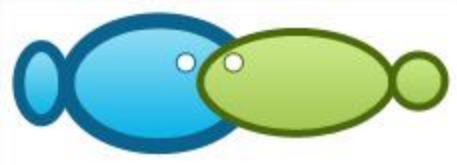

Livelihood vulnerability to climate change of fishermen in the coastal area of Bengkulu Province, Indonesia

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Abstract. The current climate shocks and stresses have devastating impacts on the livelihood vulnerability of the poor fishermen in Bengkulu Province. Increasing frequency of rainfall, temperature, sea level rise, and climate extremes will exacerbate these impacts. This study aims to see how perceived climate change affects the vulnerability of fishermen's livelihoods. The Livelihood Vulnerability Index (LVI) method is used to assess livelihood vulnerability to climate change. The result of LVI analysis shows that Bengkulu City has the highest level of livelihood vulnerability (LVI = 0.472) compared to that of North Bengkulu Regency and South Bengkulu Regency (with LVI = 0.430 and 0.437 respectively). The marine capture fishermen in Bengkulu City are very vulnerable to climate change because they have a high dependence on capture fisheries sector. Internal factor constraints have a positive effect on the level of vulnerability of fishermen's livelihoods and fish production constraints negatively affect the vulnerability of fishermen's livelihoods to climate change. The decline in fish production due to climate change will certainly reduce the level of income of fishermen, thereby increasing their livelihood vulnerability.

Key Words: livelihood vulnerability, fishermen, climate change, exposure, sensitivity, adaptive capacity.

Introduction. Climate change has caused severe impacts in all parts of the world including Bengkulu Province. The low ability of adaptation and mitigation to climate change is one of the reasons for the increasing vulnerability. Studies on climate change and vulnerability has been widely carried out (Ding et al 2017; Handayani et al 2017; Fahad & Wang 2018; Jamshidi et al 2019; Kim et al 2019). However, not many research that links climate change and livelihood vulnerability have been done (Shah et al 2013; Adu et al 2018) and only few concern on livelihood vulnerability to climate change (Himes-Cornell & Kasperski 2015; Baptiste & Kinlocke 2016; Binita et al 2016; Oo et al 2018). Researches related to the impact of climate change on fishermen in Indonesia are very limited. The research is mainly about mitigation and adaptation and focuses mostly on the agricultural sector (Susilowardhani 2014; Zikra et al 2015; Gravitiani et al 2016; Nurhidayah & McIlgorm 2019; Yamamoto et al 2019); it was particularly done in Java Island, the center of Indonesia's economic growth.

The assessment of livelihood vulnerability refers to the IPCC method (2007) which examines three components, namely exposure, sensitivity, and adaptive capacity. The first stage of vulnerability analysis is to assess the potential risk (impact) by looking at the level of exposure and sensitivity. According to IPCC (2007), exposure to climate diversity is basically a function of space (region). Coastal communities will experience different exposures compared to the highlands' people to changes in certain climate conditions. Sensitivity is concerned about the impact of changes in long-term seasonal patterns, short-term adverse weather events and climate change related disasters.

Fishermen who depend on resources such as marine resources have a high sensitivity to changes in climate parameters such as sea level rise and rising temperatures. The vulnerability of marine capture fishermen to climate change depend on their exposure to climate change, the sensitivity of ecosystems to climate change and fishermen's ability to adapt to climate change (Grafton 2010).

The impact of climate change is suspected to worsen socio-economic conditions in about 10,600 coastal villages in Indonesia and coastal areas being the most vulnerable areas affected by its impacts (Diposaptono et al 2009). The research in Bengkulu Province is interesting because it is the third poorest province in Indonesia and has a long coastline of 512 km which makes Bengkulu Province vulnerable to natural disasters, earthquakes and tsunamis (BPS 2017). For example, two islands in North Bengkulu Regency, namely Bangkai Island and Pulau Satu sank due to rising sea levels, while the island of Enggano has narrowed (Wongke 2011). This study will discuss: (1) the existing livelihood vulnerability of fishermen in Bengkulu region, and (2) how climate change severely affects the livelihood vulnerability of fishermen.

Material and Method

Description of the study sites. The study was conducted in Bengkulu Province, Indonesia, covering Bengkulu City, North Bengkulu Regency, and South Bengkulu Regency. The coastal areas of Bengkulu Province are located on the west coast of Sumatera Island with a coastline of more than 525 km. These coastal areas are parallel to the Bukit Barisan Mountains and face the Indonesian Ocean (BPS 2017). The study areas were selected purposively based on the number of fishermen population (more than 200 people) and the existence of fish auction in those areas (Figure 1).

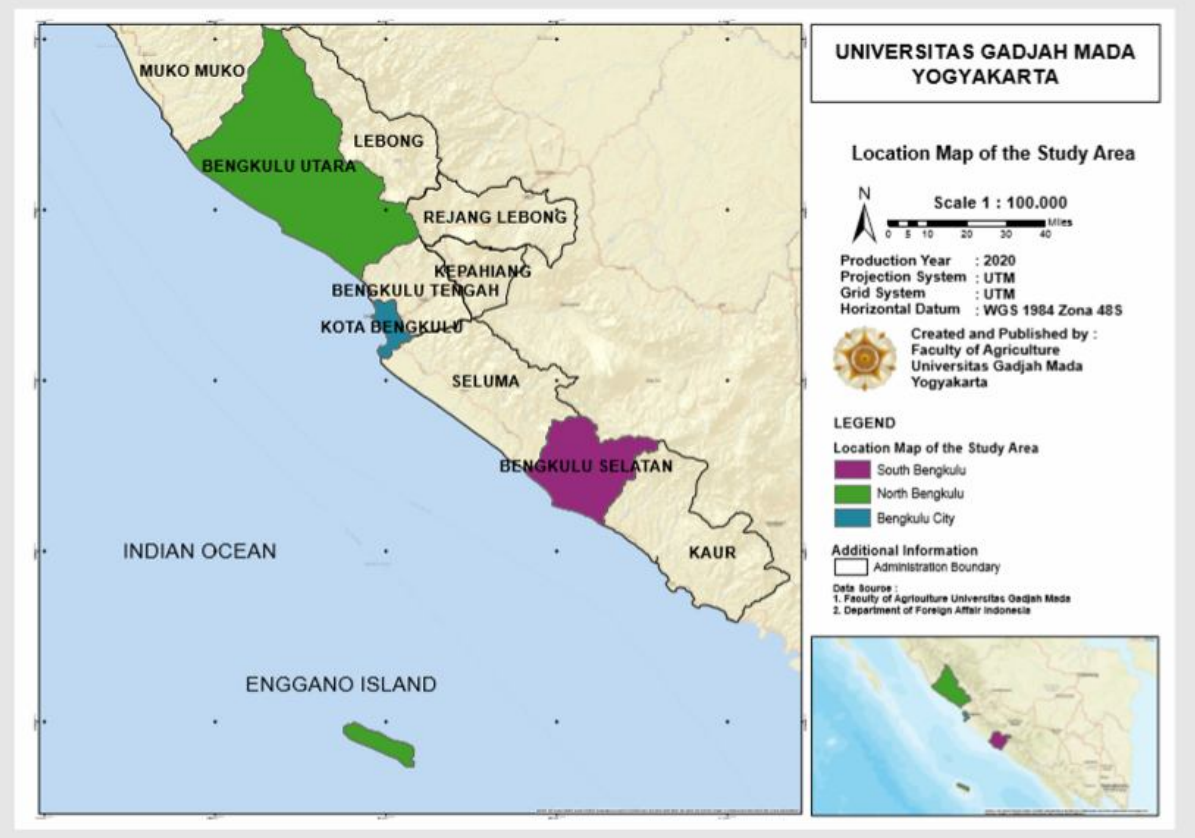

Figure 1. Study area.

Method of analysis. Livelihood Vulnerability Index (LVI) was used to analyse the livelihood vulnerability of marine capture fishermen. LVI analysis consists of three dimensions: exposure, sensitivity, and adaptive capacity with each indicator in each dimension (Table 1).

Table 1

The dimensions and indicators of livelihood vulnerability

Dimension	*Component*	*Indicator*
Exposure	Lost fishing ground	Average % decline in fish catch.
Sensitivity	Dependence on marine capture fisheries sector	Average % income from fisheries sector.
	Weather	Average number of trip.
	Operational costs	% fishermen income for operational costs.
Adaptive capacity	Social capital	% fishermen who do not join organization; % poor fishermen household.
	Economy capital	% income as fishermen; the number of active fishermen; average price of catch.
	Human resources capital	Experience as fisherman, age;
	Resources capital	% income not from fisheries sector;
	Physical capital	Ship weight; catch capacity.

Source: Chen & Lopez-Carr (2015).

The impact of climate change on the level of vulnerability of fishermen's livelihoods is analyzed by using linear regression with variables selected based on previous studies (Table 2), such as age, years of schooling, experience (Nguyen et al 2016), household size (Below et al 2012), income (Deressa et al 2009), ship weight (Senapati & Gupta 2017), fishermen group membership (Wibowo & Satria 2015), ship crew and the impact of climate change (Nguyen et al 2016). Partial elasticity is employed to measure the level of livelihood vulnerability. Partial elasticity measures the effect of increasing explanatory variable Xn by 1% on the change in the probability of fishermens' livelihood vulnerability. Statistical analyses were performed using STATA 15 software.

Table 2

Description of variable

Variable	*Description of variables*
Age	Fishermens' age (years)
Years of schooling	Fishermens' years of schooling (years)
Fishing experience	Fishermens' experience in fishing (years)
Household size	Member of fishermens' household (person)
Income	Dummy (1 = under poverty line, 0 = otherwise)
Livelihood vulnerability	Livelihood vulnerability index
Fishermen group membership	Dummy (1 = if join fishermen group, 0 = otherwise)
Ship weight	Ship weight (GT)
Ship crew	Dummy (1 = if use ship crew, 0 = otherwise)
Climate change impacts	Perception of fishermen on climate change impacts

Survey. The survey was conducted in March-June 2018. Respondents of marine capture fishermen as many as 90 fishermen were interviewed by using structured questionnaire. The first part of the questionnaire was about information on fishermen's socio-economic characteristics consisting of age, education, experience, family size, income, and capture fisheries activities. Next was the level of vulnerability of marine capture fishermen's livelihoods related to climate change, which consists of dimensions of exposure, sensitivity, and adaptive capacity with each indicator.

Results and Discussions

Profile of marine capture fishermen. The results of analysis (Table 3) shows that age, years of schooling, and fishing experience in Bengkulu City, North Bengkulu Regency, and South Bengkulu Regency are significantly different, but income and climate change perceptions are not different.

Table 3

Profile of marine capture fishermen

Characteristics	*Bengkulu City*		*North Bengkulu*		*South Bengkulu*		*Sig.*[a]
	Mean	*Std. dev*	*Mean*	*Std. dev*	*Mean*	*Std. dev*	
Age	41.76	10.63	35.23	9.16	40.36	8.42	0.022**
Years of schooling	8.50	3.51	6.30	2.96	7.66	3.14	0.032**
Fishing experience	17.70	8.15	15.00	6.38	19.63	7.76	0.060*
Household size	3.26	1.01	2.96	1.21	3.50	1.33	0.229
Income	2450000	1003012.703	2923333.333	1556672.697	2217500	1678273.307	0.161
Ship weight (Gross tonnage/GT)	1.81	0.77	11.30	3.94	6.40	2.62	0.000***
Perception of increased rainfall	7.26	1.14	6.43	1.56	8.43	1.07	0.000***
Perception of increased temperature	4.16	0.59	3.33	1.18	4.16	1.14	0.002***
Perception of sea level rise	3.36	0.85	2.83	0.59	3.73	1.14	0.001***
Perception of rob, high wave, and climate extremes	17.90	2.29	14.86	2.82	19.96	3.36	0.000***

Source: Primary Data is processed, 2018. [a] Significance based on One-Way ANOVA for the compare means in proportions between the three groups; *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Fishermen are the most suffering group with a level of well-being far below other community groups (Kusumastanto 2002) and Indonesian fishermen have income levels below the poverty line set by Indonesia. The fisheries modernization policy carried out by the Government to improve the welfare of fishermen does not change substantively much. What happened was just the opposite, namely the widening of the socio-economic gap between social groups in fishing communities and the widespread poverty (Kusnadi 2002). Fishermen in the coastal area of Bengkulu are traditional and have one day fishing with short distance (±6.44 miles). This condition has an impact on the results that are not optimal so that the production level is low and their income is not optimal. The one day fishing system has become the habit of fishing fishermen in Bengkulu, so the Government program with increasing vessel size and changing fishing patterns from one day becomes more difficult to implement. The profession of fishermen in Indonesia is not a promising profession, which can provide a good future or welfare.

Perceptions of fishermen on climate change and its impacts on marine capture fisheries. The results showed that there were differences in the impact of climate change felt by fishermen in Bengkulu (Table 4). The impact of climate change in this study is represented by external factor constraint, internal factor constraint, and fish production constraint. Most of fishermen in the coastal area of Bengkulu Province have a poor understanding of the current climate change. Fishermen perceived that climate change is only a change between east and west monsoon, while for climate change indicator covering temperature change, rainfall and others they have no knowledge (Mulyasari et al 2018). South Bengkulu Regency as a whole has the highest value on the impact of climate change, compared to Bengkulu City and South Bengkulu Regency, except for changes in patterns of fish distribution and the difficulty in determining fishing areas. The South Bengkulu coastal region has a high increase in temperature which can also cause rising sea surface temperatures. The increase in sea surface temperature will cause fish migration patterns and changes in fishing areas (Diposaptono et al 2009). South Bengkulu waters are good fishing ground for tuna and skipjack tuna, but with the increase in high temperatures in this region, the migration of tuna and skipjack tuna is indeed very sensitive to changes in sea water temperature, so fishermen find it difficult to determine fishing areas.

Table 4

Climate change impacts on marine capture fisheries

Impact	*Bengkulu City*	*North Bengkulu*	*South Bengkulu*	*Sig*[a]
A. External factor constraint				
Changes in rainy and dry season	$4.000_{(2)}$	$3.533_{(3)}$	$4.400_{(1)}$	0.000^{***}
Changes in wind direction	$2.433_{(3)}$	$2.633_{(2)}$	$3.966_{(1)}$	0.000^{***}
Increased storm frequency	$3.833_{(2)}$	$3.033_{(3)}$	$3.966_{(1)}$	0.000^{***}
Increased temperature	$4.166_{(1)}$	$3.333_{(3)}$	$4.166_{(1)}$	0.002^{***}
Unpredictable storm	$3.966_{(2)}$	$3.300_{(3)}$	$4.600_{(1)}$	0.000^{***}
B. Internal factor constraint				
Increased sea level rise	$3.366_{(2)}$	$2.833_{(3)}$	$3.733_{(1)}$	0.001^{***}
Ocean currents that are getting stronger	$3.766_{(2)}$	$3.000_{(3)}$	$4.000_{(1)}$	0.000^{***}
Changes in ocean currents direction	$3.666_{(2)}$	$3.200_{(3)}$	$4.033_{(1)}$	0.001^{***}
The sea wave is getting higher	$3.233_{(2)}$	$2.866_{(3)}$	$3.600_{(1)}$	0.012^{**}
C. Fish production constraint				
Changes in fish distribution patterns	$3.533_{(3)}$	$4.300_{(1)}$	$3.700_{(2)}$	0.022^{**}
Unpredictable fish season	$4.300_{(2)}$	$4.200_{(3)}$	$4.900_{(1)}$	0.006^{***}
Difficult to determinant in fishing ground	$3.466_{(3)}$	$4.500_{(1)}$	$4.233_{(2)}$	0.001^{***}
Decreased fish production	$3.333_{(3)}$	$3.833_{(2)}$	$4.166_{(1)}$	0.025^{**}

Source: Primary Data is processed, 2018. (1), (2), (3) are rank of each impacts; a = significance based on One-Way ANOVA for the compare means in proportions between the three groups; *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

North Bengkulu Regency has the characteristics of a coast that has a barrier so that abrasion is a major problem in this region. In the last few decades, the coastal areas in North Bengkulu have been severely damaged due to coastal erosion that took place from time to time. In the last 10 years, North Bengkulu has lost several villages because the coastal area was eroded several meters from the previous shoreline. In addition, many infrastructures (roads and bridges) and settlements that were built in the coastal areas are affected by erosion, creating the concern to many parties about the loss and damage of these facilities. On the other hand, Indonesian Exclusive Economic Zone (ZEE) is increasingly small due to this situation because the coastline is always moving towards the mainland (Samdara 2014).

The high abrasion in the coastal areas of North Bengkulu has made it difficult for fishermen to determine fishing areas, especially fishermen using simple fishing technology (Setyawan 2017). Abrasion in the northern Bengkulu coastal area is relatively faster than in the coastal area of the city of Bengkulu, which greatly affects the activity of fishermen in fishing. The speed of abrasion is exacerbated by the destruction of forests in the coastal borders which are used as oil palm plantations by residents and unattended sand extraction accelerates the rate of abrasion. Because sand and stone are one of the natural coastal absorbers / abrasions in addition to mangrove trees. Other factors are morphology and coastal vegetation which also affect the speed of abrasion. The North Bengkulu coast has a high abrasion speed, which is 2-2.5 meters per year, which causes no more distance between the beach and the road. Mangroves planted on the sidebeach are also no longer able to withstand high waves (Setyawan 2017).

The impact of climate change felt by fishermen in the Bengkulu City is relatively lower and stable compared to South Bengkulu Regency and North Bengkulu Regency, except for increasing temperatures. As the provincial capital, Bengkulu City has the highest temperature due to various factors such as high human activity, increasing population, increasing pollutants due to motorcycle fumes, and the lack of open land for vegetation growth (Tjasyono 1999). Local Governments began to plant mangroves to anticipate the increase of temperature and as a form of climate change adaptation in the Bengkulu City. The mangrove ecosystem in the Coastal of Bengkulu City has an area of approximately 214.62 ha located around the mouth of the muddy Jenggalu River and its coastal coasts (Senoaji & Hidayat 2016). Coastal forests such as mangroves help reduce the risk of various disasters associated with extreme climatic conditions (storms or cyclones) and rising sea levels (flooding on the coast). Research in India (Das & Vincent 2009) and Vietnam (Tri et al 1998) showed that coastal settlements adjacent to mangrove forests suffered less damage due to these disasters compared to non-mangrove forested settlements.

The assessment results of livelihood vulnerability to climate change. The results of the study shows that livelihood vulnerability of fishermen among the regions not different significantly, but these values can indicate which areas are more vulnerable due to climate change (Table 5).

Exposure. The exposure aims to find out more about the effects of climate change experienced by fishermen in Bengkulu. South Bengkulu Regency has a high level of vulnerability in terms of exposure, followed by North Bengkulu Regency, and the city of Bengkulu. A significant decline in catch due to climate change is experienced by fishermen in South Bengkulu Regency and North Bengkulu Regency because the coasts in these two regencies have a high erosion rate of 2-3 m per year due to strong wave/pressures that hit the coastline, so that the coastal areas in these regencies are vulnerable to climate change which causes the coastline to move very fast. The fact shows that all the plants growing in places where there is seawater intrusion are dead. These conditions can be found in some villages in Lais Subdistrict and Batik Nau Subdistrict, North Bengkulu Regency. The death of the coastal trees and plants due to seawater poisoning has a further effect: the coastal land becomes vulnerable so that erosion becomes faster (Suwarsono et al 2011).

Sensitivity. The indicators of measuring the sensitivity index include the percentage of income from the fisheries sector, the number of fishing trips, and the percentage of fishermen income used for operational costs. Fishermen in North Bengkulu Regency have a high level of sensitivity to climate change, followed by those in Bengkulu City and South Bengkulu Regency. Fishermen in North Bengkulu Regency are more sensitive to the shift of the west and east monsoon, high waves, storms, and strong winds, so they stop fishing temporarily to avoid accidents at sea due to extreme weather. Fishermen in North Bengkulu Regency have higher number of fishing trips than those in Bengkulu City and South Bengkulu Regency. They leave for fishing trips twice a day, at 05.00-10.00 and 11.00-15.00. This way, the fishermen in North Bengkulu Regency are very sensitive to climate change. They hope to increase their income as fishermen to help pay the palm plantation costs that they manage. In fact, their income from the side job as oil palm farmers continues to decline since the world's palm oil prices have decreased dramatically.

Table 5

The results of livelihood vulnerability index (LVI)

Dimension	*Indicator*	*Weights*		
		Bengkulu City	*North Bengkulu*	*South Bengkulu*
Exposure	Decline in catch	0.092	0.315	0.466
	Weights of Exposure	**0.092**	**0.315**	**0.466**
Sensitivity	Average income from fisheries sector	0.963	0.808	0.890
	Average number of trip	0.529	0.789	0.430
	Proportion of fishermen income for operational costs	0.130	0.115	0.196
	Weights of Sensitivity	**0.541**	**0.571**	**0.506**
Adaptive capacity	Fishermen not joining any organization	0.967	0.033	0.200
	Poor fishermen household	0.267	0.200	0.533
	Income as fishermen	0.362	0.442	0.260
	Number of active fishermen	1.000	1.000	1.000
	Average price of catch	0.405	0.394	0.205
	Experience as fishermen	0.410	0.524	0.573
	Age of fishermen	0.437	0.480	0.420
	Income not from fisheries sector	0.037	0.192	0.101
	Ship weight	0.528	0.292	0.640
	Catch capacity	0.485	0.447	0.198
	Weights of Adaptive Capacity	**0.489**	**0.400**	**0.414**
	Livelihood Vulnerability Index (LVI)	**0.472**	**0.431**	**0.437**

Source: Primary Data Analysis, 2018.

Adaptive capacity. Adaptive capacity is needed to find out how fishermen make efforts to deal with climate change. The indicators of the adaptive capacity dimensions include the participation of fishermen in an organization, the number of poor households, fishermen income, the number of active fishermen, average prices of catch, experience, age of fishermen, income not as fishermen, ship weight, and catch capacity. The LVI calculation in terms of the adaptive capacity dimension shows that Bengkulu City, North Bengkulu Regency, and South Bengkulu Regency have levels of vulnerability that are not too different from each other. Bengkulu City has a slightly higher adaptive capacity index value than North Bengkulu Regency and South Bengkulu Regency. Marine capture fishermen in Bengkulu City are traditional fishermen using the simplest technologies and classified as poor people. Most fishermen in Bengkulu Province do not have side jobs and have a very high dependence on the capture fisheries sector, so that with relatively low income levels, fishermen find it difficult to improve their family welfare (Mulyasari et al 2019). They are also not active in organizations related to marine capture fisheries. This way, the efforts to deal with climate change are very low and they tend to survive only

by utilizing their own resources. Low levels of education and adaptability make the marine capture fishermen in Bengkulu vulnerable to the effects of climate change.

Determinants of livelihood vulnerability to climate change. The results of this study indicate that livelihood vulnerability is influenced by fishing experience, income, ship weight, crew ship, fishermen group membership, internal factor constraint, and fish production constraint (Table 6). Fishing experience has a positive effect to the level of livelihood vulnerability, which means that increasing experience will increase the level of livelihood vulnerability. The socio-cultural life of fishing communities is inseparable from the limitations of technology, the culture of laziness, wastefulness, and poor management, so that the increase in experience does not guarantee that it will reduce the level of livelihood vulnerability because of the difficulty in changing the behavior and habits of fishermen. When interpreting climate change on the basis of experience, fishermen attend to multiple characteristics of climate change, but also their ability to do something about the climate change, and what they know about the climate change in question (Witte 1994; Morgan et al 2002; Fischhoff 2009). To reduce the level of vulnerability, fishermen must change their habits, mindset and behavior to be able to receive information and technology that can be used to adapt to climate change. Zameer et al (2014) stated that human resources are required to have knowledge, skills, abilities, experience, work motivation, self-discipline, and high morale so as to reduce the vulnerability of fishermen and adapt to climate change.

The income level has a significant effect on the level of livelihood vulnerability, which means that if income falls, it will increasingly increase the vulnerability of fishermen's livelihoods. The results of observations in the field, most of the fisheries caught in Bengkulu Province are traditional fishermen who still use capture fisheries technology which is still simple and does not have side jobs. If fishermen do not go to sea because of extreme weather or strong storms and high waves occur, then what fishermen do is only repairing nets or ships, which has no economic value. Climate change causes unfriendly water conditions so fishermen often delay fishing activities and ultimately affect the income (Purnomo et al 2015).

Ship weight and the use of crew ship also have a significant effect, which means that the weight of ships and the use of crew will increase the vulnerability of fishermen's livelihoods. Most fishermen in Bengkulu province use the ship weight ≤ 10 GT and are a category of traditional fishermen. The addition of ship weight and the use of crews will increase fishing operational costs, so the level of income will also decrease. Especially with the impact of climate change, fishermen find it difficult to determine fishing ground and have to move from one place to another to find fish. This means that there are additional fuel costs incurred by fishermen, so that to increase ship weight and use of crew ship, it will increase the livelihood vulnerability of fishermen.

The participation of fishermen in organizations can reduce the level of livelihood vulnerability of fishermen due to climate change. The use of organizations and social networks is a very important social capital in the fishing community that can help fishermen to interact related to climate change problems faced by fishermen. By participating in the organization, it will improve the means of information on knowledge, and solutions to the problems that fishermen face related to climate change. Organizational culture makes a goal successful and becomes more stable, more advanced, more anticipatory towards environmental change (Maith 2015).

The impact of climate change that affects the level of vulnerability of fishermen's livelihoods is the internal factor constraint and fish production constraint. The increase in sea level and wave height will increase the vulnerability of fishermen. Sea level rise, coupled with a higher incidence of intense storm activity, is expected to have negative impact on coastal breeding grounds of some key species in Bengkulu Province, such as tuna fish. Changes in ocean circulation are also expected to reduce new primary productivity in key fishing areas (Behrenfeld et al 2006). In the last 10 years, sea level has risen 0.1-0.3 m, whereas using a predictive model, it is estimated that there will be sea level change between 0.3-0.5 m, and possibly covering an area of one million km^2 (Roessig et al 2004).

The coastal areas of Bengkulu are characterized by steep seabed topography, and large waves, and are directly adjacent to the Indian Ocean, this boundary directly forms characteristics of oceanographic parameters that occur on the west coast of Sumatra, besides oceanographic parameters, the Indian Ocean forming unique geology that forms different oceanographic conditions compared to other seas. The large waves are characteristic of the sea in the coastal area in Bengkulu, because the coastline is directly adjacent to the high seas. Based on the theory, there are three factors that trigger the occurrence of waves, namely tidal currents (swell), coastal wind (local wind), and shifts (up and down) of rock mass on the ocean floor.

On the coastal areas of Bengkulu, a combination of tidal waves and strong local winds, especially during the west season, will cause big waves. In certain places, interference between swell waves and local wind waves - for example in Cimaja, Pelabuhan Ratu, or in Karangbolong, Surade - can form waves as high as 2-3 m. Another type of wave that is very dangerous in Bengkulu Beach is a tsunami wave. This wave is triggered by a shift in the rise and fall of rock mass in the ocean floor. The interaction between the three types of waves (swell, local wind waves, and tsunamis) is believed to produce powerful waves that suddenly come sweeping the coast.

The shape of the seafloor morphology in a number of locations in the coastal areas of Bengkulu is also very possible to cause severe waves to the coast which at the same time trigger the occurrence of drag currents. As an *uplifted shoreline* with a strong abrasion process, the profile of Bengkulu coast generally has a *breaker zone* near the coastline. As a result, the *surf zone* becomes narrow. If there is wave interference, the attenuation of the waves will occur to form a large wave. Because the exposure area is narrow, even though the waves will break in the ruptured zone, the waves can still sweep the beach with enough energy. This is what causes a rise in wave height which will make it difficult for fishermen to go to sea and ultimately impact the declining catches.

Table 6

Determinants of livelihood vulnerability to climate change

Variable	*Livelihood vulnerability*		
	Estimation coeff.	*t*	*Partial elasticity (P>|t|)*
Age	0.0012	1.56	0.124
Years of schooling	0.0002	0.11	0.913
Fishing experience	0.0038	3.72	0.000***
Household size	-0.0031	-0.59	0.554
Income	-0.0434	-3.42	0.001***
Ship weight	0.0015	3.24	0.002***
Ship crew	0.0264	1.97	0.052*
Fishermen group membership	-0.0326	-1.87	0.065*
External factor constraint	0.0015	0.68	0.499
Internal factor constraint	0.0050	2.06	0.043**
Fish production constraint	-0.0066	-3.27	0.002***
Constant	0.33750	5.84	0.000

Source: Primary Data is processed, 2018. R-squared = 0.5665; Adj R-squared = 0.5053; Root MSE = 0.5116; *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

In the coastal areas of Bengkulu, the average sea level elevation is affected by storm waves and will increase further with the presence of wind waves influenced by the season. These wind waves are considered to represent (proxy) the danger of storm waves, because the magnitude of the waves depends on the wind that raises it. Fishermen know the west monsoon as wet season, because this wind passes through the Pacific Ocean and the Indian Ocean and carries a lot of water vapor, resulting in the rainy season in Indonesia. The rainy season covers the entire territory of Indonesia, with uneven distribution, not only between the western and eastern part of Indonesia but also between the coast areas and the inland areas. The western part has higher average annual rainfall than the eastern part, so do the inland and the coastal parts (Ilahude &

Nontji 1999). An opposite condition occurs during June-August, that was known as east monsoon that coincide with dry season in Indonesia, with some exception of the west coast of Sumatra, Southeast Sulawesi, and the southern coast of Irian Jaya. Between the dry and the wet seasons, there is a season called a transition season, it occurs during March-May and September-November. The characteristics of the transition season are: high air temperature, irregular wind direction and sudden rainfall with high intensity occurs in a short and dense time.

In east monsoon conditions, fishermen usually have a high frequency of going to sea but fish migration has increased because of the rising sea water temperature resulting in a decrease in catches. And at west monsoon, fishermen have a reduced frequency to go to sea because of high waves, storms and climate extremes so that fishermen's catch is reduced. The decline in fish production due to climate change will certainly reduce the level of income of fishermen, thereby increasing the livelihood vulnerability of fishermen. The social characteristics of fishermen who generally have low levels of education and skills do not allow them to look for other jobs that can be used to reduce the livelihood vulnerability to climate change. It is urgent for Indonesia to set climate change adaptation strategy in order to reduce livelihood vulnerability. Yao-Dong et al (2013) explained one of the most important of climate change adaptations in the coastal areas is to improve the monitoring and early warning system and reduce the adverse effects of climate change. It is critical to optimize the monitoring and forecasting system on marine disasters, particularly on storm surge, sea wave, sea fog, red tide, sea level rise, etc., and to improve the emergency scheme and response procedure.

Conclusions. The highest livelihood vulnerability is in the Bengkulu City, followed by South Bengkulu Regency and North Bengkulu Regency. The high dependence on the capture fisheries sector as the main source of household income is the reason why fishermen in the Bengkulu City are more vulnerable to climate change. Overall, fishermen in the Bengkulu region are poor fishermen with simple and traditional capture fisheries technology so that only a few changes to climate indicators greatly affect the level of livelihood vulnerability. Internal factor constraint (increased sea level rise, ocean currents that are getting stronger, changes in ocean currents direction) and fish production constraints (changes in fish distribution patterns, unpredictable fish season, difficulties in finding fishing grounds), decreased fish production) is the impact of climate change which greatly affects the level of livelihood vulnerability of fishermen. In addition, the vulnerability of fishermen is also influenced by socio-economic characteristics such as fishing experience, income, ship weight, ship crew, and fishermen group membership.

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