Social and economic influences on CO$_2$ emission from capture fisheries in West Java Province

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Abstract. Low carbon development has become a trendsetter in this millennial era. The social and economic factors of the community are commonly used variables in assessing linear functions of the level of social welfare. The level of social welfare is then thought to be one of the main drivers of anthropogenic pressure on the environment. We examine the extent to which social and economic aspects of capture fisheries activities influence the dynamics of CO$_2$ emissions generated from capture fisheries activities in all coastal areas in West Java Province during the 2007-2016 period. Based on the results of geographic information system and statistical analysis, we find that the increasing economic factor can reduce the ghg emission while the increasing of social factor on the contrary can increase the ghg emission. The GIS analysis also show that the level of CO$_2$ emissions was found to be lower in districts that had relatively high levels of social index. It is estimated, the higher level of education and social welfare has a real positive correlation with increasing public awareness in conducting fishing activities that are environmentally friendly and carbon friendly.

1. Introduction.

The fisheries sector so far has not been taken into account as one of the sectors that contribute to GHG emissions in the context of climate change. This sector is discussed more precisely as a recipient of the effects of increased GHG emissions and climate change. Even some literature says that it is quite difficult to calculate the impact of climate change on the fisheries sector. The sea and the coast as the place where the fish resources are located, is one of the most vulnerable ecosystems affected by climate change. Sea level rise, coastal abrasion and rising sea temperatures that cause coral bleaching are some of the impacts that occur in coastal and marine areas caused by climate change [1, 2].

Greenhouse gas emissions from the fisheries sector should be taken into account as one of the contributors to the total national emissions, especially if Indonesia seriously wants to reduce its emissions to 26% by 2020. The consideration raised in this regard for Indonesia is mainly because Indonesia is an archipelagic country the largest in the world and most of its inhabitants live in coastal areas. In addition, not a few people depend on fisheries directly or indirectly for their livelihoods.

GHG emissions from fisheries activities, especially from the use of fuel oil used in capture fisheries, may not be significant compared to the 5 other sectors that are already a national priority for reducing emissions, but their contribution still needs to be considered to be included in the calculation of total national emissions. Even though it has not been calculated significantly, emissions from fishing vessels will still increase the amount of GHG emissions released into the atmosphere.

As for the consequences that the sea as a carbon sink or carbon sink, it will be increasingly difficult to absorb more GHG emissions, especially carbon in the atmosphere. The further consequence is that the more carbon absorbed by the sea, the temperature of the sea water will get hotter and the ocean will also become acidic (ocean acidification) [3, 4]. This will then have an impact
on the death of phytoplankton which has so far played a major role in carbon sequestration in the atmosphere, and also the destruction of marine ecosystems such as seagrasses and coral reefs. If a scenario like this continues, it is not impossible that it will result in a decrease in fishery production from marine catches due to damage to marine and coastal habitats [5, 6]. The decline in catches will also have an impact on further reducing the level of welfare of the fishing communities that depend their lives and livelihoods on these marine and coastal resources [7, 8].

Coastal ecosystems such as mangrove forests and seagrass beds are well-known ecosystems as the best carbon sinks and storers compared to other ecosystems. IPPC estimates that the amount of carbon stored in the soil in mangrove forests is around 55 - 1376 Mg ha⁻¹ or can reach five times greater than that stored in the soil in tropical forests [9-11]. Conversion of mangrove forests into ponds will certainly release significant GHG emissions into the atmosphere. Based on data released by the UN World Food Organization (FAO), currently only 10% of the world's fisheries conditions can still be declared healthy and to be caught [12]. Meanwhile, the rest are in different conditions. With such conditions, it is time for fisheries sector development to start considering emission reduction activities that are integrated with environmental, social and economic development.

2. Methodology

2.1. Description of the study sites

West Java Province with 6 coastal regencies was chosen as the study area in the study because it was considered to represent several other coastal districts in West Java. The regencies selected as the study area are 3 regencies located in the northern coastal region of West Java, namely Subang, Indramayu and Cirebon, and 3 regencies on the south coast of West Java, namely Sukabumi, Garut and Pangandaran. The two coastal regions have two different coastal characteristics and are also dealing with two different oceans namely the Indian Ocean and the Pacific Ocean. West Java Province is also a province with the largest population in Indonesia. Regencies that are located on the coast of West Java also generally have a high number and population density of more than 1 million people. The high population in this region will also result in high economic activity of the population which has implications for increased greenhouse gas emissions in the coastal and marine areas of West Java [13-16] . The research location can be seen in Figure 1

![Figure 1. West Java Province, Indonesia.](image-url)
2.2. **Statistical and Data analysis.**

Survey data which are primary data are processed statistically while secondary data such as maps of 6 districts which are the study areas and spatial planning policy documents are processed using Geographic Information Systems (GIS). Primary and secondary data obtained from this study were processed statistically to see the relationship and significance of each variable used. Pearson linear correlation analysis and multivariate statistical methods are components of statistical analysis used to see the correlation between variables used in this study. The calculation of Pearson linear method and multivariate statistics will be done using SPSS 24 software. The choice of this method is due to the need to consider the many factors involved and explain the relationship that occurs in a complex social or natural phenomenon [17, 18].

3. **Results and Discussion**

3.1 **Result**

The analysis carried out in this study included a review of the socioeconomic patterns of the community in 6 regencies which were the study areas. The analysis carried out is GIS analysis, as well as statistical analysis to find out the socio-economic conditions of the communities in the 6 regencies including the condition of marine capture fisheries activities and greenhouse gas emissions produced by existing fishing vessels. Based on data and information on the level of education and the level of welfare that exists in the 6 regencies that are the study areas, it can be made a class distribution of social index values per district in the 6 regencies.

**a. Subang Regency Profile**

The results of data processing at the level of education and welfare to produce social index grades indicate that Subang District generally has low social index grades. Classes of social index values are very low to low generally found in sub-districts in the coastal zone, while increasingly middle and south classes value of social index tends to be low to moderate. There are no sub-districts that have high and very high social index grades in Subang Regency.

![Figure 2. Distribution of Social Index Value Classes by sub-district in Subang Regency 2010](image)

**b. Indramayu Regency Profile**

The results of data processing at the level of education and welfare to produce a social index value class, indicate that Indramayu Regency generally has a low social index value class, especially sub-districts in the coastal area. Very low social index value classes are found in Karangampel sub-district, whereas social index value classes are found in Indramayu sub-district. There are no sub-districts that have high and very high social index grades in Indramayu Regency.
c. Cirebon Regency Profile

The results of data processing at the level of education and welfare to produce social index grades indicate that Cirebon Regency generally has very low to low social index grades. Social index grade classes for sub-districts located in the coastal area of Cirebon Regency are low to moderate. There are no sub-districts that have high and very high social index grades in Cirebon Regency.

d. Sukabumi Regency Profile

The results of data processing at the level of education and welfare to produce social index grades indicate that Sukabumi Regency generally has low to moderate social index grades. Sub-districts located in the coastal area of Sukabumi Regency generally have medium social index grades. There are no sub-districts that have a high and very high social index class in Sukabumi Regency. The results can be seen in Figure 5.

e. Garut Regency Profile

The results of data processing at the level of education and welfare to produce social index grades indicate that Garut Regency generally still has low social index grades. Sub-districts located in the coastal area of Garut Regency also generally have low social index grades. Only Pamengpeuk sub-district in the Garut coastal area has a moderate social index value class. There is no sub-district region that has a high social class index value and is very high in Garut Regency. The results can be seen in Figure 6.

Figure 3. Distribution of Social Index Value Classes by sub-district in Indramayu Regency 2010

Figure 4. Distribution of Social Index Value Classes by sub-district in Cirebon Regency 2010

Figure 5. Distribution of Social Index Value Classes by sub-district in Sukabumi Regency 2010

Figure 6. Distribution of Social Index Value Classes by sub-district in Garut Regency 2010
f. Pangandaran Regency Profile

The results of data processing at the level of education and welfare to produce social index grades indicate that Pangandaran Regency generally has low to high social index grades. Out of the 6 districts that were the study areas, Pangandaran Regency was the only regency that had a high social index class in one of its sub-districts, Kalipucang sub-district. Kalipucang Sub-district is also one of the sub-districts in the coastal area of Pangandaran Regency. Other Pangandaran Regency regions have low to moderate social index grades. There are no districts with very high social index grades in Pangandaran Regency.

Figure 5. Distribution of Social Index Value Classes by sub-district in Sukabumi Regency 2010

Figure 6. Distribution of Social Index Value Classes by sub-district in Garut Regency 2010

Figure 7. Distribution of Social Index Value Classes by sub-district in Pangandaran Regency 2010
g. Capture fisheries in West Java

Sea fishing activities are found in 6 regencies which are the study areas. The development of the number of fishing vessels in the 6 regions is shown in Figure 8.

The results of the analysis above show the development trend of the number of fishing vessels in West Java Province in the period 2007-2016. Cirebon Regency and Subang Regency showed an increase in the number of fishing vessels until 2016, while other regencies showed an increase until 2014, but then decreased in 2015 and 2016. The number of fishing vessels in the northern coast of West Java Province was more than fishing vessels in the southern coastal region.

The development of fishing vessels in the period 2007-2016 was also followed by the development of the number of fishermen in the 6 regencies that became the study area. The regency of Subang, Indramayu, Garut and Pangandaran showed an increase in the number of fishermen until 2016. While the regencies of Cirebon and Sukabumi showed an increase until 2014 but decreased in 2015 and 2016. The number of fishermen found in the northern coastal area of West Java was more than the number of fishermen in the southern coastal region [16]. Increased catches or fisheries production in the 6 districts of this study area are shown in Figure 10.
Indramayu Regency is the regency with the largest capture fisheries production from 6 regencies which is the study area. Fisheries production in the northern region of West Java is far greater than fisheries production in the southern region. Even though the number of fishing vessels and the number of fishermen still showing a tendency to decrease in number, the capture fisheries production in West Java Province continued to show an increase until 2016 [16].

h. Carbon emissions from capture fisheries activities

Fisheries activities, especially marine capture fisheries, contribute to emitting greenhouse gases, especially carbon from the use of fuel oil to operate the fishing vessels. The number of fishing vessels in West Java Province, especially in the 6 regencies that became study areas tended to increase in the 2007-2016 period. The increase in the number of fishing vessels will certainly have consequences for the increase in the amount of carbon emissions from these activities.

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Figure 10. Distribution of Total Fisheries Production in 6 Regencies in the Study Area in 2010

Figure 11. Development of the Number of Fishing Vessels in Southern and Northern Coast West Java 2007-2016
From the number of fishing vessels, carbon emissions are calculated annually for fishing vessels in the northern coast and southern coast of West Java. The results of the calculation of carbon emissions from fishing vessels in the period 2007-2016 can be seen in Table 1.

Table 1. Calculation of Carbon Emissions from Fishing Vessels in Southern and Northern Coast, West Java in 2007-2016

| No. | Year | CO₂ Emission Southern coast (ton CO₂) | CO₂ Emission Northern coast (ton CO₂) | CO₂ TOTAL Emission (ton CO₂) |
|-----|------|--------------------------------------|--------------------------------------|-----------------------------|
| 1   | 2007 | 34,245.01                            | 91,795.14                            | 126,040.15                  |
| 2   | 2008 | 31,114.44                            | 110,684.42                           | 141,798.86                  |
| 3   | 2009 | 31,126.23                            | 115,369.23                           | 146,495.46                  |
| 4   | 2010 | 31,827.57                            | 107,984.29                           | 139,811.86                  |
| 5   | 2011 | 40,235.56                            | 108,968.42                           | 149,203.98                  |
| 6   | 2012 | 43,495.49                            | 75,885.00                            | 119,380.49                  |
| 7   | 2013 | 44,024.80                            | 114,456.74                           | 158,481.54                  |
| 8   | 2014 | 51,059.79                            | 118,270.12                           | 169,329.91                  |
| 9   | 2015 | 18,844.97                            | 75,885.00                            | 94,729.97                   |
| 10  | 2016 | 25,484.02                            | 82,293.09                            | 107,777.12                  |
|     | TOTAL| 351,457.88                           | 1,001,591.44                         | 1,353,049.32                |

Table 1 above shows that carbon emissions from fishing vessels in the northern coast region of West Java are higher than carbon emissions in the southern coast region. The highest carbon emissions in the northern and southern coast West Java occurred in 2014. The lowest carbon emissions in the northern coast occurred in 2012 and 2015, while the lowest carbon emissions in the southern coast occurred in 2015.

Figure 12. Carbon Emissions from Fishing Vessels in Northern coast and Southern coast, West Java, 2007-2016
i. Regression correlation analysis of greenhouse gas emissions in the capture fisheries subsector with socioeconomic factors

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|---|----------|------------------|---------------------------|
| 1     | .276 \(^a\) | .076 | -.540 | 3,000.15431 |

a. Predictors: (Constant), Economy, Social

| Model | Unstandardized Coefficients | Standardized Coefficients | t | Sig. |
|-------|-----------------------------|---------------------------|---|------|
| (Constant) | -1,864.758 | 17,853.210 | -.104 | .923 |
| Social | 40.066 | 86.838 | .289 | .461 | .676 |
| Economy | -20.043 | 52.699 | -.239 | -.380 | .729 |

a. Dependent Variable: Emisi 2010

The Equation: \( Y = -1.864,76 + 40,066X_1 - 20,042X_2 \)

Table 2 above shows the regression correlation analysis of greenhouse gas emissions in the capture fisheries subsector with socioeconomic factors.

3.2 Discussion

Capture fisheries activities in West Java Province are found in the northern and southern shores of West Java. The two regions have quite different characteristics in terms of natural contours, fishing boats or boats used, fishing gear used, fish catches as well as the social and economic conditions of the fishing communities. Capture fisheries activities in the northern coast of West Java are dominated by motorboats. More than 60% of the total fishing vessels in the northern coast West Java area are motorized boats or small size fishing vessels. Therefore fishing activities in northern coast West Java are still widely referred to as small scale fisheries [16].

Fishing activities in the southern coast of West Java is dominated by outboard motor which is also a small-scale fisheries with limited cruising at sea. In addition, the southern coast of West Java also has quite a lot of large vessels over 100 GT to anticipate the condition of the region that has large waves compared to the north coast region.

In carrying out activities to reduce greenhouse gas emissions, it is not enough to be carried out only by the government, but also must cooperate and be supported by the community. Awareness of the importance of protecting the environment becomes important when the environment actually becomes the support of one's life or society.

The awareness of the fishing community in West Java Province is already quite good about the need to protect the environment such as coastal ecosystems. Even though the facts and data of the fishermen’s life that exist in both the north coast and West Java, there are still many that are below the level of welfare and also a low level of education, West Java fishing communities have understood the importance of being a marine and coastal environment. The results of GIS analysis conducted for social and economic indicators in the coastal regions of West Java Province show that the majority of residents living in coastal areas still have low levels of education and welfare, in contrast to those who live in areas close to the center of the city or mountains.

The proper level of education and welfare can make it easier for government development programs to be understood and implemented by the people. However, the willingness and delivery of these programs and policies must be implemented as well as possible by the government with technological adjustments that will be transferred to the people through policy socialization properly.
If these programs and policies are felt to be good and beneficial to the community, the community will easily accept fisheries development policies or programs carried out by the government in Indonesia.

The government needs to be more intensive in improving the standard of living of fishermen through programs to improve the education of fishing communities. However, increasing the level of education does not always have a good impact on the sustainability of the fishing business. This is due to the many tendencies of fishermen children who have attained a level of education up to junior or senior high school no longer interested in continuing their parents’ business in the field of capture fisheries. Such cases occur quite a lot in fishing families found on the north coast of West Java such as Subang and Indramayu. Therefore, the government must also be able to convince the younger generation that the fisheries sector is a promising and profitable sector. This applies generally to small scale capture fisheries businesses, but does not have much effect on large scale fishing businesses with vessels above 50 GT or even 100 GT.

The statistical analysis in this study shows that the direction of the relationship X1 (social factors) with emissions in 2010 is positive with a coefficient value of 40.066. That is, when social factors increase by one unit, it will cause an increase in emissions by 40.066 units. On the contrary, the direction of the relationship between X2 (economic factors) and emissions in 2010 is negative with a coefficient value of 20.043. That is, when economic factors increase by one unit, it will cause a reduction in emissions of 20.043 units. However, when the analysis is viewed from its significance, indeed social and economic factors do not have a significant effect on emissions. It can be seen from the significant value which is far greater than 0.05 (5%) [17]. Based on this result, it can be assumed that the economic factor or increasing community welfare can reduce the ghg emission, while increasing education level not usually can reduce the ghg emission. People have better option when they have higher education that could lead to the consequence of increasing consumptive behaviour.

Estimation and calculation of greenhouse gas emissions from the fisheries sector which has so far been done is only based on fuel consumption [19-25]. The method of calculating emissions issued by the IPCC (International Panel on Climate Change) in 2006 is the method used by all countries that ratified the UNFCCC [26]. One of the objectives of this research is to try to apply the use of the 2006 IPCC Guideline in calculating emissions in Indonesia, specifically from the capture fisheries subsector. This research also looks at data and information needs as well as various obstacles encountered in the GHG inventory especially in the fisheries sector. This is done so that the implementation of a Greenhouse Gas (GHG) inventory or calculation of emissions can be done comprehensively by involving social, economic and environmental development in various emission reduction activities as directed in the low carbon development concept [26, 27].

The estimation of the calculation of greenhouse gas emissions from capture fisheries is also based on a mathematical model that has been produced by integrating fuel consumption as the main source of greenhouse gas emissions from fishing vessels with social, economic and environmental factors in an area [18-22]. Calculation of greenhouse gas emissions with a mathematical model that has integrated social and economic factors in it is expected to provide a more realistic and more accurate picture of the conditions of greenhouse gas emissions in an area from various sectors in the region including fishery.

This study tries to look further at the characteristics of greenhouse gas emissions resulting from the marine capture fisheries activities which is associated with the socio-economic aspects of the fishing community itself [31-33]. This is in line with the concept of low carbon development which also incorporates socio-cultural and environmental aspects into its development principles [29, 30]. It is the socio-cultural and environmental aspects that distinguish the previous development concept from the low carbon development concept.

Calculation of greenhouse gas emissions from various sectors that have the potential as sources of emissions should have also included socio-economic and environmental aspects in the calculation of emissions. The concept and model of GHG emission calculation like this which then differentiates formulas and models of calculation of existing greenhouse gas emissions. Public perception and
understanding of the importance of protecting the environment and ecosystems through reducing greenhouse gas emissions need to be improved to achieve the expected development targets.

Taking into account the social, economic and environmental factors involved in reducing greenhouse gas emissions, the calculation model for estimating greenhouse gas emissions from capture fisheries should be adopted by other sectors. IPCC calculation methods must also begin to consider more realistic methods for calculating emissions from each sector that contributes to greenhouse gas emissions. The calculation model for estimating greenhouse gas emissions from capture fisheries activities resulting from this research has tried to adopt the concept of low-carbon development, namely carrying out activities to reduce greenhouse gas emissions that are integrated with social, economic and environmental development.

4. Conclusions.

From the results of the analysis and discussion above, it can be said that the development approach which is still focused on one side of economic development must be immediately revised by integrating the concept of sustainable development in which there is also social development and environmental development. All development activities related to reducing greenhouse gas emissions must also integrate social, economic and environmental development.

The application of the greenhouse gas emission model that integrates social, economic and environmental factors is expected to have a better and more sustainable impact on these three aspects.

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