Land cover disturbance due to tourism in Djuanda Forest Park, Indonesia

H Marhaento1*, R Purnama1, L Rahayu Wijayanti Faida1, Noorhari Rahardjo2

1 Faculty of Forestry, Universitas Gadjah Mada, Yogyakarta, Indonesia
2 Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia

E-mail: marhaento@ugm.ac.id

Abstract. Tourism activities in conservation areas may provide benefits for both the regional and local economy. However, these activities often deliver negative impacts on the surrounding environment such as deforestation and forest degradation. This research aims to analyse the land cover disturbance due to tourism in Djuanda Forest Park, Indonesia. Djuanda Forest Park is a well-known tourist area in Bandung, Indonesia that also functions to preserve the biodiversity of various trees species. Historical land cover data acquired from high-resolution satellite imageries from the years 2007 to 2017 were used and analysed. Changes in land cover were calculated based on Pairwise Comparison Methods. The results showed that the forest cover was degraded and decreased in the period 2007 – 2017, while the grassland and built-up area for supporting tourism increased. In addition, the highly-developed tourist objects such as the Tebing Keraton, Monumen Ir. H. Djuanda, Air Terjun Maribaya, and Goa Belanda have more loss of green spaces, indicating that tourist object development in the Djuanda Forest Park was mostly based on the building development.

1. Introduction

Indonesia is rich in biodiversity for both floral and faunal biodiversity including 10% of the world’s plants, 12% of the world’s mammals, 16% of the world’s reptile–amphibians, and 17% of the world’s bird species, which then places Indonesia among the world’s mega-diverse countries [1]. This rich biodiversity is one of the main reason Indonesia become a well-known ecotourism destination in the world [2]. Ecotourism in Indonesia is often developed in conservation areas as to conserve nature and support local welfare. Three conservation areas in North Sulawesi and found that ecotourism has mutually benefited the local people and the natural resources in those area [3]. In another place, Suarthana found that ecotourism in Tanjung Puting National Park, Borneo has resulted economic incentives for the local communities and therefore decreased the unemployment [4].

Utilizing of forest environmental services in tourism activities, especially in conservation areas, evidently provides benefits for both the area manager and the local communities. In fact, many conservation areas make tourism as their main financial support [5, 6]. However, besides financial benefits, tourism in conservation area is often accused to bring negative impacts on the surrounding environment. Dong argue that changes in landscape structure and land use are the main consequences due to tourism development [7]. Pickering and Hill found that tourism activities and development in protected areas in Australia have damaged the natural vegetation in the surrounding area [8].

Assessment of changes in landscape structure due to tourism has been commonly done by using Geographical Information Systems (GIS) tools. Atik used combinations of GIS and statistical correlation correlation
analysis to assess land use changes in relation to coastal tourism developments in Turkish Mediterranean [9]. In their research, historical land use changes for the periods 1974, 1988, 1990 and 1996 were derived from the national repository and then statistically correlated with the trend of developments in the study area.

This study aims to assess land cover disturbance due to tourism development in the Djuanda Forest Park in Bandung, Indonesia. The Djuanda Forest Park is a well-known tourism area that also function to preserve biodiversity of various trees species. However, within the last 10 years, pressures to the forest area has increased due to the mass-tourism strategy that have been applied. Similar with the study of Atik we combines the examination of land use changes in the Djuanda Forest Park using high resolution satellite imageries from Google Earth products [9]. Images from Google Earth were used because it provides the latest satellite imagery with a sub meter spatial resolution. In addition, Google Earth also provides images taken at different time periods which will be very useful to perform land use change detection studies. Furthermore, correlations between land use change and tourism development were explained descriptively based on the literature studies and the results of interviews with relevant stakeholders.

2. Study Area and Methods

2.1. Study Area
Djuanda Forest Park is located between 107°30’ East longitude and 6°52’ South longitude on the border of between Bandung city and West Bandung district, which covers around 590 Ha. Most of the Djuanda Forest Park area is a riparian ecosystem where plant communities are typical for the river margins and banks. The topographic conditions are mostly steep slope with an altitude range from 770 to 1,350 meters above sea level. The annual temperature ranges from 22°C to 24°C (at the low altitude) and from 18°C to 22°C (at the high altitude), while the annual rainfall ranges from 2,500 to 4,500 mm/year. In addition, Andosols are dominant soil type of the Djuanda Forest Park. Since 1985, Djuanda Forest Park is appointed as a conservation area functioning to preserve species diversity and to support tourism in Bandung city. Figure 1 shows the location of the Djuanda Forest Park.

![Figure 1. Location of the Djuanda Forest Park in Bandung, Indonesia.](image)

2.2. Methods

2.2.1. Data acquisition, pre-processing analysis, and land cover classification. In this study, spatial and non-spatial data were used. For the spatial data, images from Google Earth acquired from three different years i.e. years 2007, 2013 and 2017 were used and analysed. These images were download by using Google Earth Pro and then geometrically corrected by a topographic map (RBI map) from the Geospatial.
Information Agency of Indonesia at 1:25,000 scale. In total, hundreds of GCPs were collected and used to carry out image correction, which the result of ground RMSE is less than 5 m. Subsequently, we did masking analysis to obscure the area beyond the Djuanda Forest Park. After the pre-processing analysis, land cover classification was carried out using visual interpretation while the delineation processes were carried out by the head-up digitizing procedure. The selected Google Earth images were inserted as background image under the ArcGIS editing tools environment, then by using snapping and zooming tools, the boundary of each land cover detected by the Google Earth image were digitized. Furthermore, the analysis of land cover changes was carried out using Pairwise Comparison Methods, which each land cover class was compared each other in the subsequent year.

2.2.2. Accuracy assessment. An error matrix was made to calculate the accuracy of land cover classification using three measures: the producer’s accuracy, the user’s accuracy, and the overall accuracy [10]. The producer’s accuracy is to measure how well a certain area can be classified, the user’s accuracy is to measure how well labels on a map represent each category on the ground, and the overall accuracy is to measure the total number of correct samples divided by the total number of samples. These accuracy assessment were carried out by using the following equations.

\[
\text{User's accuracy} = \frac{\text{Total of reference sites correctly classified sites}}{\times 100}\%
\]

\[
\text{Producer's accuracy} = \frac{\text{Total of reference sites correctly classified reference sites}}{\times 100}\%\]

\[
\text{Overall accuracy} = \frac{\text{Total number of correctly classified sites}}{\text{Total number of reference sites}} \times 100\%
\]

In total, 150 ground points were collected during fieldwork across the study area. Besides collecting information on the land cover classes, the fieldwork also collected information about the land cover characteristics such as: land use management and causes of land use change. These land cover characteristics were obtained based on field observation and interviews with the forest park staffs and local communities.

2.2.3. Relationship between tourism and land cover. In order to assess relationship between land cover change and tourism development in the study area, we carried out 1) an analysis of tourism development by describing the levels of tourism object development based on accessibility, amenities and institutional support of the study area, following the procedures from Fandeli [11], 2) a spatial analysis by creating a 100 meter buffer area around the tourism objects, 3) an assessment on the changes in land use inside the buffer area, and 4) a descriptive analysis to correlate the levels of tourism development and land cover change.

3. Results and discussion

3.1. Accuracy assessment

The results showed that there are five land cover classes in the Djuanda Forest Park, namely forest area, agricultural area, grassland, built-up area and water body. Forest land is heterogeneous forest area that consists of hundreds of tree species, agricultural land is land devoted for seasonal crops production (i.e. palawija), grassland is abandoned area covered by herbaceous plants, built-up area is building area and its surroundings as part of tourism facilities development, and water body refers to rivers and ponds. By applying an error matrix [8] using 150 (unit) samples, we found an average producer’s accuracy of 94.1%, an average user’s accuracy of 96%, and an overall accuracy of 92.7%. According to Anderson
[12], our accuracy assessment results may represent a strong agreement and high accuracy for producing a land cover map. Table 1 shows the confusion matrix of land cover accuracy assessment in the study area.

**Table 1. Confusion matrix of land cover accuracy assessment**

| Classified data | Forest area | Built-up area | Agricultural area | Grassland | Water body | Total | User’s Accuracy |
|-----------------|-------------|---------------|-------------------|-----------|------------|-------|----------------|
| Forest area     | 48          | -             | -                 | 2         | -          | 50    | 96             |
| Built-up area   | 1           | 17            | -                 | 2         | -          | 20    | 85             |
| Agricultural area | 1           | -             | 22                | 4         | -          | 27    | 81.48          |
| Grassland       | 1           | -             | -                 | 44        | -          | 45    | 97.77          |
| Water body      | -           | -             | -                 | -         | 8          | 8     | 100            |
| Total           | 51          | 17            | 22                | 52        | 8          | 150   |                |
| Producer’s Accuracy | 94.11      | 100           | 100               | 84.61     | 100        | -     |                |

**Figure 2. Land Cover Maps of Djuanda Forest Park in 2007, 2013 and 2017**
3.2. Land Cover Change
Figure 2 shows land cover in year 2007, 2010, and 2017. It was observed that forests occupied most of the area in the Djuanda Forest Park. However, the forest area has continued to decline from 72.79% in 2007 to 69.51% in 2013 (i.e. decrease of about 3.28%), but then increased in the period 2013 – 2017 to 79.84% (i.e. increase of about 10.33%). On the contrary to the forest area, grassland has increased from 24.47% in 2007 to 29.56% in 2013 (i.e. increase of about 5.09%), and then decreased by 10.17% in the period 2013 – 2017. A continued decline has been performed by the agricultural area. In 2007, the agricultural area occupied 2.53% of the area, but it decreased to 0.47% in 2013, and 0.44% in 2017. On the contrary to the agricultural area, the built-up area has continuously increased from 0.2% of the area in 2007 to 0.46% in 2013, and to 0.52% in 2017. For the water body, the area was relatively constant occupied of about 0.2% of the area.

3.3. Tourism development
Based on the interviews to the officers of the Djuanda Forest Park, number of visitors in the Djuanda Forest Park has increased since 2007, in particular after 2014. This significant increase in 2014 was due to the development of the Tebing Keraton in 2013. Besides the Tebing Keraton, three other objects were identified as highly developed objects namely Monumen Ir. H. Djuanda, Air Terjun Maribaya and Goa Belanda. These sites are easily accessible by road and have relatively good tourist amenities such as toilets, mosque, souvenir shops, and guides. Therefore, these four objects become visitor’s favourite site over the Djuanda Forest Park. For a moderate developed objects, it was identified five objects namely Curug Dago, Outbound, Goa Jepang, and Penangkaran Rusa. In these objects, basic supporting facilities were available but not as complete as those in highly-developed objects. Lastly, we identified four objects that were low-developed namely Curug Koleang, Curug Kidang, Batu Batik and Curug Lalay. For these objects, adequate tourist support facilities were not available, where paths and directions to get to the area from the main entrance were the only tourist’s amenities available. Figure 3 shows the spatial distribution of tourist objects in the Djuanda Forest Park including their development level.

![Spatial distribution of tourist objects](image)

Figure 3. Spatial distribution of tourist objects in the Djuanda Forest Park including their development level.

3.4. Impact of tourism development on land cover change
Figure 4 shows the change in land use for each development level. From this figure it can be seen that within the 100 meter buffer area around the tourism objects, a significant decrease in forest area occurred in the highly developed objects where forest has decreased by 9.38% in the period 2007-2017, followed by the moderate developed where forest has decreased by 5.27%. In fact, forest area has increased by
1.12% in the low developed objects. On the contrary, built-up area has increased by 5.98% and 1.32% in the highly developed objects and moderate developed objects, respectively, while in the low developed area, the built-up area has not changed. These conditions indicated that tourist object development was relatively identical with the building development that mostly occupied the green area like forest or agricultural area.

![Figure 4. Changes in land use for different objects-development level](image)

3.5. Discussion
The main idea of tourism development is to create added values of the tourist objects through build facilities, infrastructure and tourist attraction objects [13, 14]. However, tourism in the conservation area cannot be treated as common mass-tourism. According to the Indonesian Law No. 5/1990, tourism in conservation area must be environmentally sustainable (i.e. ecotourism). In addition, it should bring benefits for the local economy and contains education [15].

Djuanda Forest Park is one of the leading natural tourism in Bandung which significantly contributes to the local government revenue. It is also a conservation area that the main mandate is to preserve biodiversity. With an increasing trend of visitors coming to the Djuanda Forest Park, more tourist facilities have been developed in the last ten years which has significantly changed the land cover of the area. The construction of roads, tracks, car parks, toilets, visitor centers, mosque, and other tourist amenities have decreased green spaces such as forest and agriculture area. This land use change may directly and indirectly impacts the environment [8].

Budowski argue that the relationship between tourism and conservation is usually one of coexistence because of an increase in tourism and the shrinking of natural areas [15]. Furthermore he argues that mitigation steps need to be taken to avoid a catastrophic situation for the nature. For the case in the Djuanda Forest Park, adequate administrative arrangements need to be established, supported by all interested parties. Those who handle tourism must be adequately educated to recognize the signs of environmental degradation in the area especially when built-up area largely occupies the area to attract more visitors to come. We agree that rather being stopped, the tourism development must be better planned and controlled. This is to create mutual benefits between nature concerns and social-economic interest, in which tourism and conservation can derive benefits from the relationship.

4. Conclusion
This research provides the evidence of land cover change due to tourism in Djuanda Forest Park where forest area has decreased in the surrounding of highly-developed tourist objects. Apparently, tourist object development in the Djuanda Forest Park is identical with the building development such as...
construction of roads, tracks, car parks, toilets, visitor centers, mosque, and other tourist amenities. Indeed the tourist development have a positive trend with the number of visitors coming to the Djuanda Forest Park. However, the land use change (i.e. shrinking of natural areas) may affect in the environment, which the park manager should be aware of this. Thus, mitigation steps need to be taken to avoid a catastrophic situation in the future.

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