Tracking Environmental Quality of Indonesia's New Capital City and its Surrounding Area

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Abstract. Environmental degradation is often a trade-off from development, and this is a challenge in the development of Indonesia's new capital city. This study aims to provide historical information on environmental quality in the new capital city and its surroundings to broaden understanding of the development of a new capital city in realizing the forest city concept. Study review, descriptive statistics, and spatial analysis were used in this study. NDVI from MODIS imagery was processed using Google Earth Engine. Spatial data from various sources were overlaid and analyzed to identify deforestation, forest cover, forest degradation. The result of this study clearly shows that Kutai Kartanegara, Paser, and Kutai Barat Regencies will become an environmental buffer for Indonesia's new capital city with dynamic environmental quality. There was a decreasing trend in deforestation, while the trend of the increase occurred in Kutai Barat and Kutai Kartanegara. Paser and Kutai Barat, which have the highest percentage of forest cover > 40%. The forest degradation only occurred in three regencies, Kutai Kartanegara is the highest. The ratio of forest biomass potential to the area: Kutai Kartanegara > Paser > Kutai Barat > Penajam Paser Utara > Balikpapan.

1. Introduction

Relocation of the national capital city is the choice of the Government of Indonesia to realize the new city growth and reduce other problems which shows that Jakarta, the current Capital City, is no longer supported as the nation's capital. As the capital city of Indonesia, Jakarta has received warnings of land subsidence at a rate of 1–15cm/year [1]. The centralized government system and multi-functional system concentrated in Jakarta make Jakarta's burden even heavier so that the carrying capacity of Jakarta's environment continues to decline [2].

Several other countries have also moved their national capital cities, such as Brazil, which moved its capital from Rio de Janeiro to Brasilia; Australia, which moved its capital from Sydney to Canberra. The main reason for moving the capital cities of the two countries is to share the burden of the city as a business center and government center while reducing population density [3]. The relocation of the nation's capital city (IKN) has been stated in the National Medium-Term Development Plan (RPJMN) for 2020–2024 [2,4]. According to The Ministry of National Development Planning/National Development Planning.

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Development Planning Agency, the plan to move the country's capital city from Jakarta to other regions is caused by, among other things: 1. The development gap between the western and eastern regions. The capital city needed is geographically in the middle of Indonesia, 2. Prone to earthquakes, 3. Traffic in Jakarta is congested, crowded, and slum, 4. Prone to flooding, 5. The quality of river water is heavily polluted, and clean water is unavailable, 6. The required capital city reflects the nation's identity, modern, international class (smart, green, and beautiful city) [2].

The areas in Penajam Paser Utara Regency and Kutai Kartanegara Regency, East Kalimantan Province, were chosen as the new capital city (IKN) of Indonesia, including the core IKN area and its expansion area. The area in Penajam Paser Utara Regency as the IKN Core Area becomes the center of new growth. In contrast, the surrounding regencies with direct borders, namely Kutai Kartanegara Regency, Paser Regency, Kutai Barat Regency, and the city of Balikpapan, will become hinterland areas. The new growth center in the Penajam Paser Utara Regency area is expected to create a spread effect for the economy and downstream natural resources for energy in the hinterland area. Spread-effect is a condition in which the flow of population, capital, and goods and services from developed areas to underdeveloped areas and vice versa will positively influence each other so that there is a balance of regional development. According to the Basic Conception of Regional Development in Indonesia, the transfer of IKN is part of the development of Indonesia's national territory by [5]: 1. Realizing a balance between regions in terms of their growth rate, 2. Strengthening national economic, and 3. Maintaining national growth efficiency.

As a center of social and economic activity, usually with a high or dense population, a city, to some extent, offers transformational change in terms of efficiency and innovation [6]. However, along with urbanization, cities need to develop over time and consume natural resources in excess, which poses a risk to the environment's carrying capacity [7]. The plan to relocate the National Capital City (IKN) has significant environmental aspects, especially how to ensure that urban development can maintain forest functions and biodiversity and not damage the environment. The relocation of the capital city does not only think about the carrying capacity of the region that is suitable and meets the needs of the capital city but also considers environmental impacts that are the focus of the world today to maintain the sustainability of the country's future. Environmental degradation is often a trade-off from development, so that preparing environmental safeguards from the planning stage to the implementation of development activities is essential. The paradigm shift of sustainable development where there is the intersection of economic, social and environmental capital and assuming that economic, social, and environmental capital is complementary and non-interchangeable ("Strong Sustainability") is a challenge in the development of Indonesia's New Capital City. The Forest City concept is presented as a concept for Indonesia's new IKN development to mitigate opportunities for environmental damage, especially forests, in the planning and development of IKN [8]. Indonesia has used the Environmental Quality Index (IKLH) as an index that describes the condition of the results of environmental management. Forest cover is an indicator of environmental quality in addition to indicators of water quality and air quality [9]. To broaden the understanding of the forest condition of the new capital city in realizing the Forest City Concept and to prepare environmental safeguards, tracking the quality of forests in the New Capital of Indonesia and its surroundings is very important.

2. Method

2.1. Study site
The area that is the object of the study is Penajam Paser Utara Regency, East Kalimantan Province, which is the location of the IKN area and the surrounding regencies that are directly adjacent, namely Kutai Kartanegara Regency, Kutai Barat Regency, Paser Regency, and Balikpapan City (figure 1).
2.2 Methods
The methods used in this study are literature study, tabular and spatial analysis to determine the parameters related to Environmental Quality in the 2011-2020 period. The analyzed parameters include natural forest cover, vegetation cover, deforestation, forest degradation, and greenhouse gas emissions due to land cover changes. Processing and analysis are carried out using QGIS 3.14 software, Google Earth Engine, and Microsoft Excel.

Data from various sources were used in the analysis, including 1) Natural Forest cover in 1973 [10] 2) Land cover maps, Ministry of Environment and Forestry (MoEF), 3) Deforestation maps, MoEF, 4) Aboveground Biomass maps [11], 5) Hansen Global Forest Change v1.8 (2000-2020) [12], 6) MOD13A1.006 Terra Vegetation Indices 16-Day Global 500m.

Forest cover based on the Land Cover Quality Index can be expressed as natural forest cover, including plantation forest, and vegetation cover. "Forest" has been defined in many ways. In general, the definition reflects forest diversity and forest ecosystem types. As a "general" reference, the Food and Agriculture Organization's Global Forest Resources Assessment, as a "general" reference, defines forest as a land area of more than 0.5 ha with a tree crown cover of more than 10 percent and trees with a height of more than 5 meters at maturity [22]. Forest-based on its structure can be natural forest and plantation forest. Based on the Land Cover Map - KLHK, these Forest cover parameters consist of classes (1) primary dryland forest; (2) secondary dryland forest; (3) primary mangrove forest; (4) secondary mangrove forest; (5) primary swamp forest; (6) secondary swamp forest, and (7) plantation forest.

The calculation of GHG emissions is carried out based on an approach used in the Indonesian Forest Reference Emission Level (FREL) submission, where deforestation is the conversion of natural forest to non-forest. In contrast, forest degradation decreases forest quality from primary forest to secondary forest [13]. The loss of aboveground biomass (AGB) and its changes from primary forest to the secondary forest of natural forests in Kalimantan are emission factors (table 1). GHG emissions are
calculated by multiplying the emission factor by activity data and carbon conversion factor of 47% and CO₂-e equivalent of 44/12 [14].

| Forest Type              | Mean AGB (Mg ha⁻¹) | 95% Confidence Interval (Mg ha⁻¹) | N of plot measurements | SE(%) |
|--------------------------|--------------------|----------------------------------|------------------------|-------|
| Primary dryland          | 269.4              | 258.2                            | 280.6                  | 333   | 4%                        |
| Secondary dryland        | 203.3              | 196.3                            | 210.3                  | 608   | 3%                        |
| Primary swamp            | 274.8              | 269.2                            | 281.9                  | 3     | 2%                        |
| Secondary swamp          | 170.5              | 158.6                            | 182.5                  | 166   | 7%                        |
| Primary mangrove         | 263.9              | 209.0                            | 318.8                  | 8     | 21%                       |
| Secondary mangrove       | 201.7              | 134.5                            | 244.0                  | 12    | 21%                       |

Source: FREL documents submitted by Indonesia [14].

3. Result and Discussion

President Joko Widodo announced that IKN would be moved from DKI Jakarta, and a new IKN will be built in the administrative areas of Penajam Paser Utara (PPU) and Kutai Kertanegara Regencies, East Kalimantan. About 250,000 ha in the Penajam Paser Utara and Kutai Kertanegara Regencies have been prepared for IKN development, of which 40 percent will be confirmed to be IKN green areas. The IKN area is divided into three zones: the Central Government Core Area of 5600 ha, the Capital City Area of 56,000 ha including the core area, and the Capital City's expansion area [14]. As a new IKN, Penajam Paser Utara Regency will become a new growth center expected to have a double effect on the Hinterland area, namely Kutai Kertanegara, Kutai Barat, Paser Regency, and Balikpapan City. The principle of sustainability is the importance of integrating environmental factors in a development. Economic values cannot replace existing environmental values.

The Land Cover Quality Index, one component of the Environmental Quality Index, represents green issues in assessing environmental quality management policies. The Land Cover Quality Index is compiled on Forest Cover and Vegetation indicators in the form of shrubs found in forest areas and protected function areas in Other Use Areas. The IKTL value is influenced by several factors, including land clearing activities, forest/land fires, illegal logging, forest/land rehabilitation activities, coastal area rehabilitation, ex-mining land restoration activities. The results of the analysis of environmental quality parameters including natural forest cover, vegetation cover, deforestation, forest degradation, and greenhouse gas emissions due to changes in land cover in the new capital city and its surroundings are:

3.1. Natural Forest Cover

Indonesia defines a forest as an ecosystem unit in natural resources dominated by tree communities in nature, which cannot be separated from one another (Forestry Law 41/1999). Decree of the Minister of Forestry of the Republic of Indonesia, No. 14/2004 on A/R CDM, as a "formal right", defines forest as "Land with an area of more than 0.25 hectares with trees more than 5 meters tall at maturity and a canopy cover of more than 30 percent, or trees can reach this threshold in situ" [23]. Changes in natural forest cover from 1973 to 2020 in the new IKN area and surrounding areas can be seen in figure 2.
Natural forest cover in 1973 is based on a study from Gaveau that conducted an analysis of deforestation and industrial plantations development in Borneo [10], while natural forest cover in 2000 and 2020 is based on the Land Cover Map, KLHK. Natural forest cover in 1973 in the five regencies reached 4.3 million ha, of which Penajam Paser Utara Regency had the second smallest natural forest cover area after Balikpapan. The percentage of natural forest cover this year is still high, greater than 75% of the total area of each area except for Balikpapan, which only reaches 38%. After 1973 the extraction of natural resources began to be carried out through timber harvesting and mining in addition to natural disturbances due to fires driven by the extreme conditions of the El Nino in 1997/1998. In 2000, based on data from the Directorate General of Forestry Planning and Environmental Management 2000, only 50% of the five regencies remained, namely 2.4 million ha, the most significant percentage of natural forest cover was in Paser Regency 59%. Natural forest cover in Penajam Paser Utara Regency in 2000 was only 33%, while Balikpapan was only 19%. Twenty years later, the natural forest cover in the five regencies was only 1.9 million ha. Penajam Paser Utara Regency has a drastic change, i.e. its natural forest cover is only 52% from 2000, which is 17% of the regency area. Balikpapan is relatively stable, with natural forest remaining is 19% of the total area while other regencies continue to decline of 14-23%.

3.2. Forest Cover
Analysis of changes in the percentage of forest cover in the IKN and surrounding areas during the 2011 – 2020 period shows that Paser Regency and Kutai Barat Regency, which have the highest percentage of forest cover compared to other areas > 40%, have a downward trend in the 2011-2020 period. Kutai Kartanegara Regency and Penajam Paser Utara Regency tend to have the same pattern, fluctuating with the percentage of forest cover still above 30%. Balikpapan City tends to be relatively stable with a forest cover percentage below 20%.

This change in forest cover is triggered by land conversion, which results in deforestation [17] revealed that there was a severe threat from deforestation in Kalimantan; the development of plantation forests, including oil palm plantations, is believed to be the driver of the loss of natural forest cover. His analysis revealed that the Kalimantan region had experienced large-scale forest loss before the expansion of industrial plantations. This cleared land allows the development of several large-scale industrial plantations without necessarily causing additional forest loss. Nonetheless, in the last decade, plantations have become a major direct cause of deforestation.

Kutai Barat Regency and Kutai Kartanegara Regency have an increasing trend of deforestation area while Paser Regency and Penajam Paser Utara Regency tend to decrease (figure 3). The decrease in deforestation area in Penajam Paser Utara Regency will have a different pattern with the development of IKN. The Central Government Core Area, located in Sepaku Sub-district, is entirely under the
Timber-Plantation Forest Product Utilization Business Permit (IUPHHK-HT) PT. International Timber Corporation Indonesia Hutani Manunggal (PT. IHM).

Forest degradation is often a transition process to deforestation. The history of forest degradation in Kalimantan, especially in the IKN and surrounding areas, has been going on for quite a long time. Historically, during 1975-1990, the Government of Indonesia has granted logging permits to forest concession holders. Approximately 69.4 million ha of forest area have been allocated to 651 forest concessions, and other studies report that the Government of Indonesia has allocated more than 60 million ha of forest to logging companies over more than 30 years [24]. Apart from these legal logging activities, encroachment and illegal logging also occurred extensively after the 1997/1998 forest fires. Forest fires have also occurred in Indonesia in 1982/1983. These fires have contributed to high forest loss and forest degradation. The burned area accounts for about 3.2 million ha of forest, of which 2.7 million ha is the remaining essential tropical rainforest in Kalimantan and Sumatra. Incidents of significant fires have occurred repeatedly in Indonesia. After the fires in 1997, significant fires occurred again in 2003, 2006, 2009, 2012, and 2015. Forest fires occur almost every year, although in a smaller areas.

The analysis of level of forest degradation in the new IKN area and its shows that Kutai Kartanegara Regency is the regency with the highest forest degradation area compared to other regencies in the region the 2011-2019 period. According to [25], the level of forest degradation is likely to be higher due to the possibility of degradation in forests that are included in the secondary forest category. The Forest City concept in the IKN development plan should be aware with this condition, must pay attention to the balance between urban development and the preservation of nature and the environment, especially in maintaining and preserving forest functions which are the main potential on the island of Kalimantan. The IKN area and its surroundings include part of the island of Borneo which is one of the main biodiversity hotspots in Indonesia, the habitat of several species that are categorized as protected or important. The sustainability of these animals and plants is starting to be threatened due to the potential for increased deforestation and forest degradation with the development of IKN.

Figure 3. Trends in deforestation in the new IKN area and its surroundings.

3.3. Tree Cover
In the 2019 Indonesian Environmental Quality Index report, improvements were made to calculating the Land Cover Quality Index, i.e. by adding parameters, which were initially only forest cover to vegetation cover, including shrub cover in forest areas and protected function areas in use areas. Other. Observation of the earth's surface covered with vegetation can use the vegetation index generated from remote sensing data. The value of the vegetation index is one of the parameters resulting from remote sensing data extraction, which is used as a physical parameter of vegetation.
The value of this vegetation index can reflect the level of greenery and the condition of vegetation vigor \[26\], and its application can provide information about vegetation dynamics on a global scale. Therefore, the vegetation index data can be used to monitor the condition of vegetated land in a large area. Observation of the earth's surface using satellite imagery simultaneously over a long period, both seasonal and annual, will provide information on the temporal dynamics of vegetation. The results of research \[27\] indicated that the temporal dynamics of vegetation characterization over a long period could be used to observe trends in changes that occur in one land-use class, both gradual changes due to extreme climate variations, as well as drastic changes caused by humans and nature (for example changes in land use and forest fires). The characterization of this change is an alternative method to determine the trend of continuous land cover change so that it can be used to see forest cover performance as a benchmark for policy performance \[28\].

Analysis based on the NDVI vegetation index with Modis imagery shows that during the period 2001 – 2020 in the new IKN area and its surroundings, there is no significant difference in changes in the daily index value based on the date of image coverage, although in general there is an increase. Balikpapan City has the lowest trend index value while the highest is in Kutai Barat Regency (figure 4). In general, the IKN area still has a high average value of the vegetation index, above 0.65 which illustrates the dominance of tree cover. Balikpapan City is slightly lower than other regions, which is 0.57.

![Figure 4: Average Vegetation Index Value by date in IKN and surrounding areas.](image-url)

### 3.4. Biomass

Biomass is one of the parameters that describes forest productivity \[29\]. The analysis was carried out in the IKN area based on the Biomass map \[11\]. This dataset provides an estimate of aboveground biomass in the Kalimantan region that is representative of end-of-2014 conditions. The analysis results in the IKN and surrounding areas show that the Ratio of forest biomass potential to the area is as follows: Kutai Kartanegara Regency > Paser Regency > Kutai Barat Regency > Penajam Paser Utara Regency > Balikpapan City. This illustrates that forest productivity is still high in several areas around the new IKN. Paser Regency, Kutai Barat, Kutai Kartanegara have the highest average aboveground biomass, i.e. 122 - 152 Mg ha\(^{-1}\), while Penajam Paser Utara is 70 Mg ha\(^{-1}\). Balikpapan is the city with the lowest average aboveground biomass, i.e., 35 Mg ha\(^{-1}\). The spatial distribution of AGB in the IKN area and its surroundings can be seen in figure 3.
This condition illustrates that the forest city that will be developed in the development of the capital is in an area that already has high forest productivity. In contrast to the concept of forest city in general as an effort to reforest cities as a result of the impact of development, especially pollution and environmental damage, such as the Forest City concept which is quite massively developed in China. The concept of Forest City was formulated by [17] as a forest city dominated by landscapes with a forest structure or green open space with ecosystem service functions such as forests and an integrated landscape approach to create life side by side with nature. There are at least six principles that can be demonstrated as a Forest City Concept, namely: 1) conservation of natural resources and animal habitats; 2) connection to nature; 3) low carbon development; 4) adequate water resources; 5) controlled development (Anti-Sprawl Development); 6) community involvement in realizing Forest City.

![Figure 3. Map of biomass in the IKN and surrounding areas.](image)

3.5. GHG Emission.

The incidence of deforestation and forest degradation is a source of emissions in the land sector. The Indonesian Greenhouse Gas Inventory Report [30] shows that the forestry sector is one of the most significant contributors to emissions produced in Indonesia apart from the energy sector. The results of the calculation of the national GHG inventory contained in this report show that Indonesia's GHG emission level in 2018 was 1,637,156 Gg CO$_2$e with a contribution from the forestry sector of 723,510 Gg CO$_2$e. Based on the analysis conducted, the GHG emissions resulting from deforestation and forest degradation during the 2011-2019 period, the new IKN area and its surroundings have contributed GHG emissions of 13.9 million Mg CO$_2$e from deforestation and forest degradation. The most significant emission contribution occurred in the 2017-2018 time period. Kutai Kartanegara Regency is the largest emitter compared to the new IKN area and other regencies.

Bappenas predicts that there will be an additional population of around 1.5 million people to new IKN locations over the next 5-10 years if the relocation begins in 2024 [19]. It is predicted that in 2045 the population of East Kalimantan will reach 5.6 million. Furthermore, the population is concentrated in two regencies, namely Penajam Paser Utara and Kutai Kartanegara. This condition will be a challenge in managing forest ecosystems in the IKN area. Community involvement in maintaining forest ecosystems is significant. The application of non-timber forest product management can be a new
approach in improving the community's welfare around the forest while maintaining the sustainability of the area. The potential for biodiversity loss in the IKN area becomes a real threat if the government does not prepare strategies and policies for community readiness. Therefore, the government needs to ensure the community's readiness that is adaptive and aware of the existence of conservation areas. There is a need for a conservation partnership approach while maintaining the area's ecology by strengthening the community forest economy based on non-timber forest products, agroforestry, and environmental services. Revitalizing production forests, conservation areas, and maximizing other areas (non-forest areas) by involving residents is needed. Furthermore, the protection of customary space (forest area) and rearrangement of production forest areas need to be carried out to support the conservation of new IKN areas [20].

4. Conclusion
As in Kalimantan in general, Indonesia’s new capital city and its surrounding area have a long history of dynamics of forest cover change, the era before timber exploitation in the 1970s and after. Forest cover was quite massive in the 1970s and then decreased over time with Deforestation and Forest Degradation. In the current condition, the forest cover in the new IKN area is still above 30%, except for Balikpapan. This condition is expected to be a capital for the development of IKN with the concept of a forest city that maintains existing forests and prevents forest destruction from continuing. Kutai Kartanegara, Paser, and Kutai Barat Regencies will become an environmental buffer for Indonesia's New Capital City with the ratio of forest biomass potential to the area: Kutai Kartanegara > Paser Regency > Kutai Barat Regency > Penajam Paser Utara Regency > Balikpapan City.

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