Regional Case Study

Socio-Spatial Analysis of Deforestation in Soeharto Forest Using Remote Sensing Method

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Abstract

The broader transformation of forested areas into open land is commonly referred to as deforestation. Deforestation poses a significant challenge to forest preservation and environmental sustainability. This study aims to employ remote sensing methods to analyze the spatial patterns of deforestation in the Soeharto Forest. It is complemented by in-depth interview data gathered from individuals engaged in forest exploitation activities. The findings reveal a notable decline in land cover within the Soeharto Forest Park area from 1992 to 2022, resulting in a reduction to 335,994,000,000 m². Further analysis of the in-depth interview data indicates that forest fringe communities have taken control of 15,536,393.69 m² of land to fulfill their livelihood and cultivation needs. The decline in land cover will also be more critical because of moving the national capital. The research results also discussed land cover areas using remote sensing. However, social support discusses whether land cover change is caused by land tenure by forest fringe communities and plans to relocate the national capital. Where this is also influenced by the formulation of government policies that have not balanced bee interests of ecology and the social culture ture of the community.

Keywords: Deforestation; forest fringe communities; social ecology; soeharto forest park

1.   Introduction

Soeharto Forest Park is one of 33 in Indonesia, located in the administrative area of Kutai Kartanegara Regency and North Penajam Paser Regency, East Kalimantan Province. This area is a lowland tropical forest ecosystem still left and has many important roles. Apart from showcasing wet tropical rainforests, it also functions as a water catchment area and a microclimate balancer (Suryadi et al., 2017). Judging from its strategic location between two major cities, namely Balikpapan and Samarinda, exposing the   Soeharto area to the risk of high environmental pressure. The impact of the Kalimantan Highway Project (projakal) construction along 115 km connecting Balikpapan and Samarinda in 1961 divided the Soeharto area into two parts. Further implications of these activities are forest fragmentation, fauna habitat fragmentation due to stand damage, forest accessibility, and deforestation (Sumardi & S.M Widyastuti, 2007)

Threats to the sustainability of Soeharto forests were also contributed by widening and maintaining the axis road. Massive encroachment, which makes forests public housing, plantations, plantations, and coal mining activities, as well as other non-forestry activities, is a challenge in the management of Soeharto's forest area so far (Nawir & Ani, 2008). Furthermore, an issue that must be addressed related to the preservation of Soeharto's forest area is the plan to move the national capital to

Sepaku District, North Penajam Paser Regency. The selection of East Kalimantan Province as the location of the National Capital City plan is based on landscape ecology considerations with advantages, including the availability of large land, especially state-owned land, the availability of surface water, safe and free locations against the risk of earthquakes, volcanoes and tsunamis and close to the existing cities of Balikpapan and Samarinda (Regulation of the (Peraturan Menteri Perencanaan Pembangunan Nasional, 2015).

However, the development plan of the National Capital City is like a double-edged sword. In addition to aiming for economic equality, it is also a threat to the sustainability of forest areas, considering the plan's location for developing the National Capital City adjacent to the Soeharto Forest area. The exodus of workers from outside the region, land clearing, and increased pollutants are just a few of the many problems the government will face to preserve Soeharto forest control (Yeshey et al., 2023).

Based on the interpretation of aerial photos of the Ministry of ATR/BPN in 2019, more than 5,000 Ha (7%) of the Soeharto Conservation Area has been converted into oil palm plantations . The existence of oil palm plantations in forest areas has been around for a while, considering that oil palm plants, as one of the agricultural sub-sectors, have excellent economic prospects, so they become an attraction for the community to try and invest in oil palm plantations (Ariyani et al., 2020).

In this context, remote sensing methods refer to using satellites or airplanes to obtain data about the Earth's surface. Data collected through remote sensing can provide important information about land-use change, including deforestation. This study uses these data to analyze spatial deforestation patterns in Soeharto Forest (Nugraha Muslim et al., 2022). The spatial pattern of deforestation refers to the spatial distribution of deforestation in the area studied. In this study, analysis of spatial patterns of deforestation can involve identifying areas most affected by deforestation, observing changes over time, and mapping and spatial modeling to understand the relationship between deforestation and the factors that influence it. As well as this research is study of the socio-spatial analysis in the context of deforestation, especially since minimum studies have used this method.

The research has several potential benefits. First, a better understanding of spatial deforestation patterns in Soeharto Forests could help identify areas vulnerable to deforestation and support more effective forest protection efforts (Camino et al., 2023). Second, remote sensing methods provide an efficient and accurate way to monitor land change on a large scale, which is challenging to do with traditional field surveys (Nita et al., 2023). Third, this research can contribute to scientific knowledge about deforestation and the factors that influence it, which can be used as a basis for the development of better environmental policies (Mutolib et al., 2020). Thus, this study aims to explore information about spatial patterns of deforestation in the region using remote sensing data supported by social data developing in the surrounding community. This research is expected to provide a better understanding of deforestation and facilitate more effective forest conservation efforts.

2. Methods

2.1. Time and Location of Research

This research was conducted in the Soeharto Forest Park Area, in Kutai Kartanegara Regency and North Penajam Paser Regency, East Kalimantan Province. The study was done for two months, including one week of preparation and data collection, four weeks of research implementation, and three weeks of data processing.
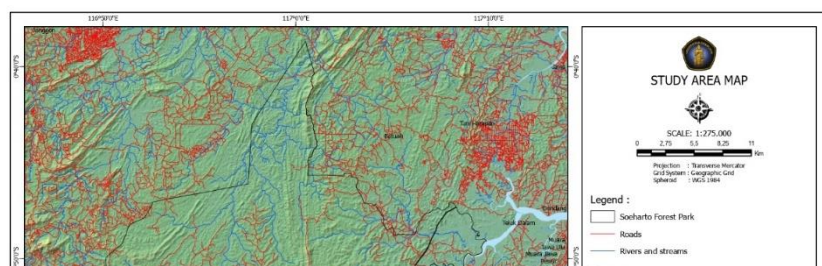
Figure 1. Map of Research Location

2.2.   Research Methods
2.2.1.   Index Pre-processing and Transformation

Aerial photographs are processed into orthotics using the Agisoft Metashape. Orthomosaic is a combination of several photographs taken during a flight. RGB and NIR orthostatic aerial photographs are then transformed into vegetation indexes. Vegetation index transformation was performed using QGIS 3.4.11 application with different formulations (Table 1). Vegetation and non-vegetation classifications are required to remove soil background from aerial photographs using supervised classification in PCI Geomatica 2013. Extraction of vegetation index values is done using zone statistics as tables in ArcGIS 10.3.

Table 1. Index vegetation formula

Indeks	Formula	Reference
Normalized Difference Vegetation Index (NDVI)	$\dfrac{(\lambda\,\text{NIR} - \lambda\,Red)}{(\lambda\,\text{NIR} + \lambda\,Red)}$	(Gitelson and Merzlyak, 1998)

2.3   Data Analysis

In addition, structured interviews were also conducted to gain a deeper understanding of the perspectives and experiences of forest fringe communities. The research team interviewed representatively selected respondents to interview them about their land use history, tenure rights, environmental changes, and their feelings regarding conflicts between land tenure and conservation efforts. Then, in addition to primary data sources, secondary data analysis was also carried out in this study. Secondary data includes pre-existing information and records, such as government reports, previous studies, location maps, and statistical data related to forests and land in the region. These secondary data provide a broader context and support findings from field surveys and structured interviews (Kaehe, Ruru, and Rompas, 2019).

Data was collected to understand community land tenure, including tenure rights, land use, and agricultural practices. Data analysis uses descriptive qualitative analysis using graphs and tables associated with previous research (Ibrahim & Syarifuddin, 2017).

3.   Result and Discussion

The socio-ecological study of the analysis of spatial deforestation patterns in Soeharto Forest with remote sensing methods aims to understand and analyze the complex interactions between social and ecological factors that contribute to deforestation. Soeharto Forest was chosen as a case study for regional deforestation patterns in this context. Soeharto Forest Park is a forest area located in East Kalimantan, Indonesia. This Forest Park is named after the former President of Indonesia, Soeharto. Soeharto Forest Park has an area of about 61,840 hectares and is one of the important forest areas in Indonesia (Suryadi et al., 2017). Soeharto has the primary function as a conservation area and nature preservation. It contains high biodiversity, including various species of flora and fauna that are protected. This Forest Park has an important role in maintaining a balanced ecosystem, maintaining water sources, and as a habitat for various types of wildlife, such as orangutans, probosci's monkeys (probosci's monkeys), and various species of birds (Evans & Guariguata, 2013).

In addition to conservation functions, Soeharto Forest also has an important role in supporting the economic activities of local communities. Within this area, several traditional villages still maintain and utilize natural resources sustainably. Local communities can conduct ecotourism-based activities like nature tourism, hiking, and scientific research. The Indonesian government, through the Ministry of Environment and Forestry, was responsible for the management of Soeharto Forest Management efforts include monitoring human activities within the area, law enforcement against violations, monitoring forest sustainability, and developing sustainable management and conservation programs (Regulation of the Minister of National Development Planning, 2015).
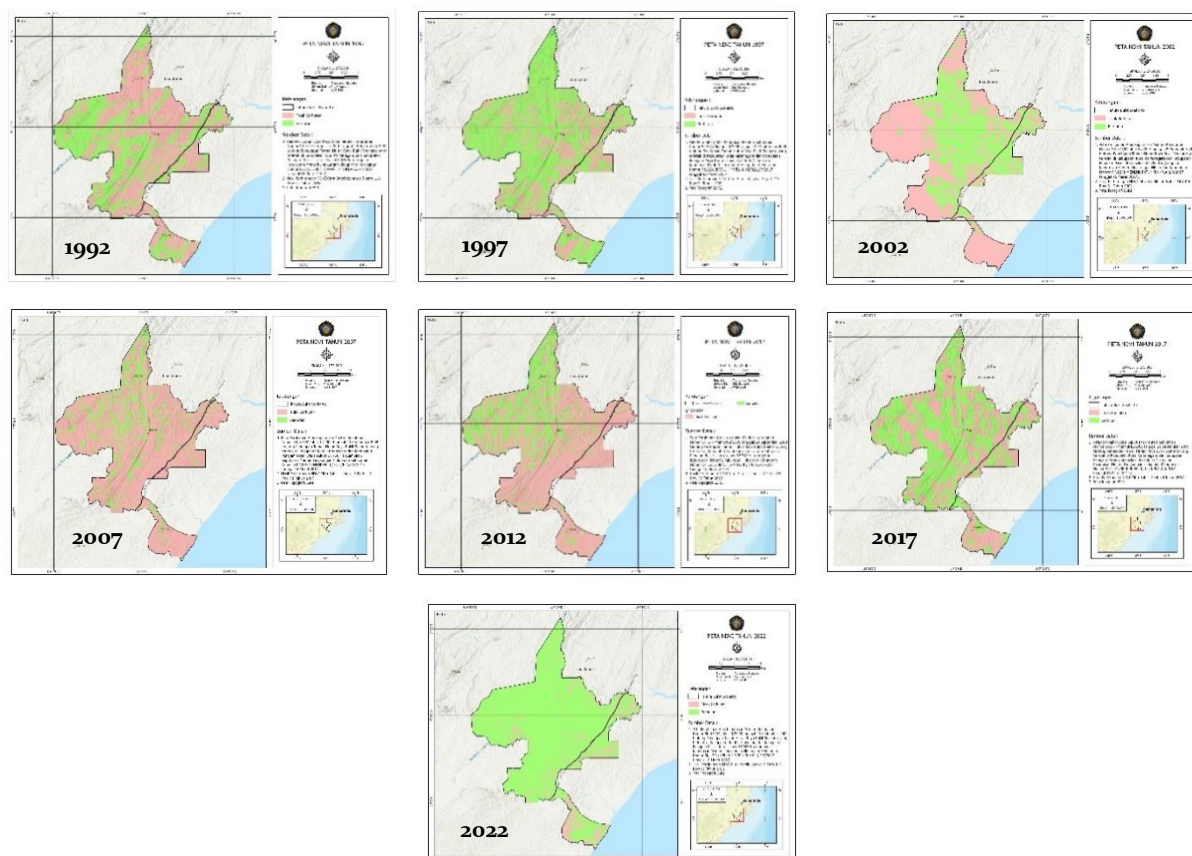

Figure 2. Land cover map of soeharto national park from 1992, 1997, 2002, 2007, 2012, 2017, 2022

Figure 2 provides a visual representation of the complex dynamics within the Soeharto Forest. It vividly illustrates the spatial distribution of land control within the forest, differentiating between areas controlled by local communities (indicated by the red legend) and areas that remain as natural forests (highlighted by the green legend). This differentiation is crucial in understanding the multifaceted nature

of deforestation and its underlying causes. The presence of red-coded sections on the map indicates the active involvement of local communities in land tenure activities. These communities, driven by livelihood necessities and other socio-economic factors, have asserted control over specific portions of the forest. This raises questions regarding the sustainability of these practices and the impact they may have on the overall health of the forest ecosystem (Ranjan et al., 2022).

Conversely, the green-coded areas on the map represent the remaining natural forest cover. These regions are essential for biodiversity preservation, carbon sequestration, and overall environmental balance. The existence of these pristine forest areas underscores the importance of conservation efforts to safeguard such critical ecosystems. The interplay between these two categories, the controlled sections and the natural forests, is central to the broader issue of deforestation within Suharto Forest. The study should delve deeper into the motivations behind community-led land control, examining whether it is driven solely by survival needs or influenced by broader socio-economic factors (Grejo and Lunkes, 2022).

Soeharto Forest also had a role in public education and awareness about the importance of nature conservation. Through environmental education programs and socialization activities, the community is expected to understand better the importance of maintaining biodiversity and forest sustainability. Soeharto Forest Park is one of Indonesia's most important forest areas. By properly maintaining and managing this area, it is hoped that a balance can be achieved between nature conservation and sustainable human activities (Anggoro, 2006). The negative impacts of land clearing in the Soeharto area extend beyond mere conflict and conservation concerns. Forest destruction resulting from these activities can have far-reaching consequences, such as a decrease in water quality and loss of biodiversity. By employing remote sensing techniques, the ongoing deforestation in the area can be clearly observed.

It's just that over time, the connection of the surrounding community with Soeharto Forest Park is very high. Many people use the area as settlements and yards, plantations, to rice fields. This lasted from 1957 to 2022. The total area that has been opened is 335,994,000,000 m². The large number of Soeharto suburban communities that cleared land and used it for settlements, plantations, and rice fields from 1957 to 2022 highlights the changes in land use around the area over a considerable time. These changes reflect social, economic, and policy dynamics that affect local communities and the surrounding environment.

In 1957, Soeharto Forest Park was established as a protected conservation area with the primary objective of preserving biodiversity and maintaining ecosystem functions. During this period, land clearing by communities around Soeharto was still relatively limited due to strict supervision and law enforcement from the government. However, social and economic changes around the area can affect community actions in clearing land to meet their living needs (Mutolib et al., 2020). After the Reformation era, changes in politics and government policies could impact land use around Suharto. Community involvement in land clearing and its use as settlements, plantations, and rice fields may increase due to more accessible access to natural resources and policy changes affecting forest management. Population growth and local communities' economic needs can also motivate them to open new land.

Land clearing around Soeharto for settlements, plantations, and rice fields often occurred in response to economic pressures and people's living needs. Conflicts arise when these activities conflict with Soeharto conservation goals and can result in ecosystem damage and habitat loss for protected flora and fauna. The government and relevant stakeholders need to find solutions that balance the needs of communities and environmental sustainability, such as by developing sustainable forest management programs or providing alternative livelihoods to communities. The clearing of land around Soeharto for settlements, plantations, and rice fields can negatively impact the environment, including forest destruction, decreased water quality, and decreased biodiversity. If viewed through remote sensing, this can also be seen if deforestation occurs every year. The analysis showed that the Soeharto area continued to decline in land cover starting in 1992 and was analyzed every five years. This decrease in land cover is indicated due to land tenure carried out by the periphery of Soeharto Forest Park (Abab et al., 2023).

Overall, each neighborhood found land tenure with various characteristics of land description status. Data shows that the community carries out ten land information statuses to control land in the

Soeharto Forest Park. The status of the land information is in the form of land tenure, certificates, seals, transitions, inheritance, buying and selling, arable, grants, compensation, and state land and has yet to be detected. The area of each land status in 2022 is listed in Table 2.

Table 2. The extent of land description status in soeharto forest park

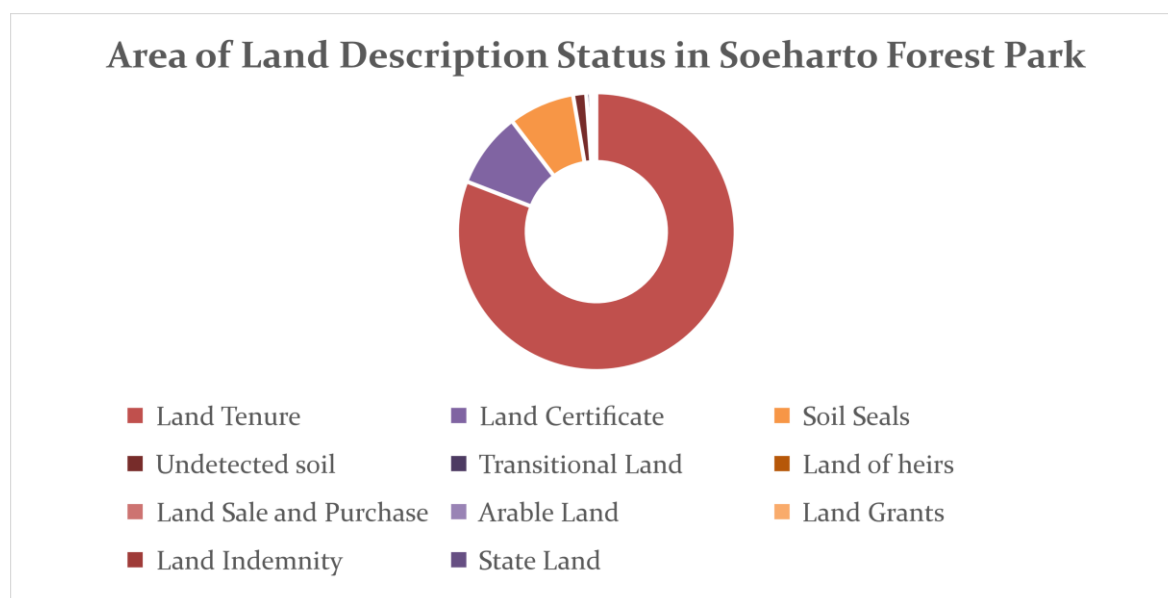| Information	Total Area (M²)
Land Tenure	15,536,393.69
Certificate Land	1,681,910.77
Soil Seals	1,474,918.34
Undetected soil	292,691.40
Transitional Land	100,392.59
Land of heirs	49,912.14
Land Sale and Purchase	36,920.30
Arable Land	23,023.67
Land Grants	11,161.44
Land Indemnity	3,524.96
State Land	954.14

Figure 3. The comparative ratio of the extent of land information status in soeharto forest park (m2)

In Indonesia, forests are natural resources controlled by the state and used as much as possible for the prosperity of the people. Forests controlled by the state are natural or cultivated forests (plants) in state forest areas. For community prosperity, state forest management is implemented to encourage community-based forestry development. These activities can include Forest Resource Management with village communities. This activity is carried out by encouraging the cultivation of forestry commodities on people's lands (Nandika, 2005).

The role of communities living around forests is expected to participate in forest security, forest product utilization, and forest rehabilitation and conservation to achieve these goals. This community-based forestry development continues to grow so that pressure on natural forests in the form of exploitation for the fulfillment of legal and illegal industries will be reduced. Community-based Forest development is expected to provide a significant role for the community to participate as a guarantee for the sustainability of the national forestry industry. Forest development is a conscious and planned effort to create better environmental conditions (Jacobus, 2006). The right to open land and collect forest

products can only be owned by Indonesian citizens and regulated by Government Regulations. By this, intercropping is very suitable for implementing community forests. Community forests are expected to empower communities, especially those close to forest areas (Perum Perhutani, 2004).

However, at the end of the new order and the occurrence of the monetary crisis, the decline in the rupiah exchange rate against the dollar (inflation) has resulted in the economic decline of rural communities, including people living around forest areas. This resulted in the low income of villagers around the forest. Therefore, to meet their needs, people encroach on the contents of the forest. Forest encroachment at that time severely damaged forest land (Sumardi and S.M Widyastuti, 2007). Activities in forest encroachment by the community due to the lack of patrols that should be carried out to maintain the security of forest areas. Knowledge about the sustainability and benefits of the community's forests is minimal. In addition, most people living around forest areas do not have other skills to meet the needs of life except farming. On the other hand, the area of village agricultural land is narrowing to meet the people's daily needs around the forest, and encroaching on the forest becomes inevitable (Gunawan, 2000).

This practice has been going on for decades. It continues to the next generation, where the land area cultivated initially was only for the needs of farmers and families as if it had become private property. Not to mention the ownership status and boundaries of the area that need to be neatly recorded in administration and documentation make this even more biased. In such cases, it is essential to involve competent authorities, such as the East Java Natural Resources Conservation Center (BBKSDA) or relevant government agencies, to understand the situation more deeply and legally resolve land status issues and accordance with applicable law (Nawir & Ani, 2008).

Initial data collection is essential to identify and verify land boundaries and ownership status. This can help keep a neat record of administration and documentation related to the land. Authorities can mediate and consult with landowners and other relevant parties to find a fair and acceptable solution for all parties involved. In this case, consideration must be given to the interests of environmental conservation and sustainability of Soeharto Forest Park (Mayboroda and Spirin, 2023).

If necessary, an administrative and documentation update process can be carried out to record the area's boundaries and the existing land's status. This can involve the process of legalization or updating ownership documents (Wignjosoebroto, 2002). In addition, it is essential to engage legal experts who are competent and experienced in land matters to help understand and navigate these situations appropriately (Mayboroda and Spirin, 2023). Experts can provide appropriate guidance based on applicable laws and procedures to resolve land status issues in Soeharto Forest Park so that land tenure carried out by forest fringe communities does not expand (Poerwidodo, 1991).

In addition to land tenure carried out by the community, an issue that must be addressed related to the preservation of the Soeharto forest area is the plan to move the National Capital to Sepaku District, North Penajam Paser Regency. Since the reign of President Soekarno, it has been proposed to move the new capital to Balikpapan, then the second President Soeharto proposed Jonggol as the new capital. Until the fifth President, Joko Widodo, proposed the North Penajam Paser and Kutai Kertanegara regions as the new capital. Thus, relocating the new capital has become an issue for every ruling regime (Herdiana, 2020).

Alternative relocation of the national capital outside Java: Kalimantan and Sumatra. The advantage of Kalimantan is that its location is the center of the archipelago. The land is still vast, so it can arrange an ideal spatial layout of the country's capital. The disadvantage is that the infrastructure and facilities need to be more adequate; most have to build new ones, meaning expensive costs. Another drawback is the provision of clean water; Forest fires, floods, and landslides are hazards that need to be used as a basis for consideration (Irwanugroho, 2019). There are several potential environmental impacts of the development of the National Capital City, where the most significant potential for environmental change is deforestation. The increasing need for space in the process of implementing development impacts the use of available space.

Based on (Agustino, 2014), land use change is a phenomenon that everyone must avoid in the transformation process of allocating existing natural resources from one use to another. The National Capital City has significant development challenges in the forestry sector, especially forest degradation. Decreasing forest cover indicates forest degradation caused by using land in forest areas for non-forestry activities such as mining, settlements, and plantations (overlapping permits for Production Forest concessions in Soeharto) (Yeshey et al., 2023). Even though the National Capital City is part of Kalimantan Island, whose spatial planning direction is to realize the preservation of biodiversity conservation areas and protected areas with wet tropical forest vegetation of at least 45 percent of the area of Kalimantan Island (Anggoro, 2006), therefore, the development plan of the National Capital City must pay attention to and conserve forests and other protected areas to protect biodiversity in supporting sustainable urban development.

Despite the comprehensive exploration of land tenure in the Soeharto Forest Park, there are still unidentified or undocumented land information statuses that require further investigation. The existing data does not provide a complete picture of all the mechanisms and arrangements through which land is controlled and managed within the park. Therefore, future research efforts should focus on uncovering these undetected land information statuses to gain a more comprehensive understanding of land tenure dynamics in the area (Edeh et al., 2022).

By identifying and documenting these previously undetected land information statuses, policymakers and stakeholders can gain valuable insights into the complex land management practices within the Soeharto Forest Park. This knowledge can inform the development of effective and inclusive land governance strategies that respect the diverse needs and rights of local communities while ensuring the conservation and sustainable use of natural resources in the park (Rakotonarivo et al., 2023).

4.   Conclusions

Soeharto Forest Park is one of 33 Forests in Indonesia, located in the administrative area of Kutai Kartanegara Regency and North Penajam Paser Regency, East Kalimantan Province. Its strategic location makes Soeharto Forest Park experience a decrease in land cover. The community's rampant land tenure reports this to meet the needs of life and the issue of moving the state capital in this region. The results show that the area of land cover in the Soeharto Forest Park area from 1992 to 2022 has decreased to 335,994,000,000 m². This is further analyzed through in-depth interview data until it is obtained that forest fringe communities control 15,536,393.69 m² to meet the needs of life and cultivation. In addition, the decline in land cover will also be more critical because of the issue of moving the national capital. This is triggered by government programs that do not balance the community's ecological, economic, and socio-cultural interests.

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