Analyses of land cover change of Singkil Swamp Wildlife Reserve in the last 20 years

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Abstract. Singkil Swamp Wildlife Reserve (SSWR) is remaining tropical coastal forested wetland in west coast of Sumatra. The conservation area is also facing habitat loss and destruction due to illegal activities, such as logging and land conversion. However, there is no data available on land cover change of important habitat of great ape critically endangered, Sumatran orangutan (Pongo abelii). This study aimed to determine the rate of change in land cover of the SSRW and to analyze the factors causing these changes in the last 20 years using landsat image. Land cover classification was carried out using supervised classification with maximum likelihood approach. The result showed that primary swamp forest area of the SSRW continued to experience a significant decline every year during the period 1998-2018 that around 24% of primary swamp forest was lost in the period due to deforestation and degradation. Therefore, degraded forests of SSWR should immediately be rehabilitated to restore ecological functions and to increase their productivity as well as education program to increase awareness coupled with forest monitoring and law enforcement to reduce illegal activities. Finally, appropriate management should be applied with co-management between government and local communities in conserving the important conservation areas.

1. Introduction

Over time, the condition of forest areas including conservation forests, in terms of vegetation cover has experienced rapid and dynamic changes in line with development progress. Development that continues to increase along with population growth and increased necessities of life causes increasing physical pressure on conservation areas. The Singkil Swamp Wildlife Reserve (SSWR) as one of the conservation areas is currently also not immune to change due to land conversion and land use change. At the beginning of the area designation in 1998, SSWR had an area of 102,500 ha and since 2015 it has decreased to 81,802 ha. This area is representative of coastal forested wetland ecosystems in lowland tropical rain forests and part of the Leuser Ecosystem. The SSWR is a major habitat for protected and endangered wildlife globally, one of them is the Sumatran orangutan (Pongo abelii) [1-4].

Approximately 50% of Sumatran orangutan habitat is within conservation areas that are managed directly by the Ministry of Environment and Forestry, and 78% of Sumatran orangutan habitat is within the Leuser Ecosystem [5] both inside and outside of conservation areas. Forest loss that continues to occur in conservation areas, especially in peat swamps of SSWR, increasingly threatens the lives of wildlife including Sumatran orangutans. According to Wich et al. [6], Sumatran orangutans are facing extinction mainly due to habitat loss and fragmentation. Most of the forests that
are function as habitat of Sumatran orangutan have been converted into agriculture lands and others. However, to date there has been no data related to changes in land cover in the SSWR since it was designated as a wildlife reserve. Therefore, this study aimed to determine the rate of change in land cover of the SSRW and to analyze the factors causing these changes.

2. Study Site and Method

2.1. Research site and period

This study was carried out from April to July 2019. The study site cover SSWR area, comprising 81,802 ha located at south western of Aceh Province (Figure 1) that is distributed at three districts/city, namely South Aceh District, Aceh Singkil District and Subulussalam City. Astronomically, the area is situated in 2°15’12” - 2°45’25” N and 97°30’28”- 97°45’25” E.

![Figure 1. Study area of Singkil Swamp Wildlife Reserve in south western coast of Aceh.](image)

2.2. Data collection and analyses

Main tools/equipments were used in collecting data, such as GPS, camera, compass, and stationary. Subsequently, analyses data tools were ArcGIS 10.1, ENVI 4.7, ERDAS Imagine 8.5 and ms excel. The ground truthing was conducted in April 2019 to collect training data.

In this study, land cover classification was carried out using supervised classification with maximum likelihood approach in Landsat images of 1998, 2007, 2014 and 2018. This approach was the most effective classification method when equipped with accurate training data and is one of the most effective algorithms as well as most widely used [7]. Supervised classification is a classification process by selecting desired information categories and selecting training areas (sample areas) for determining each land cover category as a key interpretation [8]. The training area is taken to prove the plausibility that is adjusted to Landsat imagery as a tool for ground check. Subsequently, we determine and select training area locations to collect statistical information on land cover types [9].
3. Results and Discussions

Based on the interpretation of Landsat imagery in 1998, 2007, 2014 and 2018, the SSWR area land cover classification was identified by 6 classes, namely water bodies, primary peat swamp forests, secondary peat swamp forests, bare land, plantations, and shrubby swamp. Accuracy test results showed an overall accuracy of 89.83% and kappa accuracy of 87.41%. This shows that the image classification results can be used because the accuracy of the test value is more than 80% [10]. In Figure 2, visualization results from image interpretations that produce the land cover map of the SSWR region are presented in the past 20 years (1998 - 2018). Subsequently, the area of land cover change in the period is presented at Figure 3.

![Figure 2](image)

**Figure 2.** Land cover map of Singkil Swamp Wildlife Reserve over the last 20 years.
According to Figure 3, in the period 1998 - 2018, primary swamp forest area of the SSWR continued to experience a significant decline every year. At the beginning of the analysis period, in 1998, primary swamp forest was the largest land cover type in the region with a total area of 69,809.99 ha or around 85% of the total area. However, it continued to decrease to 64,451.22 ha in 2007, 60,453.07 ha in 2014 and 50,048.88 ha in 2018 or only around 61% of the total area. It means, around 24% of primary swamp forest was lost in the period due to deforestation and degradation.

This is inversely proportional to the change in secondary swamp forest or logged-over forest. Secondary swamp forest in the period 1998 - 2018 experienced an increase of about 15%, from the total area of 7,291.55 ha in 1998 to 19,761.18 ha in 2018. Likely secondary swamp forests, a similar trend also occurs in shrubby swamp which increased by about 8%, from a total area of 3,894.78 ha in 1998 to 10,622.26 ha in 2018. Whereas for others land cover such as water bodies, plantations and bare land in that period did not experience significant changes. According to Zulkarnain and Widayati [11], after disturbances those forests are allowed to experience natural succession.

Overall, in 2018 SSWR forest cover has experienced a change of around 8.9% from forest cover in 1998 (Figure 4). The average rate of change in forest cover in the three analysis periods was around 205 ha / year in 1998 - 2007, around 336 ha / year in 2007 - 2014 and around 774 ha / year in 2014 - 2018. Thus, within a period of 1998 - 2018, the forest area of SSWR continued to experience degradation and deforestation even increasing every period. The following is a graph of the average rate of change in the SSWR forest area presented in Figure 5.
Figure 4. Changes in forest cover of Singkil Swamp Wildlife Reserve over the last 20 years.

Figure 5. Rate of forest cover change of Singkil Swamp Wildlife Reserve over the last 20 years.

Based on Figure 5, the largest change in the SSWR’s primary swamp forest area occurred in the period 2014 - 2018. During that period the forest area experienced degradation at an average rate of 2,160 ha per year and also experienced deforestation at an average rate of 779 ha per year. On the other hand, this is not accompanied by well reforestation that only around 4 ha per year and is the smallest reforestation from previous periods (Figure 5). This shows that in that period the SSWR forest area experienced degradation and decreased forest quality with very limited improvement. Forests or peat swamps that are degraded both as a result of illegal logging, encroachment, forest fires and others should immediately be rehabilitated to restore ecological functions and to increase their productivity. Hopefully, at the end, the function of the ecosystem can immediately recover.

Forest degradation and deforestation generally occur on the edge of the forest and mostly on the border between the SSWR area and the village (Figure 6). This is due to lack of awareness and responsibility by opening up land in this area, coupled with intentional illegal logging activities. To reduce illegal activities, forest monitoring and law enforcement are key and must be optimally strengthened. Meanwhile, alternative choices for the welfare of the community around the forest must also be promoted to reduce disturbance to forests and conservation areas [11].
4. Conclusion and Recommendation
In the last 20 years, forest cover of SSWR continued to experience a significant decline every year due to illegal activities, mainly forest conversion and logging. This condition threatens the critically endangered great ape, Sumatran orangutan, and critically endangered large mammal, Sumatran orangutan, and other wildlife due to loss and degradation of their habitat. Subsequently, this disturbance also causes decreasing ecosystem functions and services.

Therefore, the education programs are to increase awareness need to be done as well as alternative livelihood choices for the welfare of the community around the forest should be also promoted to reduce disturbance to forests and conservation areas. On the other hand, forest monitoring and law enforcement are key and must be optimally strengthened to reduce illegal activities. Finally, degraded forests of SSWR should immediately be rehabilitated to restore ecological functions and to increase their productivity.

5. References
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