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Economic losses and forest fire causes at Ranu Pani Resort, Bromo Tengger Semeru National Park

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Abstract. Forest fire is one of the main causes of forest destruction that can threaten the sustainability of forest resources. Uncontrolled forest and land fires can generate environmental damages in several aspects, i.e. social, economy, and ecology. Bromo Tengger Semeru National Park (TNBTS) is one of the national parks in East Java province which is frequently experiences forest fire. The largest forest fire in TNBTS area in 2015 was located in Ranu Pani Resort, which is the entrance of hiking trails in Semeru Mountain. Forest fires on Ranu Pani Resort caused substantial losses for communities and managers. Considering the important role of the national park in managing and protecting forest resources, research about economic losses due to forest fire, the time pattern of forest fire, and the causal factors of forest fires in Ranu Pani Resort is necessary. Data analysis in this research include benefit transfer approaches, loss of earning, descriptive analysis, and logistic regression. Result show that total economic loss of forest fires in Ranu Pani Resort is IDR 2,296,172,122. The forest fires on Ranu Pani Resort often occur in August, September and October. Human factors (the number of farmers) are more likely to cause fires in TNTBS compared to natural factors (intensity of rainfall).

1. Introduction

Indonesian forest is the third largest tropical forest in the world, covering up to 129 million hectares [1]. In the forest resources management, Indonesia faces many challenges, such as illegal logging, land conversion, and forest fires. The forest fires have become a threat to Indonesian forests over the last three decades [2]. For example, in 1982 around 3.2 million hectares of forest was burnt down. The area burned by forest fires increased to 9.7 million hectares in 1997/1998 [3]. Furthermore, in 2015, there were 11,240 ha of forest affected by fire [4].

Forest fires occur not only on forest land or forest estate, but also in conservation forests such as Bromo Tengger Semeru National Park (TNBTS). The area affected by fire within TNBTS has fluctuated from 2000 to 2015, reaching its highest level in 2014 (2,415 ha).
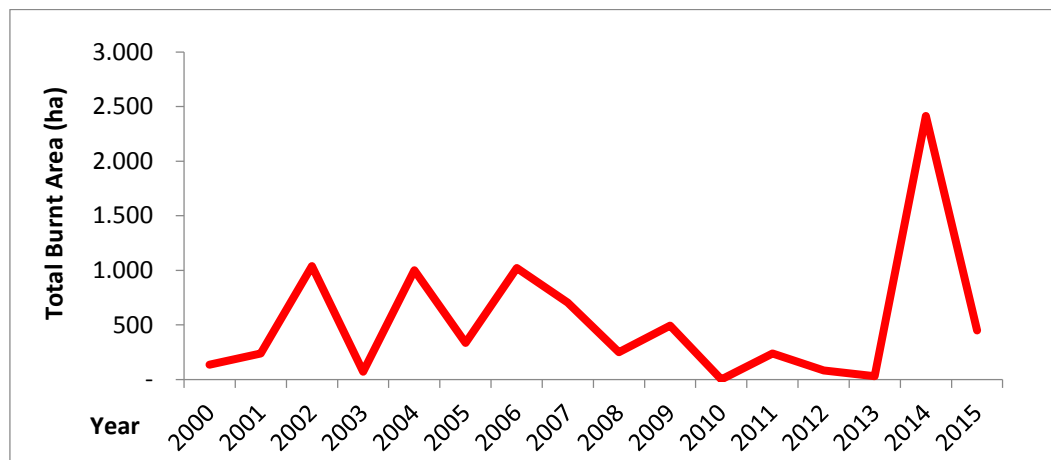
Source: [5]

Figure 1. Total Burnt Area of Forest in TNBTS during 2000-2015

These findings require an immediate response, because the national park has important roles for managing and protecting the natural resources. Preventive action against threats which can occur in the TNBTS, especially forest fire, is necessary. Forest fire is regarded as a potential threat because it directly impacts ecological, economic, and social function [6]; [7]. However, the cause of forest fires is often in question [8], [9].

Based on the conditions, the objectives of this research examines the economic impact and the cause of forest fire on Ranu Pani Resort TNBTS. This comprises three specific research objectives:

1. To estimate the economic losses due to forest fire in Ranu Pani Resort, TNBTS.
2. To study the time pattern of forest fire in Ranu Pani Resort, TNBTS.
3. To analyze the causal factors of forest fire in Ranu Pani Resort, TNBTS

2. Methodology

2.1. Research location
This research was conducted in the Ranu Pani Village, Senduro - Lumajang District, East Java Province. This administrative area was selected because it experienced the largest forest fire in TNBTS in 2015.

2.2. Sampling
Respondents consisted of the farmers, business units and labors. Farmers were selected purposively based on the criteria that they do not have any affiliation with tourism and have cultivated crops for at least one year. Business units and laborers were selected using the snowball sampling method. Beginning with an initial key person who introduced the first respondent to the authors, they authors made surveyed additional business owners and laborers suggested by this respondent, and so on. The criteria for business units are: the business must be located around the Semeru Mountain hiking trails, and it must have been in operation for at least one year. Laborers were selected who were part of the Ranu Pani's community, who are members of tour guide organization for Semeru Mountain hiking tourism and lodging, and who have been working for at least one year.

2.3. Data analysis
Benefit transfer and loss of earning. The economic losses due to forest fire in Ranu Pani Resort are estimated from the impacts, classified into direct impacts and indirect impacts. The direct impacts in this research are loss of biodiversity and carbon release as for the indirect impacts are loss of business unit earning, loss of labor earning and loss of government earning.

Benefit transfer analysis is a secondary approach, commonly used if time, budget and unavailability of data are become the constraint [10]. This method is conducted to estimate the value of damage and

restoration cost for 355 ha forest affected by fire. The estimation and the result was then adjusted to local regulation, i.e Regulation of the Minister of Environment of the Republic of Indonesia No.7 Year 2014 About Losses Due to Environmental Pollution and/or Environmental Damage and appropriate exchange rate in time of research. The equation to estimate the direct impact is:

$$ERC = (BL \, x \, FA) + (CR \, x \, (FA \, x \, C)$$

Where:
ERC = Ecological Restoration Cost
BL   = Biodiversity Loss (IDR/ha)
CR   = Carbon Release (IDR/ton)
FA   = Forest Fire Area (ha)
C   = 3,15 carbon (ton/ha)

Loss of earning is an economic valuation method that use market based approach [11]. This method is conducted to calculate the difference of income of business unit, labor and government before and after the forest fire occurred. So the total indirect impacts are calculated with this equation:

$$\sum_{i=1}^{3} \Delta Rt = \sum_{i=1}^{n} \Delta Ri + \sum_{j=1}^{n} \Delta Rj + \sum_{k=1}^{n} \Delta Rk$$

Where:
$\sum 3i=1\Delta Rt$ = Total loss of earning due to forest fire (IDR)
$\sum ni=1\Delta Ri$ = Loss of earning from business unit (IDR)
$\sum nj=1\Delta Rj$ = Loss of earning from labor (IDR)
$\sum nk=1\Delta Rk$= Loss of earning from government (IDR)

The accumulation of the direct and indirect impacts values are the total economic losses due to forest fire in Ranu Pani Resort, the equation can be written as:

$$TEC = ECR + \sum_{i=1}^{3} \Delta R_t$$

Note:
TEC   = Total Economic Losses (IDR)
ERC   = Ecological Restoration Cost (IDR)
$\sum 3i=1\Delta Rt$ = Total loss of earning due to forest fire (IDR)

Quantitative and qualitative descriptive analysis. Analyzing the time pattern of forest fires in the TNBTS area is conducted to identify the pattern of forest fire occurrences, so that the fire can be prevented and controlled. This analysis uses secondary data of the time the fires occurred. The data were obtained from the TNBTS manager. The time pattern data of forest fires were collected and processed, then explained through diagrams to figure and describe the datasets using qualitative quantitative analysis.

Logistic regression. Logistic regression model is a variation of regression model [12]. Binary logistic regression model is logistic regression model that used in this research. The expected causal factors are obtained through interview with local communities and TNBTS manager. Based on the obtained expected causal factor, the model can be described as:

$$\ln \frac{P_i}{1 - P_i} = KH_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

Where:

P_i　 = the chance of forest fire occur

　　　　(P_i = 0; no forest fire occur, P_i = 1; forest fire occur)

KH_i = the occurrence of forest fire

α　 = Constant

β_i　 = Variable coefficient of X_i

i　　 = Variable-i (1, 2,3)

X1　 = rainfall (mm)

X2　 = number of climbers (people)

X3　 = number of farmers (people)

Based on the result of logistic regression analysis, other causal factors such as forest fire threat from community activities in the forest was analyzed using quantitative descriptive method.

3. Results and discussions

### 3.1. The estimation of economic losses due to forest fire

The forest fire in Ranu Pani Resort caused damage to the biodiversity - flora and fauna - in the forest, including Akasia Gunung (*Acacia deccurens*) and Cemara Gunung (*Casuarina junghuniana*). Moreover the fire disturbed the Semeru hiking tourism so that the manager must temporarily close the hiking trails. The closure held for 40 days as the managers extinguished the forest fire. The impact of this condition is the loss of income of the community who affiliate with the hiking tourism. The estimation of the value is presented in table 1.

Table 1. Total Economic Losses due to Forest Fire in Ranu Pani Resort, TNBTS

Type of Losses	Cost (IDR)
1. Direct impact	
a. Biodiversity losses	1.461.606.000
b. Carbon release	153.468.630
Total	1.615.074.630
2. Indirect impact	
c. Loss of earning from business unit	336.084.849
d. Loss of earning from labor	209.212.644
e. Loss of earning from goverment	135.800.000
Total	681.097.492
Total Economic Losses	2.296.172.122

3.2. The pattern of forest fire at TNBTS in 2015

Forest fire occurred in August and October 2015, due to low rainfall (there was no rainfall on October). The fire is also triggered by the large number of climbers and many farmer activities, such as burning trash, burning straw, or burning crop waste further, climber activities which may cause a forest fires include cooking fires, bonfires, and cigarette disposal. Therefore, the correlation among the forest fire frequency, rainfall, the number of farmer and climber and their activities must be identified. The correlation among them is presented in figure 2.
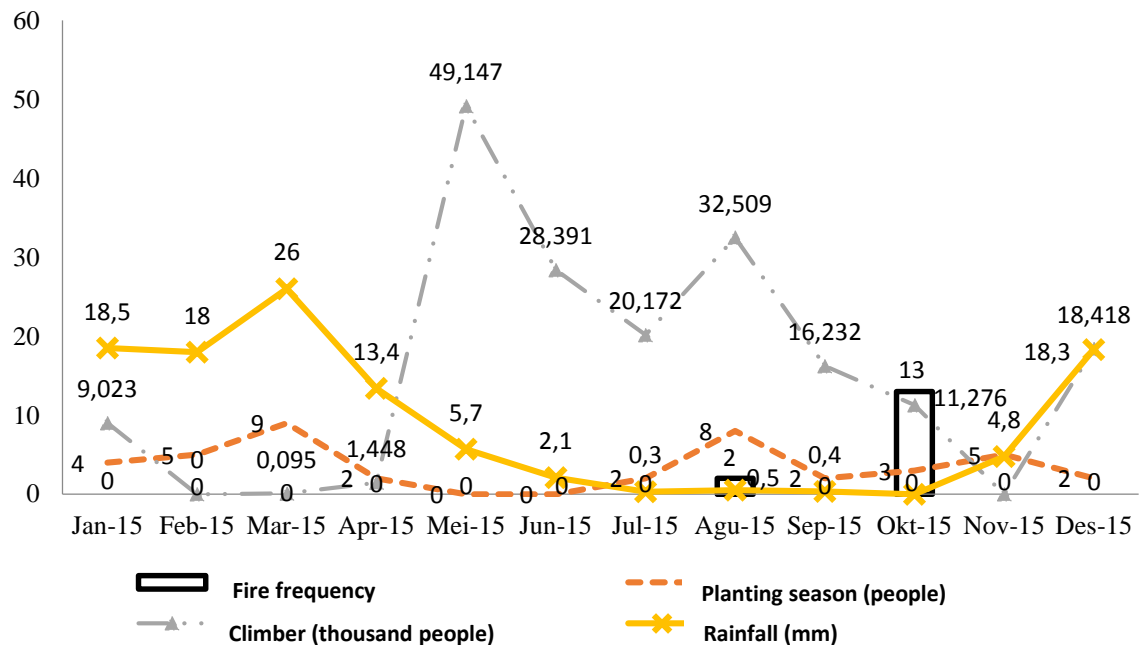
Figure 2. Graphics of Total Climbers, Farmers, Rainfall, and The Frequency of Forest Fire in Ranu Pani Resort 2015

3.3. *Factors affected forest fire in TNBTS*

In order to determine the causality of natural and human factors with forest fire, it is necessary to use logistic regression model. The independent variables in the logistic regression model are rainfall, the number of climbers, and the number of farmers while the dependent variable is the occurrence of the forest fire (0 = no forest fire occur, 1= forest fire occur). The logistic regressions of forest fire causal factors are presented in table 2.

Table 2. The logistic regression of forest fire causal factors

Predictor	Coef.	P	Odds Ratio
Constant	-5,78197	0,059	
Rainfall (X1)	-12,5164	**0,057**[*)]	**0,29**
Number of mountain climber (X2)	0,0002019	0,247	1,00
Number of farmers (X3)	1,20072	**0,100**[*)]	**3,32**

Note: [*)] significant at á 15%

The logistic regression model of forest fire occurrence in Ranu Pani Resort TNBTS :

$$KH = -5{,}7820 - 12{,}5164\ X_1 + 0{,}0002\ X_2 + 1{,}2007\ X_3$$

The rainfall and the number of farmers are potential causal factors of forest fire. Farming activities such as burning the trash, straw and crop waste will potentially cause fire, especially when these activities conducted during the low rainfall or drought season. The causal factors of land and forest fire in Indonesia are mostly caused by human, either intentionally or unintentionally rather than nature itself [2][13].

4. Conclusions

The conclusions of the study are: 1) Total economic losses of forest fire in Ranu Pani Resort was up to IDR 2,296,271,122. Forest fires directly and indirectly impact the forest resources and the income of communities in tourism sector; 2) The forest fires in Ranu Pani Resort often occur in August, September, and October due to the low rainfall and high activities of farmers as well as mountain climbers; and 3) The human factor (the number of farmers) is more likely to cause forest fire than the natural factor.

Based on the results, thus we elaborate several recommendations, are: 1) Optimize local institution development such as Fire Care Community/*Masyarakat Peduli Api* in preventing and controlling the forest fire through incentive and disincentive system, e.g. giving the incentive if the communities can protect the forest from the fire and not giving them incentive if the opposite happens; 2) Improve the role of the tour guides and volunteers to help preventing fire during the climbing activities. Climbers are obligated to use their services to prevent doing careless and risky activities that can lead to forest fire; and 3) Design an early warning system related to forest fire such as warning signs or poster about potential fire particular months for the communities and tourist to prevent the forest fire in TNBTS.

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