Community Perception Of Predicted Sea Level Rise In Coastal Village Of East Belitung Regency, Indonesia

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ABSTRACT:

The global warming issue has a direct impact on the rise in sea levels whereby the trend has reached 0.8-1 cm/year within the last 20 years. This research aims to determine the coastal community's perception of the predicted sea level rise in coastal villages in East Belitung. Spatial analyses, field surveys, and local interviews were performed and applied to the three Coastal Tourism Villages in East Belitung Regency: Bukulimau, Baru, and Lalang. The research results show that, generally, coastal communities and small islands in East Belitung Regency are aware of the impact of rising sea levels. Of particular concern, based on the simulation results, an increase in sea level of about 100 cm will occur in 2090, meaning that the Baru Village is vulnerable with the expected flood area of about 85.8%, followed by Bukulimau Island with 83%, and Lalang Village with a vulnerable submerged area of approximately 50.8%. Therefore, advance mitigation and disaster preparedness are necessary to minimize the further impacts of sea level rise in East Belitung.

Keywords: global warming adaptation, community perception, sea level rise, coastal areas, small islands. communities and small islands in East Belitung Regency are aware of the impact of rising sea levels. Of particular concern, based on the simulation results, an increase in sea level of about 100 cm will occur in 2090, meaning that the Baru Village is vulnerable with the expected flood area of about 85.8%, followed by Bukulimau Island with 83%, and Lalang Village with a vulnerable submerged area of approximately 50.8%. Therefore, advance mitigation and disaster preparedness are necessary to minimize the further impacts of sea level rise in East Belitung.

Keywords: global warming adaptation, community perception, sea level rise, coastal areas, small islands.

1. INTRODUCTION

Based on the Law No. 27 of 2007 in conjunction with Law No. 1 of 2014 regarding Coastal and Small Island Management, it stipulates that coastal areas are measured from coastline to the administrative boundary towards the land and the sea area is

measured from the coastline along 12 nautical miles towards the sea. This stipulation makes the coastal area significant which has a substantial potency in the economy and ecology, even though on the other hand, hazard and disaster threats could not be neglected. Sea level rise issue currently becomes a considerable problem, particularly in the equatorial region. The average increase in sea level from 1993 – 2003 was approximately 3.1 mm/year (2.4 – 3.8 mm/year) (Fitriana et al., 2022).

This study will address the threat of sea level rise in coastal areas. The rising sea level becomes a problem when the seawater invades the land and causes damage to the coastal zones (Wisha et al., 2023). This issue becomes serious as sea level continues to rise in conjunction with global warming and other factors such as wind influence, waves, and tidal effects.

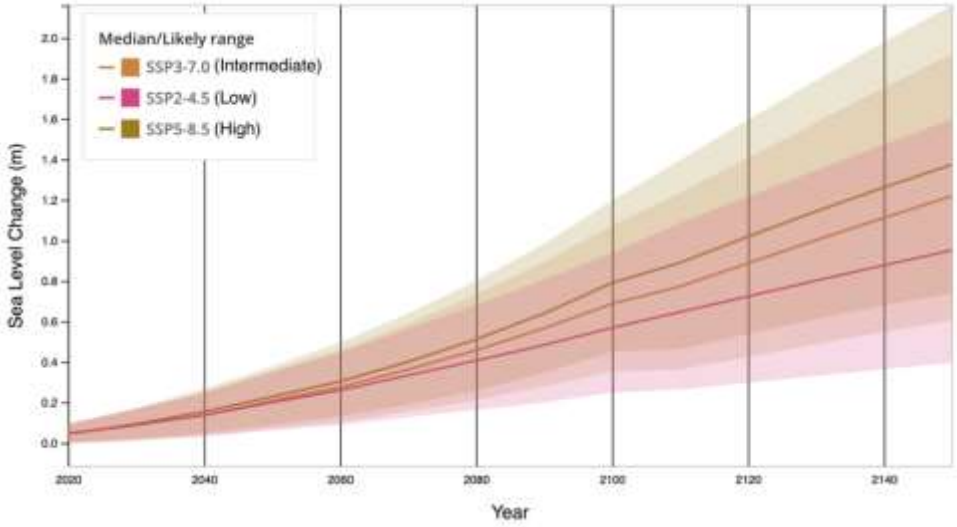

Fig. 1. Sea level Projection estimated by IPCC AR6 in Belitung Island in 2100

Recently, scientists and researchers have shown significant interest in studying global warming, particularly concerning sea level rise. This aspect has become a significant issue that requires a deeper investigation, whereby observations and calculations based on historical data could be considered. According to the research findings presented by experts at the IPCC (Intergovernmental Panel on Climate Change) 2018, the average increase of sea surface temperature on Earth is estimated ranging from 0.3-0.6℃ since the late 19th century. If

this trend continues, it is projected that by the year 2100, the sea surface temperature on Earth will increase by 1.4℃ (Figure 1) (Hidayah et al., 2018; Houghton, 2009). The IPCC report (IPCC, 2018) explains that coastal areas in Southeast Asia will experience a sea level rise 10-15 percent higher than the average global sea level. The sea level rise in 2050 will increase by about 50 cm and in 2090, it could reach approximately 100 cm (Figure 1). This natural process occurs very slowly and often goes unnoticed by humans, with its effect becoming apparent over many years (Yamori and Goltz, 2021). **Fig. 1** shows the projected sea level rise in Belitung Island in 2100, accompanied by upper and lower limit predictions.

Fahruri (2007), Yanuar (2008), and Ramdhan et al. (2012) determined the level of coastal vulnerability due to sea-level rise, which the level was equivalent with tsunami impacts. They also described the story and potential for rising sea levels, especially in coastal areas with low and flat contours. A similar state is also identified in the coastal villages in East Belitung Regency. According to Maurisxha et al. (2023), coastal and small islands are threatened by high environmental risk and high vulnerability to pollution and damage due to natural or non-natural disasters or environmental changes. One of the coastal areas threatened by sea level rise is the eastern coast of Manggar in East Belitung Regency (Figure 2). The unstable coastline changes, aside from the influence of local hydrodynamics, could be caused by the change in coastal structures, massive urban development, dredging, and even long-term effect of sea level rise (Yulius and Ramdhan, 2013; Taofiqurohman and Ismail, 2012; Wati, 2010). Furthermore, Nurhidayah and Mcllgorm (2019) stated that the implications of sea level rise have led to increased vulnerability to floods, abrasion, and inundation in low-lying coastal areas.

Based on the above background, this research examines the physical vulnerability aspects in the East Belitung coastal area as input for the adaptation patterns to sea level rise for the community in the coastal villages of East Belitung. This study will provide recommendations for spatial planning and development in the coastal villages of East Belitung by adjusting areas threatened by sea level rise disasters through adaptation measures.

2. STUDY AREA

The research was conducted in the coastal villages of East Belitung Regency on May – June 2023. Belitung waters are significantly influenced by ocean-atmosphere interactions. The rainfall intensity in this region is controlled by monsoonal cycles. Belitung Island is bordered by the South China Sea in the north, the Karimata Strait in the east, the Java Sea in the south and the Gaspar Strait in the west (Wisha and Khoirunnisa, 2018). Observations were carried out in the villages of Bukulimau, Baru, and Lalang (**Fig. 2**).

3. ATA AND METHODS

3.1. Data collection

We employed a quantitative method using a multidisciplinary approach, considering sociological, geospatial, applied oceanographic, and geomorphological aspects. These approaches will be used as the input on the physical vulnerability assessment as the basis for optimizing coastal community protection toward the sea level rise issue. It also involves the management of existing natural environmental systems and actions to enhance physical and ecological development, taking account into economic, social, environmental, and other dynamic aspects in the coastal villages of Bukulimau, Baru, and Lalang, East Belitung Regency.

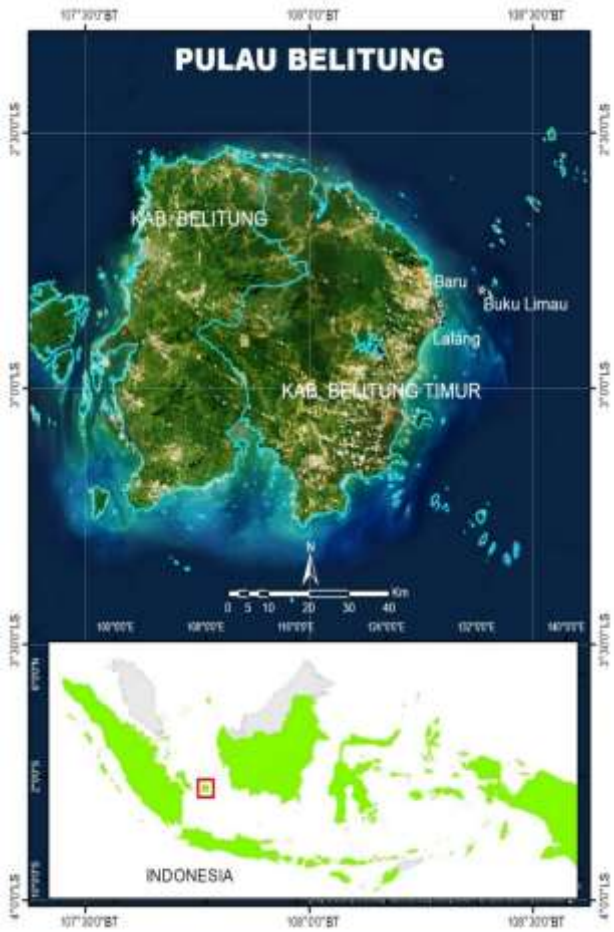

Fig. 2. Map of the study area

Field surveys were conducted through interviews to gain data on community activities and the impact of sea level rise, as well as historical disaster aspects from economic, social, environmental, and other dynamic perspectives (Aswin et al., 2023). Field observations were carried out to obtain data on the condition of the coastline, land use, coastal ecosystem, and infrastructure damage in the coastal villages.

The secondary data comprised a literature review and digital elevation model (DEM). Literature reviews were gained from journals, student theses, or reports on previous research results related to adaptation to sea level rise, abrasion/erosion, and the history of disasters in the aquatic environment of coastal villages. Meanwhile, DEM data in this study utilized elevation (contour) data of the coastal region of East Belitung Regency, which is acquired from the website

https://tanahair.indonesia.go.id/demnas/ issued by the National Institute of Aeronautics and Space (BIG). The land DEM data was obtained from the Indonesian topographical map at a scale 1:25.000 and SRTM (Shuttle Radar Topography Mission) satellite imagery. The DEMNAS data is the best available free data, with a horizontal resolution of approximately 8 meters per pixel. Using this DEM data, GIS analysis was conducted to identify areas with elevation below 1 meter above sea level (mdpl). The subsequent data used was the distribution of settlements or buildings, retrieved from the website https://tanahair.indonesia.go.id/portal-web/download/ also issued by BIG on basic geospatial information.

On the other hand, the ocean DEM data was obtained by utilizing bathymetric data of the coastal region of East Belitung Regency collected from the Indonesian Aquatic Environment Map (LPI) at a scale of 1:50.000. The inundation area was estimated considering the sea level rise (SLR) projection for the years 2050 and 2100. The land use data for 2022 was sourced from Google Earth and demographic data from the Central Agency of Statistics (BPS) of East Belitung Regency.

As additional information, the settlement and building distribution data from BIG are based on relatively old data, necessitating updates. Updating can be done by downloading high-resolution maps from Google Earth, with the most recent data recorded on April 29, 2020. Based on this image, several settlements and buildings have been added to the research area. The next step involves overlaying areas prone to inundation (below 1 meter) with settlement-building areas.

3.2. Geographic Information System (GIS) Analysis

Geographic Information System (GIS) is a system used to collect, store, analyze, and manage data related to geographic or spatial locations. GIS integrates geographic data such as maps, satellite images, and other georeferenced data with non-geographic data such as databases and tables to provide more effective data visualization and analysis.

GIS can be utilized to facilitate the retrieval of various processed and stored data as attributes of location or object. The data processed in GIS essentially consists of spatial and attribute data in digital form, for example, the distribution/number of population (attribute) in a county

(spatial data). This system relates spatial data (e.g., county location) with non-spatial data (population), allowing users to create maps with attributes and analyze the generated information according to the analysis goals.

GIS also maintains data in digital form, making GIS data denser compared to data in the form of printed maps, tables, or other conventional forms. This technique accelerates work and reduces costs. GIS is often combined with the Dynamic/Temporal Model to obtain more comprehensive information because environmental conditions are always dynamic due to influences such as climate, weather, time, and other factors. These dynamic factors are essential in GIS and Spatial Data (SD). Users can analyze both spatial and temporal aspects for future policy decisions.

3.3 Social and economic characteristics of the respondents

An overview of respondent characteristics was examined based on age, education, occupation, and the number of family members. Age is one aspect that influences respondent in taking actions or decisions related to their business. Productive age individuals typically have excellent physical condition in conducting business (Gadzali and Ausat, 2023). Respondents in this research location generally fall within the age range from 30 – 50 years (47%), on average 47.44 years. According to categories of the Central Statistical Agency (BPS) in 2020, this age range is considered productive and ideal for fishers, requiring more physical activities than land-based occupations.

The education level of respondents will influence their ability to implement the technology used and their mindset in managing their business. The education level possessed by respondents is a community asset to make it easier to absorb the information. The applicable formal education ranges from elementary school to college. The characteristics of respondents viewed from their educational level generally show the completion of elementary school (38%) and high school (31%). There are still respondents who did not attend school (12%). Nevertheless, there are also respondents with education up to college level (3%).

The number of family members provides information about how many needs the respondent must prepare to meet household needs. The analysis shows that most respondents

(44%) have 2 – 3 family members. Of the respondent's side jobs, it was found that around 63% did not have a side job, and some respondents (37.50%) have a side job as employees, village officials, traders, and entrepreneurs.

4. RESULTS AND DISCUSSIONS

4.1. Inundation area based on sea level projection data.

In the village of Baru, almost the entire area is identified as prone to flooding due to the elevation being less than 1 meter above sea level (mdpl). Based on spatial analysis results, the village of Baru has a total area of 210.8 hectares, with settlement-building areas covering 100.6 hectares. After inundation analysis, it is revealed that 86.3 hectares of settlements are prone to flooding (40.9% of the total village area) or approximately 85.8% of the total settlements (**Fig. 3**).

The photos in the figure depict field conditions during the field survey. Residents along the Manggar River have demonstrated local wisdom in constructing a coastal protector made of arranged stones. Residents have built houses on stilts in other locations, indirectly adapting to rising sea levels. Some government efforts in the form of wave breakers could relatively minimize coastal abrasion. The common beach type is arranged of a flat morphology with brownish-white sand, and some beach vegetation provides natural protection.

As for the conditions in Lalang Village, the total area of Lalang Village is approximately 506.2 hectares, with a total settlement area of 85.3 hectares. Based on the inundation analysis, it is found that 43.4 hectares are in prone areas (50.8%). Approximately half of the settlement in Lalang Village is prone to flooding. The coastal topology in Lalang Village is almost the same as in Baru Village, characterized by a flat morphology with brownish-white sand, and some beach vegetation serves as natural protection, as shown in **Fig. 4.** Some findings during the field survey indicate that mangrove land has cleared (deforestation) for cultivation. The river's water level is not significantly higher than the ground surface, so in the event of rising water level, it can inundate the land. Some natural vegetation in Lalang Village consists of mangroves in certain areas.

On Bukulimau Island, after conducting spatial analysis, it is revealed that the island's total area is 6.7 hectares. From the

total area, 5.4 hectares are prone areas, and only about 1.3 hectares are relatively safe. The houses or buildings on Bukulimau Island cover approximately 3.3 hectares, with around 2.7 hectares in prone inundation, and only about 0.5 hectares are relatively safe. Therefore, around 83% of the houses on Bukulimau Island are susceptible to inundation.

Some findings in the field indicate the presence of remnants of buildings (house foundations) that were previously standing but were later damaged due to abrasion. Houses mostly affected by abrasion are of the ground-type construction. In some other locations, the building type reflects the local wisdom of residents constructing houses on stilts, minimizing the impact during high tides. Efforts to protect against abrasion also show the existence of wave-breaker structures expected to reduce the impact of abrasion. Based on satellite image maps, breakwater structures can be seen along approximately 1 km, enclosing almost 3/4 of the island, except for the southeastern part of the island (**Fig. 5**). These breakwater structures are built in the west, north, and east sides of the island, where massive abrasion occurs where damaged houses and bridges exist.

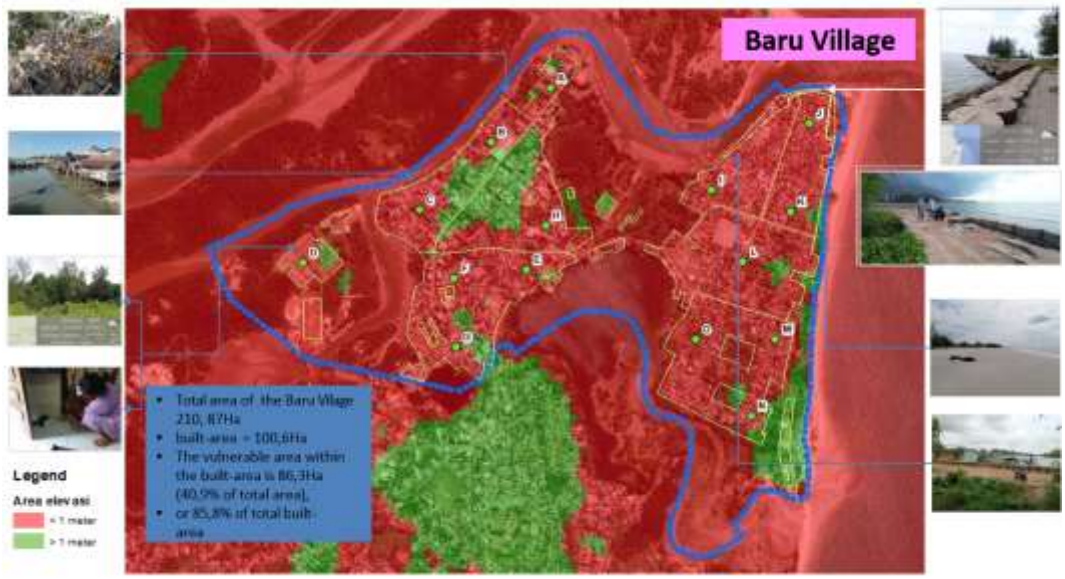

Fig. 3. Inundated area based on field survey in Baru Village

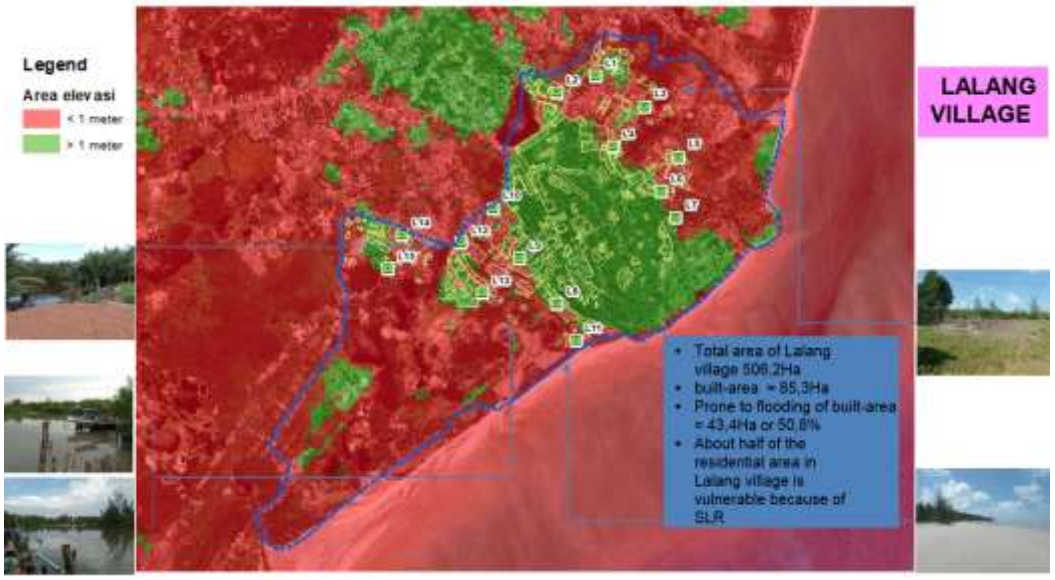

Fig. 4. Inundated area based on field survey in Lalang Village

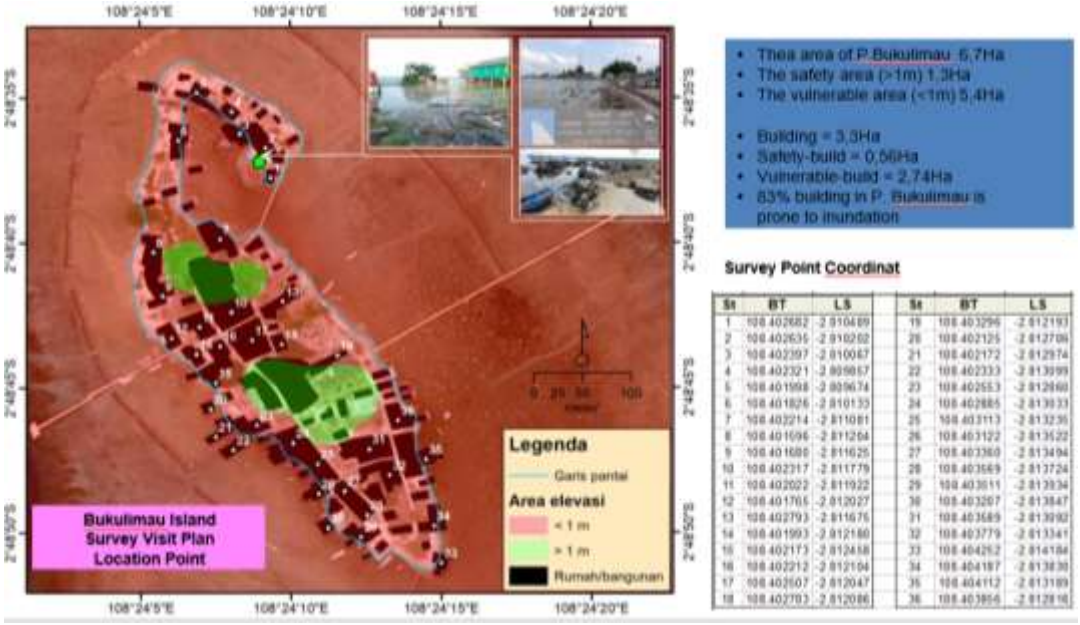

Fig. 5. Inundated area based on field survey in Bakulimau Villlage

4.2. Respondents' perception about sea level rise

The community's perception of sea level rise varies considerably, influencing adaptive responses during disasters or rising sea levels. Based on **Fig. 6** below, most respondents in this study already know the impacts of sea level rise, amounting to

87.50%. The rising sea level affects the properties owned by 37.50% of respondents because they live in those areas.

The rise in sea levels and high waves caused a flood in 2017, lasting for one week with heavy rainfall for two days. Tidal floods or high tide disasters seasonally occur, particularly in June and July during the immense tides of about 20-30 cm. High waves cause coastal erosion (abrasion), and many trees are uprooted. The adverse effects of this natural disaster on the coastal village residents include damaged houses due to tidal floods, fishermen's boats being unable to dock, and being forced to navigate rivers to avoid the ocean waves. This natural disaster claimed 1,712 persons, with one reported dead in Lalang Village and Baru Village.

Disaster mitigation, primarily to address high waves, involves the construction of seawalls to prevent wave impact. This mitigation is well-known among the local population as it relates to coastal residents' economic and social aspects. Additionally, dams are built at the river's entrance and equivalent to the river, and other disaster mitigation measures include planting pine and mangrove trees, utilizing former tin mining ponds as reservoirs for water entering from the sea, and building river embankments. Houses affected by tide floods are renovated into elevated houses with embankments in front of the doors, and housing relocation has also been conducted.

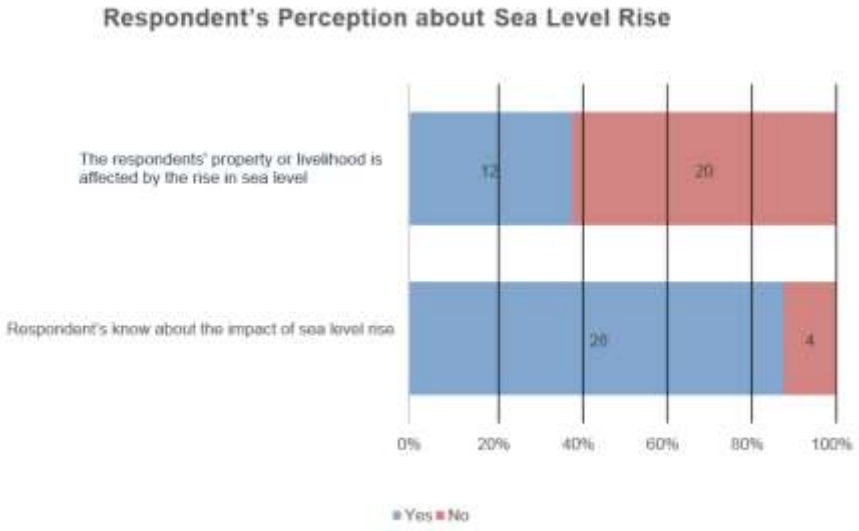

Fig. 6. Respondents' perception about sea level rise

The community is already aware of Sea Level Rise (SLR) 's impacts on various aspects of life. Survey results show that 94% of total respondents perceive the occurrence of sea level rise disasters affecting community life (**Fig. 7**). Coastal erosion (abrasion) is the most prominent natural disaster experienced by coastal community members, followed by building damage and disruption to the economic and socio-cultural activities of the community. Abrasion is massive in the study area, hampering fishing activities and access to Manggar. The port serves as a vital mobility facility for the population. According to residents, despite bad weather, it does not hinder the mobility of people from Bukulimau Island to Manggar, East Belitung.

Disaster mitigation is the government's responsibility, with respect to budget and policies. The government has conducted awareness campaigns about the disaster-prone coastal villages and formulated master plans and policies to address the impacts of natural disasters, such as sea level rise and high waves. However, the knowledge of coastal village residents regarding government disaster mitigation policies is still low (less than 50%). Residents with limited knowledge about disaster mitigation policies believe there is no such policy (59%), and few (23%) coastal village residents are aware of local government policies addressing natural disasters.

From the above description, it can be deduced that the community knows seasonal natural disasters that affect their living environment. However, the perceived losses from the impact of these natural disasters are not considered significant, and abrasion is the only disaster perceived earnestly. Not all coastal village residents know about various disaster mitigation activities, and the local government has issued very few policies to address natural disasters.

The survey results indicate that sea level rise is inundating residential areas of residents at the research location. The rise in sea levels, causing disaster, is often called exposure, which means acceptance of exposure to a hazard or the presence of stress conditions at the group or individual level due to exposure to a hazard (Tuler et al., 2008). The survey results show that the community has experienced the flooding of houses, but not all the communities in the study area thought that rising sea levels bring losses.

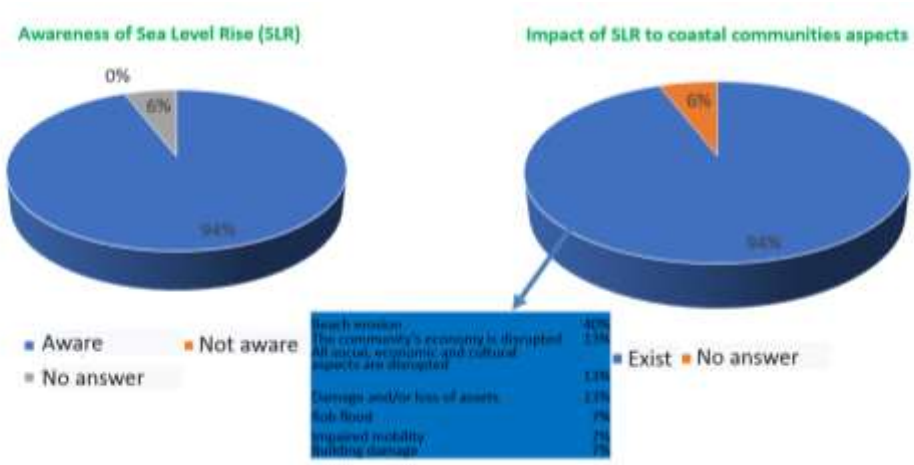

Fig. 7. The impact of sea level rise on the socio-economic and cultural aspects of coastal communities

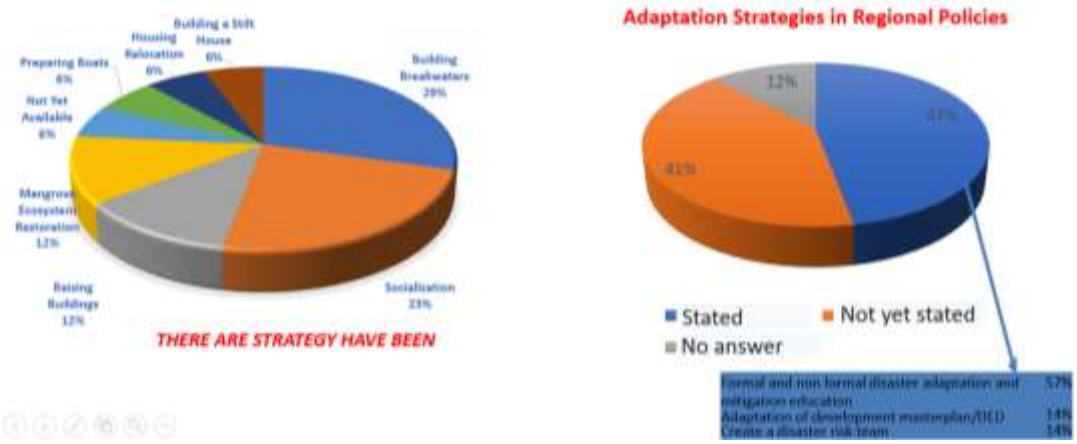

Fig. 8. The adaptation strategies employed by coastal communities in dealing with sea level rise.

In this situation, the community's sensitivity to the exposure of rising sea levels is considered low. Sensitivity always refers to the degree to which an individual or group experiences losses when disasters occur. The disaster's perception level is considered a common issue, not a significant concern. This perception is reasonable because it does not impact the livelihood system of the population. The sea level rise does not impact on vulnerability in the study area. Therefore, the perception of the disaster induced by sea level rise is not a

significant concern for the residents indicating a low sensitivity to disasters.

Sensitivity is often associated with adaptation. Adaptation refers to actions to reduce the impact of past disasters by enhancing the ability to take advantage of existing opportunities or minimize potential damage/loss (Smith, 2006; Houghton, 2009). The community's sensitivity influences their adaptation in responding to disasters. Gallopin (2006) distinguished between adaptive capacity and response to adaptation. Adaptive capacity is a long-term adjustment, while response to adaptation is coping behavior or short-term adjustment behavior. Efforts to address the impact of the rise in sea levels on settlements represent a form of sensitivity to the faced disaster, causing significant risk of loss (Tuler et al., 2008).

The losses experienced by community members engaged in chicken farming are significant. This small chicken farming business, with only a few residents, engaged it. The rise in sea levels or sea floods entering the chicken corps and chicken waste causes an increase in ammonia, leading to chicken poisoning (6.000 chickens). Additionally, it directly damages the chicken cops and houses, requiring them to be raised again. The incident resulted in significant losses, reaching over Rp—100,000,000 in 2010. Mitigation efforts will involve constructing dams at the entrance of water and estuaries and using foundations for chicken cops when the sea level is rising. The impact on the livelihood system is the difficulty for parking fishing boats, which must pass through the river to bring the boats ashore to avoid waves.

6. CONCLUSIONS

Most of the population in the coastal areas and small islands of East Belitung are already aware of the impact of rising sea levels. At the time of this research, rising sea levels have already affected the properties owned by the coastal community. Baru Village, Lalang Village, and Bukulimau Island areas are highly vulnerable to flooding if the sea level rises by 100 cm in the year 2090. Baru Village has the largest vulnerable area, covering about 85.8%, followed by Bukulimau Island, with 83% of its area vulnerable, and Lalang Village, with a vulnerable submerged area of 50.8%.

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