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The effect of abrasion on resilience of fishermen/ Fish farmer livelihoods on the North coast of central Java

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Abstract: Fishermen on the North Coast (Pantura) of Central Java are affected by abrasion and have decreased economically and environmentally. In this context, tidal flooding damaging ponds, mangroves, public facilities, roads, and settlements allow people in coastal area to immediately adapt to livelihoods. Therefore, this research aimed to identify resilience of fishermen/ fish farmer on Pantura coast affected by abrasion. Qualitative data analysis was carried out with a constructivist-interpretivist method to produce social realities from social construction. This research was conducted in 3 regencies between April - June 2024 in Central Java with the largest abrasion areas, namely Brebes Regency, Semarang City, and Demak Regency. The selected regencies and the 3 villages had the largest abrasion area. Snowball sampling was used to obtain 20 fishermen from each village; hence, the total number of respondents was 180. The results showed that there were 10 coping strategies applied by fishermen/ fish farmer in livelihoods to analyze with the effect of abrasion. Most fishermen/ fish farmer only apply coping strategies in relation to limited resources, skills, education and ability to take advantage of opportunities. A total of 39% respondents applied the strategy of adding other jobs outside fisheries sector. Respondents obtained additional income with a relatively low business risk compared to fisheries or marine sector. There were only 5 coping strategies used to increase livelihoods by adding other jobs outside and in fisheries sector, raising houses, installing nets and making embankments.

Keywords: *Adaptation, Coping strategies; Embankments; Geotubes; Waring;*

1. Introduction

The territory of Indonesia stretching from Sabang to Merauke is bordered by land and 70% water [1]. The number of islands owned is around 17,508 [2] with coastline of 81,000 km. On a global basis, Indonesia has the 2nd longest coastline after Canada [3]. In this context, the country is known as a maritime even though most of the people work in agricultural sector. The potential of underwater natural wealth provides economic benefits for people living in coastal area.

Coastal or transitional area is affected by changes in land and sea [4] as a center of various activities [5]. Initially, this area was only a place of livelihoods for fishermen/ fish farmer but functioned as a tourist attraction, agro-industry, and port [6]. The development of activities on

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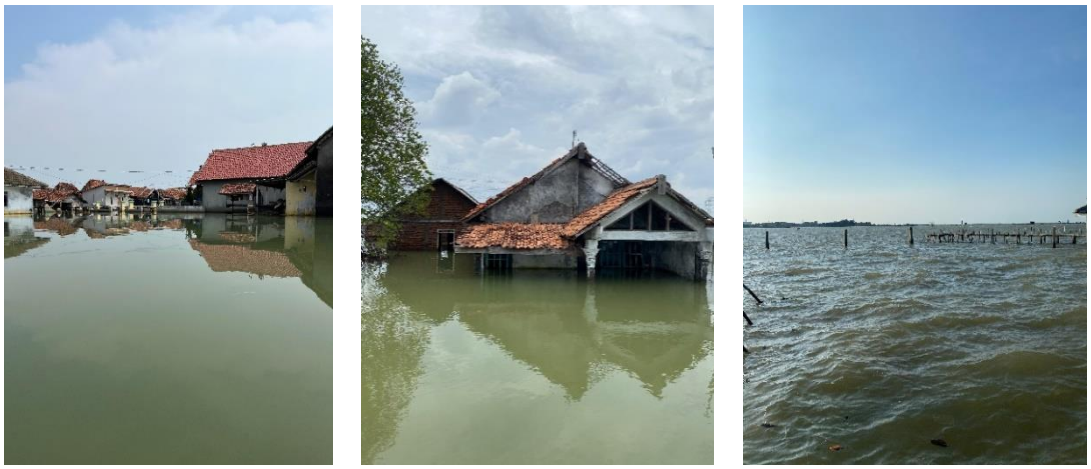
coast cannot be separated from the increasing need for life. The catch and pond production are used as raw materials by large industries. The unsold catch becomes the main source of protein for fishermen households [7]. However, livelihoods are faced with weather conditions and climate change. The risk of disaster such as abrasion is an unavoidable obstacle.

Abrasion is coastal erosion process caused by waves or ocean currents. The effect caused is affected by the speed of abrasion. According to Lakatompessy et al. [8], the erosion is caused by nature and human activity. Naturally, abrasion occurs due to the ebb and flow of seawater as well as ocean waves [9]. This natural factor becomes uncontrollable when human activity occurs, such as sand mining for building materials [7] and increasing logging of mangrove forests [10]. The area often affected is Pantura coast of Central Java Figure 1. Geologically, coastal area is composed of alluvium deposits and beaches consisting of gravel, sand, and mud [11]. The characteristics of deposits are generally loose materials with low resistance to erosion by sea waves [10]. The current of the sea waves is strong hitting coastal area accompanied by the activity of cutting down mangrove forests. Damage due to abrasion causes several problems, including shrinking beach width, tidal flooding, as well as damage to ponds, mangrove forests, infrastructure, and loss of shelter for fish in the waters [12,13].



(**a**) (**b**) (**c**)

Figure 1.
Damage due to abrasion at the research location (a); (b); (c).

The effect affects the income of fishermen/ fish farmer since the professions are switched to become factory workers. Therefore, many fishermen are unemployed and depend on other family members [14]. This phenomenon is detrimental but there is an understanding that abrasion is inevitable. The condition allows fishermen/ fish farmer to adapt continuously to survive with the uncertainty of livelihoods. Fish farming is very dependent on natural conditions, prices, and markets. Fishermen are very vulnerable to changes in the physical environment and this vulnerability affects resilience of dealing with abrasion. Each fish farmer has a different resilience when affected by abrasion because the concept depends on the control. Resilience in communities is an important determinant of the sustainability of an ecosystem vulnerable to the dynamics of change [15].

According to Kurniadi et al. [16], resilience is related to understanding survival, behavior, real actions, and strategic steps to reduce and manage risks due to unplanned conditions. In addition, the concept is a mitigation process and strategy. The support from stakeholders to assist fishermen/ fish farmer reduces the negative effect of disasters [17]. The conduction of resilience in the face of abrasion on Pantura coast is very important. This research aimed to identify resilience of fishermen/ fish

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farmer on Pantura coast affected by abrasion. In this context, some fishermen/ fish farmer cannot survive in limited situations since the choice to move is rational.

2. Materials and Method

This research was conducted on Pantura coast of Central Java which was most affected by abrasion [18]. The 3 regencies with the highest area affected were Demak Regency, Brebes Regency, and Semarang City. From each regency, selected one district that the most affected districts by abrasion were are Sayung, Brebes, and Tugu. Each the districts, 3 villages with the largest number of fishermen were selected, resulting in a total of 9 villages.

The selection of respondents was carried out by purposive sampling. The regency selected 60 fishermen/ fish farmer, with the number of respondents in each village being 20 people. Determination of respondents by snowball sampling who met the criteria as respondents [19]. A total of 180 respondents were obtained from the 3 regencies using snowball sampling. The first fisherman/fish farmer who becomes a respondent is the head of the fishermen group or the head of the fish farmer group. Based on information from the first respondent, the next respondent will be obtained who is determined according to the respondent criteria. The criteria for respondents were being able to understand and answer questions in the questionnaire and at the time of data collection. Not all fishermen/ish farmers have good knowledge, understanding and communication in answering questions so snowball sampling is the best alternative.

Data were collected using surveys, in-depth interviews, observations, and recording [20]. The research was conducted in April - June 2024. Researchers conducted a survey of fishermen/ fish farmers to collect data using a structured questionnaire in an in-depth interview. The data was then processed and interpreted based on the results of observations, records and previous research comprehensively. Qualitative data analysis was carried out using a constructivist-interpretivist method to create a meaning and subjective understanding of real-life experiences. This produces a social reality seen from the results of social construction [21] and data triangulation method was used [22] to strengthen the depth of the research. Data triangulation is carried out by checking the accuracy of the data by comparing the data submitted between respondents with various sources including the results of previous research, socio-economic conditions and the livelihoods of fishermen/fish farmers until saturated data is obtained.

3. Results and Discussions

Fishermen/ fish farmer experience uncertain living conditions because the profession is very dependent on nature [14]. Different strategies were adopted when the main source of income was unable to provide a decent living due to the effect of abrasion. Fishermen/ fish farmer households remain in locations affected by abrasion because of several considerations seen from an economic and social perspective [23]. Living decently in settlements affected by abrasion is not easy, hence, the adaptation to increasing resilience of farmers needs to be analyzed.

Table 1.
Coping strategies of fishermen/ Fish farmer livelihoods.

Coping strategies	Number of fishermen-fish farmers (People)	Percentage (%)
Adding other jobs outside fisheries sector	70	38.9
Adding other jobs inside fisheries sector	39	21.7
Adding other jobs outside fisheries sector and relying on government subsidies	14	7.8
Relying on government subsidies	11	6.1
Managing finances and relying on financial assistance from family	10	5.6

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Raising the house	10	5.6
Relying on financial assistance from family	7	3.9
Waiting for the tidal water to recede	7	3.9
Installing nets	5	2.8
Going into debt	3	1.7
Making embankments	3	1.7
Adding other jobs outside fisheries sector, raising the house and installing nets	1	0.6
Total	180	100

Based on Table 1, coping strategies most often carried out is adding other jobs outside fisheries sector and this is the main strategy to increase household income [24]. The other jobs added should not be risky and this result is in line with Susilo et al., [25]. Fishermen/ fish farmer implement a type of strategy and carry out a combination of coping mechanisms as explained in Table 2.

Table 2.
Combination of fishermen/ Fish farmer coping strategies.

Combination of coping strategies	Number of fishermen-fish farmers (People)	Percentage (%)
Single strategy	157	87
Double strategy	22	12
Triple strategy	1	1
Total	180	100

Based on Table 2, a single strategy is more widely applied by fishermen/ fish farmer. The implementation of combination depends on the skills, knowledge, resource capabilities and opportunities used by the household [26]. In addition, the pressure and the magnitude of life need also affect the number of strategies used. Combination of double strategies is mostly carried out by adding other jobs outside fisheries sector and raising the house. Specifically, each coping strategies in explaining resilience is explained as follows:

3.1. The Addition of Other Jobs Outside Fisheries Sector

The marine fisheries sector before widespread abrasion was a very promising sector among coastal communities, specifically Pantura coast in Demak Regency, Semarang City, and Brebes Regency, Central Java. This is a result of the research by Amin et al. in 2019 [27]. Milkfish and shrimp production are the main commodities produced from this coast [28]. The majority of coastal residents were previously fishermen because this business improved the welfare of all family members. After more than 20 years of abrasion, fisheries sector, including aquaculture and marine capture, has started to fade. The decline of the sector is due to the inability of the income obtained to meet the daily needs of fishermen.

The increasing daily needs have caused fishermen to add other jobs outside fisheries sector to meet household needs. This is in line with Xu et al. [29], where fishermen should effectively be part of other economic activities, including farming, raising livestock, running a small business, and investing in other alternative jobs to survive and increase income. The sectors targeted as strategic steps include becoming factory workers, casual laborers, construction workers, fish traders, boat taxi drivers, financing family members working in fishing companies, as well as entrepreneurs. The income is used to cover the lack of household needs and this job provides additional money [30].

The ability to adapt to adding jobs outside fisheries sector has problems for fishermen/ fish farmer. This is because fixed working hours are very different from the uncertain working hours

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of fishermen. In addition, low skills and education cause fishermen/ fish farmer to be limited in selecting livelihoods outside of fisheries [31]. This is because of limited choices in adding jobs outside fisheries sector to take advantage of opportunities [32].

3.2. The Addition of Other Jobs in the Fisheries Sector

The pressure to meet living needs forces farmers to think quickly and take on jobs capable of increasing income. Abrasion phenomenon has caused socio-economic changes in coastal communities of Pantura, Central Java [14]. The drastic decline in social and economic status requires coastal communities to implement strategies to survive. The efforts include increasing and changing fishing time, processing fish catches and developing cultivation in fisheries sector [33]. This job does not require different skills and education but is riskier than working outside fisheries sector.

Respondents in Semarang City carry out processing activities to increase the economic value of the catch and cultivation of milkfish. The choice to increase the added value is because the area is close to the city as the main market for processed products [34]. In this context, milkfish is processed into presto, otak-otak, crackers, and smoked fish "mangut". The government facilitates the processing of fish catches and the target of this empowerment program is to provide additional income. A well-managed home industry provides many benefits, specifically in improving the economy of the local communities [35]. The habits of fishermen/ fish farmer households cannot be easily changed in this processing business. This requires the development of confidence and strong motivation [36].

Fishermen/ fish farmer in Demak Regency cultivate green mussels on former pond land submerged and turned into the ocean. The choice is considered more profitable because green mussels are easy to cultivate and do not require additional nutrients [37]. In the presence of big waves, the green mussels are swept away underwater to reduce the production. In addition, fishermen switched livelihoods to become "boat taxis" for religious tourism in Bedono Village. These "boat taxis" are an alternative for religious tourism to reach Bedono Village which is only 1 km away. Currently there are no government regulations regarding the use of these boat taxis. The location of religious tourism near the sea was affected by abrasion and increased the difficulty of accessing roads. This provides an opportunity to conduct business by becoming a boat taxi and increase income.

Respondents in Brebes Regency added jobs as seaweed cultivators (*Gracilaria sp.*) This job does not require education or work experience since adaptation is easier and faster. *Gracilaria sp.* cultivation was selected because of the relatively low production risk, easy cultivation, does not require large capital and there are seaweed collectors. Fish farmers use pond land that has been damaged by abrasion. *Gracilaria sp.* has a relatively short harvest time allowing fishermen to obtain additional income faster [38].

3.3. Managing Finances

Another strategy used by fishermen/ fish farmer to survive are managing finances. The majority who use this strategy are unable to obtain additional sources of income. Changing a consumptive lifestyle to a frugal lifestyle is not easy to conduct in terms of habits and prestige. However, the adaptation should be conducted immediately compared to debt consideration [39]. According to Loppies [40], good financial management creates a more stable financial condition to achieve long-term sustainability of life. The respondent households reduced consumption of food and this strategy can cause several health problems and malnutrition in coastal residents [41]. Respondents who are in the poor category rely on social assistance from the government to obtain 10 kg of rice per month. However, malnourishment is experienced when the number of family members is more than 4 people. Respondents also use local potential obtained without purchasing consumed to increase household food security [42], including green mussels, sea fish, sea shells, and seaweed. Consumption of local resources is one of the efforts that can increase food security in the region [43].

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3.4. Relying on Government Subsidies

The negative effect of tidal flooding includes settlements inundated for weeks or months, inability to stock ponds with milkfish/ shrimp seeds for a long time, and loss of harvest or crop failure. The disaster occurs repeatedly every year and the people living in the area have no choice but to accept [44]. Respondents accept the situation and live-in harmony with the conditions due to the inability to overcome flooding. The households move to a higher location when flooding is high [45] but return to the settlement after receding. Living in harmony with tidal flooding is the best choice to minimize losses. In the context of livelihoods, family members are saved when tidal flooding is large rather than looking for work to cover household needs. Respondents rely on assistance from the government subsidies or donors when there is a large tidal flooding to survive.

4.5. Relying on Government Subsidies

Climate change causes tidal flooding, increased temperatures, as well as melting of the ice in the North and South Poles. The melting of ice allows the average sea level (ASL) to increase every year [46]. Another factor is land subsidence, which includes the lowering of the surface due to geological activities such as the compaction of unstable soil structures [47]. This process occurs on coast of Tugu and Sayung District due to physical development activities. For the past 10 years, land subsidence of 1 meter [48] has occurred. Tidal flooding is a common occurrence in coastal area of Pantura, Central Java. Every year coastal communities deal with the problem of high tidal flooding, specifically in the 6th or 9th month. The occurrence has damaged public facilities on coast, as well as residential roads for coastal communities.

The adaptation of respondents is to raise the height of the house building and existing road access. This elevation activity is carried out to enable activities outside the home and still live comfortably. Coastal communities on the North Coast prefer to stay and adapt to tidal flooding because of love for the homeland and work, as well as strong social relations between residents. The mindset of tagging the place of residence as a legacy of the ancestors and culture causes respondents to limit migration or relocation intention [49]. Residents prefer to increase the comfort of life by raising houses Figure 2 as a more comfortable place to live during tidal flooding and to avoid skin diseases. For respondents with limited funds to raise houses, the adaptation is carried out by raising the terrace, the entrance or the floor Figure 2. This causes the terrace building to be higher than the rooms or the height. Respondents are expected to bend when passing through the door since the height of the building is low. However, frequent bending causes the body to become hunched [50]. Some respondents and family members were already seen hunched at the time of data collection. In the long term, this has a negative effect on the growth and formation of crooked bones in the population of the research area.

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Figure 2.
Raising the terrace of the house/building (a); (b); (c).

4.6. Relying on Government Subsidies

The effect of abrasion has significantly changed conditions of fishermen/ fish farmer livelihoods, in terms of economy [51]. Reduced monthly income has an effect on the inability to meet household needs. An important way to meet household needs is to rely on financial assistance from children or relatives who are more economically stable. Family members with relatively high skills and education work outside the area [52]. Based on the results, most family members work in fishing company whose range reaches the middle of the ocean/continent. Individuals who are successfully working in the company then attract other family members, relatives or neighbors. This is a characteristic of the strength of social relationships in the lives of the communities, causing the bonds of brotherhood to be relatively strong [53]. The tradition has developed in society where the strong will attract the weak to balance livelihoods [54].

4.7. Waiting for Tidal Water to Recede

Tidal flooding is an unavoidable phenomenon for people on Pantura coast. This results in the inundation of houses and road access with ankle height to the roof for approximately 4 months from June to September every year [55]. Efforts made are to raise the house, terrace, and access to the house using piles of soil or other materials. However, this activity cannot be carried out by all levels of Pantura coastal communities because the process requires large costs [56]. Some levels of society prefer to surrender in the face of tidal flooding in the settlement. An important adaptation of fishermen is to wait for tidal water to recede. Household appliances and electronic goods are placed in higher places to avoid damage. Activities inside the house in a flooded state are common for respondents. This is the same as the communities living on the banks of Bengawan Solo River in Bojonegoro Regency whose settlements are flooded [57]. After the water recedes, the communities clean the mud carried by the rob. This is in line with Bras et al. [58] stating that adaptive management is needed due to the uncertainty of adapting to environmental changes with the aim of preserving resources for future generations.

4.8. Installing Netting

Milkfish cultivation in ponds is the main livelihood of coastal communities of Pantura, Central Java [59]. Abrasion phenomenon that occurs along coast shows changes in the lifestyle of the communities in cultivating fish in ponds [60]. Meanwhile, rob flood damages mangrove trees, pond embankments, and access roads. Rob inundation higher than embankments prevents harvest of milkfish and causes losses. The higher inundation causes the area of pond ownership to have no markers or boundaries, providing free pass to take fish.

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Figure 3 shows the adaptation carried out to reduce the risk of crop failure by installing nets or "waring" [61]. The efforts to use nets are intended for farmers to cultivate milkfish or green mussels. However, the production results are significantly reduced compared to ponds with embankments. This strategy is at risk of crop failure when there are high waves, but is carried out to obtain income. According to Zheng et al. [62], milkfish pond cultivation using nets has been increasingly conducted by the communities in recent years. The use of nets is the most important part of the pond to prevent fish from jumping out and as a sign of ownership.

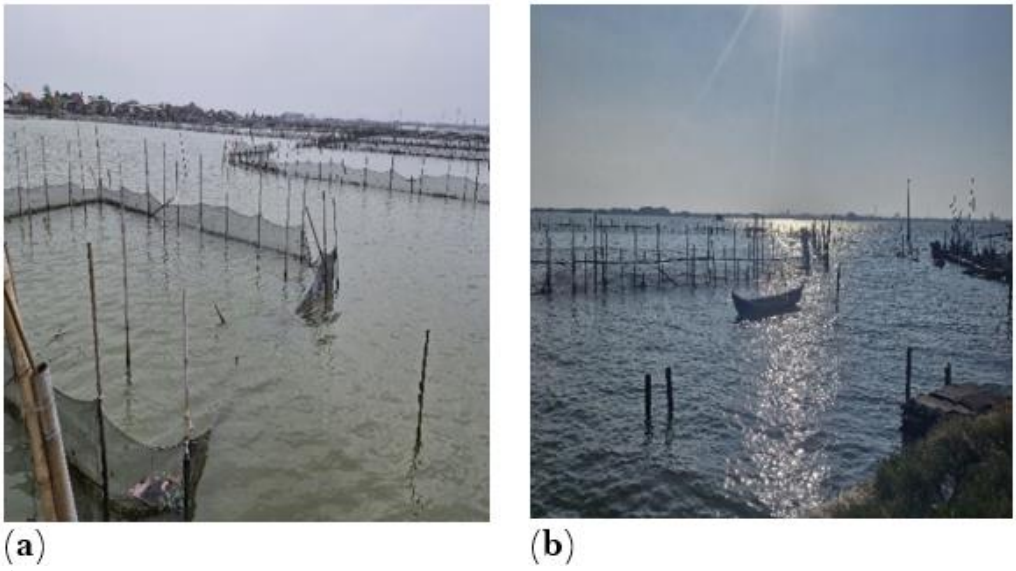

Figure 3.
Installation of netting as a boundary for a damaged pond (a); (b).

4.9. Debt

Fishermen/ Fish farmer rely on debt to survive because of the drastic decrease in uncertain income [63]. This is because the facilities and infrastructure supporting livelihoods are damaged by tidal flooding. The activity has an effect on the loss of assets and crop failure, hence, debt is an alternative to meet living needs [64]. Debt is in the form of loans or basic foodstuffs to neighbors, relatives, or friends. According to Pomeroy et al. [65], well-organized financial problems can reduce the risk of the effect of uncertainty in communities in disaster-prone area. For fishermen/ fish farmer, debt is paid with a relatively high interest rate through the harvest or fish catch [66]. This is also used to repair damaged pond facilities as well as infrastructure and operational capital.

4.10. Making Embankments

Abrasion can be handled by raising embankments of the pond [67]. Fishermen are trying to raise embankments as a step to reduce fish escaping from the ponds [68]. Efforts are made by residents to build embankments from sandbags and the results are not optimal [69]. The weaknesses of embankments are fixed by using geotubes Figure 4. Meanwhile, the construction is carried out through cooperation to prevent the entry of tidal water into ponds and settlements. The presence of geotubes functions as a barrier to tidal waves hence preventing entrance into the pond area. Embankments in the form of geotubes is durable, cheaper and effective as a wave breaker [70]. Geotubes are built on the shoreline to protect coastline from the effect of abrasion. These structures can absorb the effect of waves and reduce the force to overcome coastal erosion. These Geotubes were built with the assistance of local government, village government and self-

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help from coastal communities.

Figure 4.
Geotubes embankments (a); (b).

There are only 5 strategies that can improve resilience of livelihoods by adding other jobs outside and inside fisheries sector, raising houses, installing nets, and constructing embankments in line with Ankrah [71] and Shaffril et al. [72]. The strategies implemented are adaptation strategies to overcome or minimize the negative effect of abrasion. However, these 5 strategies have not been able to restore a better standard of living before abrasion. The condition of coastal environment requires biophysical repairs that are not easy and take a relatively long time. The role and commitment of various stakeholders are important in improving biophysical conditions.

The government minimizes and repairs environmental damage from the physical side including raising roads, making drainage channels in residential areas that are flooded by sea water, repairing drinking water and electricity facilities. This is not directly related to improving economic livelihoods for fishermen/fish farmers.

Planting of mangrove seedlings was not carried out by fishermen/ fish farmer in the research area because the process always failed. The high tidal waves caused the planted seedlings to be carried away by the current. Planting of seedlings was conducted by Non-Governmental Organizations or Corporate Social Responsibility of environmentally conscious company and the process requires high costs. The government installed a wave breaker is needed to increase the resistance of seedlings to wind and tidal waves. Therefore, seedlings are not planted on the shoreline but around residential environment.

5. Conclusion

Fishermen/farmers affected by abrasion have the ability to survive in uncertain situations. The results obtained from the sea or ponds are not able to meet daily needs. Efforts taken by carrying out coping strategies. Coping strategies applied in locations affected by abrasion were dependent on the resources, skills, education, and ability to take advantage of business opportunities. They are adding other jobs outside fisheries sector, adding other jobs inside fisheries sector, managing finances, relying on government subsidies, raising the house, relying on financial assistance from

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family, waiting for the tidal water to recede, installing nets, going into debt, and making embankments. However, only 5 of the 10 coping strategies can increase resilience. Fishermen households did not move to a more comfortable location due to the proximity of work location, as well as strong kinship and social relationships among residents. The role of government agencies and related stakeholders in minimizing the spread of the effect of abrasion was important. Rehabilitation of the biophysical environment restored livelihoods before abrasion became more widespread.

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EWR: conceptualization, methodology, original draft; MH: original draf, data curation, data analysis and review; K: supervision, original draf, and review; IK: original draf and review; NS : data analysis and editing; AQ : review and project administration; RWN: original draf and editing; SG: data curation and review.

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