |             | .000        | .000        | .112        |
|     | Sig. (1-tailed) |          | 120         | 120         | 120         |
| N   |             |             |             |             |             |
| P3  | Pearson     | .477**      | .589**      | 1           | 162*        |
|     | correlation |             | .000        | .000        | .038        |
|     | Sig. (1-tailed) |          | 120         | 120         | 120         |
| N   |             |             |             |             |             |
| P4  | Pearson     | -.031       | .112        | .162*       | 1           |
|     | correlation |             | .367        | .112        | .038        |
|     | Sig. (1-tailed) |          | 120         | 120         | 120         |
| N   |             |             |             |             |             |

Note. ** Correlation is significant at the 0.01 level (1-tailed), * Correlation is significant at the 0.05 level (1-tailed). P1: changes in rainfall, P2: increase in temperature, P3: sea level rise, A: adaptation.

### 5. Conclusions

Fishermen in the Northern Coastal of Central Java have a good understanding of climate change. This is in line with the most widely used adaptation by fishermen, who is looking for detailed information about climate change. The results show, there is a positive correlation between fisherman’s understanding of sea-level rise and adaptation. The Northern Coastal of Central Java is vulnerable with prone to tidal disasters.

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