Economic loss value from land and forest fires in oil palm plantation in Jambi, Indonesia

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Abstract. Peat fires have always become a problem for the country and result to enormous negative impact and losses to the environment and surrounding community. To clear the issues, we assess the economic valuation of peat fires in palm oil plantation in Tanjung Jabung Timur Regency, Jambi Province, Indonesia. Here, we focused on the economic losses from air pollution, environmental/ecological damage, and benefit loss of goods and services due to peat fire on 2002-2014. These economic losses are calculated based on Regulation of Minister of Environment No. 7/2014. We found the enormous total economic loss due to peat fire of more than IDR 4.46 trillion. Benefit loss of goods and services accounts for more than 50% of the total economic loss, followed by the loss from carbon emission. The area affected by the fire in the large scale-company owned palm oil plantation is found more than 29 times larger than the smallholder, but the impact/ha for the smallholder is more than twice of that in smallholder palm oil. These high lost due to peat fire on the oil palm plantation strongly suggest to escalate the fire prevention effort in the palm oil plantation to avoid further devastating peat fire and severe economic loss.

1. Introduction
Half of tropical peat area exists in Indonesia, providing Indonesian peat as a central issue for peat protection and maintenance. Tropical peat forests and peatlands experiencing deforestation and fires will in turn emit large amounts of carbon emissions affecting climate change. Combination of human activities such as land clearing, illegal logging, peat drainage, and peatland burning will change land cover on peatlands [1]. Negative impacts from forest fires include ecological damage, declining biodiversity, declining economic value of forests and land productivity, micro and global climate change and the smoke haze disrupting public health and transportation on both land, river, lake, sea and air. Smoke disruption due to Indonesia's forest fires has recently crossed national borders.

Although various efforts to prevent forest and peat fires have been carried out including the activation of legal instruments (laws, Governmental and Ministerial Decrees), they have not provided optimal results yet. Since the large forest fires in 1997/98 that devastated 11.7 million hectares of forest, the intensity of forest and peat fires in the country has continued to occur frequently with an expanded distribution.

Economic valuation of natural resources and its environment is the implementation of monitory value to some parts or all of natural resources according to its utilization objective. Economic valuation of natural resources and environment here includes total net economic value, recovery cost for damage/pollution, and prevention from damage/pollution [2]. The total net value of economic loss here include the loss of tangible value (timber, non timber forest product, genetic resources,
recreation, ecological function, carbon emission, and health) and intangible loss (hydrology, biodiversity, erosion control, soil formation, nutrient cycle, and waste decomposition). Tacconi [3] estimated the total valuation impact from forest and peat fire in Indonesia related to carbon emission reached US$ 2.8 million. However, the total loss may be higher as the loss from a failure business due to peat fire was not counted in his calculation yet.

Here, we map the potential fires area and assess the economic valuation of impacts from peat fires in Tanjung Jabung Timur Regency, Jambi Province in smallholder and large scale company owned palm oil plantation based on Regulation of the Minister of Environment No. 7/2014 [4].

2. General condition of the regency
Geographically, Tanjung Jabung Timur Regency is located at 0°53’ - 1°41’ latitude and 103°23-104°31 longitude with the elevation between 1-5 m asl. Tanjung Jabung Timur Regency has an area of 5,445 Km². The regency has 11 districts with a total area 13,102 km². Annual rainfall in 2011 was 2,231 mm with four wet months and eight dry months. Total population in 2011 amounted to 210,420 people where dense population are found in Muara Sabak Timur, Mendahara and Nipah Panjang Sub-districts while the smallest population is found in Berbak District [5].

3. Fire Potential Area
Fire potential areas is the area having moderate to high potential to be fires in all district areas. We assess the potential for the occurrences of forest, land, and peatland fires based on Terra/Aqua MODIS hotspot data with Confidence level ≥ 80 % during 2002 – 2014 and overlay it on Jambi’s administrative, landuse and landcover map, and peat depth map. Table 1 present the potential fires area in each district.

| Districts         | Peat         | %   | not peat | %   | Total area |
|-------------------|--------------|-----|----------|-----|------------|
| BERBAK            | 14,111.5     | 39.8| 21,366.6 | 60.2| 35,478.1   |
| DENDANG           | 20,031.1     | 95.9| 855.9    | 4.1 | 20,887.0   |
| GERAGAI           | 22,156.3     | 92.5| 1,799.4  | 7.5 | 23,955.7   |
| KUALA JAMBI       | 0.0          | 0.0 | 151.6    | 100.0 | 151.6   |
| MENDAHARA         | 9,595.1      | 88.6| 1,237.6  | 11.4| 10,832.6   |
| MENDAHARA ULU     | 11,016.9     | 54.4| 9,240.2  | 45.6| 20,257.1   |
| MUARA SABAK BARAT| 6,493.8      | 71.6| 2,579.8  | 28.4| 9,073.6    |
| MUARA SABAK TIMUR| 4,651.5      | 80.0| 1,159.7  | 20.0| 5,811.2    |
| NIPAH PANJANG     | 8,768.3      | 72.0| 3,408.9  | 28.0| 12,177.2   |
| RANTAU RASAU      | 6,589.1      | 88.5| 857.7    | 11.5| 7,446.9    |
| SADU              | 3,764.9      | 20.9| 14,220.8 | 79.1| 17,985.8   |
| Total area        | 10,7178.5    | 65.3| 56,878.1 | 34.7| 164,056.6  |

From Table 1 we can understand that most of the potential area to be fires exists in the peat area (65.3%). As much as 7 from 11 districts experienced large fire potential areas on the peat of more than 70%, bring the importance of peat fire prevention in these districts.

Most of the potential peat fires found in a low to medium peat depth (0-200 cm) (Table 2), However, potential deep peat fires of more than 400 cm were found in a quite large areas in Geragai, Mendahara, Mendahara Ulu, and Muara Sabak Barat Districs, bring the importance to prevent the deep peat here from experiencing devastating peat fire occurrences.
Table 2. Fire potential areas at different peat depth in Tanjung Jabung Timur Regency

| Districts       | Fire potential area (ha) at different peat depth (cm) |
|-----------------|--------------------------------------------------------|
|                 | <50 | 100-200 | 200-400 | 400-800 | 50-100 | not peat | Total |
| BERBAK          | 1,311.5 | 3,824.8 | 7,098.2 | 1,877.0 | 21,366.6 | 35,478.1 |
| DENDANG         | 3,748.5 | 3,517.1 | 12,765.4 | 855.9 | 20,887.0 |
| GERAGAI         | 5,785.8 | 4,169.0 | 1,971.7 | 10,229.8 | 1,799.4 | 23,955.7 |
| KUALA JAMBI     | 5,785.8 | 4,169.0 | 1,971.7 | 10,229.8 | 1,799.4 | 23,955.7 |
| MENDAHARA       | 2,443.9 | 3,225.2 | 2,701.6 | 1,224.3 | 1,237.6 | 10,832.6 |
| MENDAHARA ULU   | 1,746.3 | 3,662.7 | 1,388.9 | 4,168.3 | 50.8 | 9,240.2 | 20,257.1 |
| MUARA SABAK BARAT | 1,109.9 | 1,638.3 | 1,458.4 | 2,287.2 | 2,579.8 | 9,073.6 |
| MUARA SABAK TIMUR | 4,651.5 | 1,159.7 | 3,408.9 | 12,177.2 |
| NIPAH PANJANG   | 8,627.4 | 75.0 | 65.9 | 3,408.9 | 12,177.2 |
| RANTAU RASAU    | 6,589.1 | 857.7 | 7,446.9 |
| SADU            | 3,749.9 | 15.0 | 14,220.8 | 17,985.8 |
| Total           | 39,763.9 | 20,112.1 | 27,465.1 | 17,909.6 | 1,927.8 | 56,878.1 | 164,056.6 |

4. Economic valuation on peat fire impacts

Economic valuation is a relative issue and may arguable based on different approaches, individuals or group of peoples, time and place. Therefore it is necessary to have an eligible and accountable method to calculate the value. Here, we assess the economic vauation of the impact of peat fires in the regency by implementing the Regulation of Minister of Environment of the Republic Indonesia Number 7/2014 on Environmental Losses Due to Pollution and/or Environmental Damage. This regulation contains clear and appropriate substance, language and legal rules.

In general, the Valuation of the impact from peat fire in Tanjung Jabung Timur calculated by using the below equation:

\[ V_{DKG} = L_{DKG} \cdot V_{DKG} \cdot B_{DKG} \cdot (IH_1/IH_2) \]  \hspace{1cm} (1)

Where:
- \( V_{DKG} \) = Valuation or impact value from peat fire (IDR)
- \( L_{DKG} \) = Area affected by Peat Fire (ha)
- \( V_{DKG} \) = Volume of damage from peat fire (unit)
- \( B_{DKG} \) = Unit cost for peat fire impact (IDR/unit)
- \( IH_1 \) = Price index in the year of peat fire occurrences
- \( IH_2 \) = Price index for base year

Here, we focused to the economic losses from air pollution, environmental/ecological damage, and benefit losses of goods and services. These economic losses due to forest and land fire are based on the economic valuation calculation that regulate by the law.

This study revealed the total valuation of economic loss due to peat fires in palm oil plantation (smallholder and large scale) amounting to IDR 2,388 trillion (Table 3). However, the total loss per hectares in smallholder palm oil found higher than in large scale-company owned palm oil plantation (Table 4).

Table 3. Benefit loss of goods and services due to peat fires in palm oil plantation

| No. | Land use                        | Area affected (ha) | Unit Value (IDR/m³) | Economic Loss (IDR) |
|-----|---------------------------------|-------------------|---------------------|---------------------|
| 1   | Smallholder palm oil plantation | 2,385             | 80,059,000          | 190,940,715,000    |
| 2   | Large scale-company owned palm oil plantations | 70,173 | 31,320,000 | 2,197,818,360,000 |
| TOTAL |                                | 142,789           |                     | 2,388,759,075,000  |
Table 4. Economic losses due to peat fire in smallholder and company owned palm oil plantation (in IDR)

| No | Impact criteria                  | Smallholder palm oil plantation | Large scale-company owned palm oil plantation | Total (IDR) | Percentage |
|----|---------------------------------|---------------------------------|---------------------------------------------|-------------|------------|
| 1  | Air pollution                   | 37,836,087                      | 1,407,918,178                               | 1,445,754,265 | 32.41      |
|    | 1.1. Carbon emission            | 31,929,188                      | 1,188,116,606                               | 1,220,045,794 | 27.35      |
|    | 1.2. Carbon sequestration       | 5,906,900                       | 219,801,572                                 | 225,708,472  | 5.06       |
| 2  | Environmental / Ecological Damage | 46,536,894                      | 579,597,542                                 | 626,134,436  | 14.04      |
|    | 2.1. Water Storage/Reservoir    | 6,818,100                       | 80,212,160                                  | 87,030,260   | 1.95       |
|    | 2.2. Water Management           | 155,192                         | 4,566,157                                   | 155,192      | 0.00       |
|    | 2.3. Erosion Control            | 6,337,005                       | 186,451,415                                 | 192,788,420  | 4.32       |
|    | 2.4. Land Formation             | 258,653                         | 7,610,262                                   | 7,868,915    | 0.18       |
|    | 2.5. Nutrient recycling         | 23,847,830                      | 701,666,143                                 | 23,847,830   | 0.53       |
|    | 2.6. Waste Decomposer           | 2,250,283                       | 66,209,278                                  | 68,459,561   | 1.53       |
|    | 2.7. Biodiversity               | 4,748,874                       | 176,710,280                                 | 181,459,154  | 4.07       |
|    | 2.8. Genetic Resources          | 2,120,957                       | 62,404,147                                  | 64,525,104   | 1.45       |
| 3  | Goods & Services Benefit Loss   | 190,940,715                     | 2,197,818,360                               | 2,388,759,075 | 53.55      |
|    | Total                           | 275,313,696                     | 4,185,334,080                               | 4,460,647,776 |            |
|    | Area Affected (Ha)              | 2,385                           | 70,173                                      | 72,558       |            |
|    | Impact/Ha                       | 115,436                         | 59,643                                      | 61,477       |            |

Table 4 showed that peat fires on palm oil plantation resulted to the very high total economic valuation amounting to more than IDR 4.4 trillion. Highest economic valuation is found for goods and services benefit loss (53.55%), followed by air pollution (32.41%) that mainly from carbon emission (27.35%). Economic valuation from carbon emission here is more than five times of that from carbon sequestration (5.06%). Here we can see that impact of peat fires in palm oil plantation will cost the carbon emission five times greater than carbon sequestration.

The severe impact of peat fires to the environmental/ecological damage is found for erosion control and biodiversity loss, amounting to more than IDR 180 million. These two parameters contributes to more than 8% of economic loss, while economic loss from other parameters is relatively small, less than 2% of the total.

Total area affected by peat fires during 2002-2014 in large scale-company owned palm oil plantation was much larger, approximately 29 times than that in smallholder. This may pointed out that peat fire prevention effort should be taken into highest concern by company owned palm oil plantation. However, higher impact/ha in smallholder may indicate that peat fires will cost more here. Therefore, we strongly suggest to enhancing peat fire prevention effort as the top priority management of any palm oil plantation, such as avoid to utilize the deep peat for palm oil plantation development as regulate by the government [6] and maintain the ground water level more than -40 cm from the peat surface as a threshold for peat fire occurrences risk [7-9], or below that for the degraded peatland [10].

5. Conclusions

Most of the fires occurred in Tanjung Jabung Regency existed in a peatland area, bringing a total economic loss of more than IDR 4.46 trillion. The highest economic loss is found from the benefit loss of goods and services for more than 50% of the total, but the loss from carbon emission should be taken into account as it reached almost half of the loss of goods and services. Fires affected area is found higher in the large scale-company owned palm oil plantation but the impact/ha for the smallholder is more than twice of that in smallholder palm oil, pointing out the importance of peat fire prevention in both of smallholder and large-scale palm oil plantation to avoid further enormous economic losses.
6. Recommendations
1. The high potential of peatland fires in Tanjung Jabung Timur Regency makes this regency prone to experience devastating peatland fire which must be put into the highest concern of all relevant stakeholders.
2. The large economic valuation due to peat fires bring the importance of efforts to prevent peat fires absolutely carried out immediately by all relevant stakeholders, both from the government and the community. Awareness to the community of peatland fires must be done in an earlier condition as this study pointing out the highest economic loss per hectare of land acquired in smallholder palm oil.

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