Evaluating the Ecological Footprint of Nusantara: Impact Towards Key Biodiversity Regions Surrounding Indonesia's New Capital

Abstract

This study assesses the ecological impact of constructing Nusantara, Indonesia's new capital, on its surrounding key biodiversity regions. Although the construction of the new city provides the best alternative to the sinking of Jakarta, potential spillover effects towards environmental damages, such as the destruction of critical mangrove ecosystems and rare species habitats, have become an increasing concern. Despite protective measures, vital biodiversity hotspots remain outside safeguarded zones. This paper leverages remote sensing to monitor vegetation health changes as an indicator of ecological welfare pre-and post-construction. Initial findings suggest that proximity to the construction site does not correlate with declining vegetation health. Instead, some nearby biodiversity regions have shown increased vegetation health, challenging assumptions about construction impact. The paper underscores the importance of subtle analyses in environmental planning and the limitations of using proximity as a sole indicator of ecological effects.

Keywords: Borneo; IKN; biodiversity; vegetation change; protected regions.

1 Introduction

On February 15, 2022, the Indonesian government passed the IKN bill (UU IKN No.3), which instigates the construction of a new capital city that would be positioned in the east region of Kalimantan on the island of Borneo. The mega project, planned to be completed by 2045, was an ambitious attempt to alleviate the growing emergency for the sinking of the current capital city, Jakarta. Over the past few years, Jakarta has been forecasted to be unable to handle the growing city population—investment towards a more sustainable urban infrastructure proved futile, given that land subsidence remains a prominent factor. Consequently, the move towards a new city remains the most sensible long-term solution. Nevertheless, the issuance to construct the city in Kalimantan sparks international criticism for its potential impact on the region’s surrounding environment—the construction would pose a severe hazard to its water supply as well as destroy approximately 2,603 hectares of the mangrove ecosystem (Rachman, 2022). East Kalimantan is also home to some of the rarest and most endangered species, such as Sumatran Tigers, Rhinos, and Orangutans, to name a few (WWF, n.d.). These creatures, as well as their habitats, are situated in rich biodiversity regions. Although the local governments have procured several protection systems and restriction boundaries for these ecologies, the study that was published in Animal Conservation denotes that biodiversity hotspots in the Island of Borneo and Sumatra are situated outside of the protected areas—accounting for only 9.2% to 18.2% of the diversified species within the protected areas of each region, respective (Dungey, 2022).

2 Conceptual Framework

To better understand the potential ecological impacts of the construction of the new capital city, researchers have analyzed preliminary urban plans to forecast future adverse effects. A study that was conducted in 2020 by Teo, Lechner, Sagala, and Arceiz highlights how the estimates for carbon footprint due to deforestation in the direct effect of 30 km and indirect effect of 200 km surrounding the capital would be equivalent to 2.7% and 126% of greenhouse gas emissions in 2014 (Teo et al., 2020). Their study, which utilizes nightlight satellite imagery, forecasts that the impact of the construction of the new capital city would affect sensitive ecosystems such as mangroves and peat at a much higher compared to the urbanized regions of the southern side of Kalimantan near the city of Balikpapan. Teo et al. conclude that without relocating the site to other parts of Borneo, these rich ecological regions would present the brunt of the immediate effects.

Although other researchers and local experts provide similar perspectives, there has yet to be a study that observes the current state of vegetation health within the surrounding key biodiversity areas. Mapping out vegetation health as a proxy to generalize the overall welfare of these regions could provide additional insights into the effectiveness of current state protection policies. Evaluating the immediate impact of vegetation health within the specified regions would allow for real-time analysis between the pre- and post-construction periods. Though the construction of IKN has only been enacted for over two years, or 8% of the way from the estimated completion time, the framework of this study would help mitigate future destruction of ecologies by informing the current landscape of the issue. Hence, this study attempts to evaluate the ecological changes using vegetation health as a proxy for the welfare of key biodiversity areas during pre- and post-construction periods. It is hypothesized that the closer these key biodiversity areas towards the center of the IKN construction the higher the changes in significant vegetation health loss.

3 Data & Methodology

3.1 Data Source

This study utilizes satellite imagery data to perform remote-sensing analysis. The Hansen Global Forest Change v1.10 is used as a preliminary analysis of the difference in forest landscape from its baseline in 2000 to the most recent composite imagery data in 2022. Landsat 8 Collection 2 Tier 1 Level 2 is a collection of satellite imagery that will be used as the primary data source for this study. The image collection stores corrected surface reflectance satellite bands over a strip of 170 km x 183 km 'scenes.' The Landsat 8 satellite produces satellite imagery that has a spatial resolution of 30 meters. Due to high cloud coverage in the IKN regions, a cloud reducer is performed to maximize ground image coverage. Therefore, the timeframe assigned for the pre-construction period is from September 2019 to March 2022, and the post-construction period is from March 2022 to March 2024. The additional temporal variety in the pre-construction period is necessary to minimize any cloud coverage that would hinder the accuracy of the NDVI index, as discussed in section 3.3.

Using protected forest parks and areas of significant biodiversity of the proposed city location maps that were produced by Verisk, Maplecroft, a global risk intelligence company providing sustainability consulting through its geospatial data and analytics, these maps will be crucial in identifying the critical biodiversity hotspots that lie outside the official state protected ecological areas. In addition, official mapping of the IKN territories attached within the UU IKN No.3 bill proposal is also used to map out the border of where the construction is considered 'direct. The official layout of the IKN territories is separated into three areas: construction region, IKN region, and central governments region. The study will consider the IKN region as the 'direct' region of affected areas, and the construction region and its extensive surrounding areas would be considered 'indirect' regions. The original non-spatial maps used for this paper's analysis are in the appendix.

3.2 Georeference methods

These two maps that are gathered from official sources as well as from Verisk, Maplecroft, are georeferenced in QGIS using the GDAL extension to allocate spatial attributes that would be used as polygons when conducting remote sensing analysis as discussed later in section 3.3. Georeferencing methods would allocate several longitudinal and latitudinal points as crucial control points. QGIS will distort and warp the non-spatial maps to produce a map with spatial information. The different types of regions denoted in the two maps, such as the direct and indirect regions of IKN and the protected and key biodiversity areas of IKN, are extracted manually by following the grids and borders of the map's indicators. The resulting polygons are then exported to Google Earth Engine (API) for remote sensing applications.

3.3 Remote sensing methods

The normalized difference vegetation index (NDVI) is used to analyze the live green vegetation of the regions. This index would be the study's central estimate in evaluating vegetation health in the capital city and its surrounding region because green land-based plants highly absorb red bands of light while reflecting high levels of infrared bands of light. Landsat 8 band 5, the near-infrared band (NIR), and band 4, which capture the red band of the visible light spectrum, are to be used to create the NDVI index. The formula to create this index goes as follows:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

The NDVI index ranges from -1 to 1. Regions with high vegetation health will be denoted with more positive values, while regions with lower vegetation health will be denoted lower. For reference, regions with an NDVI index of 0.6 to 0.8 are commonly associated with dense forests, regions with an index lower than 0.2 are barren lands, and areas with an index between 0.2 and 0.3 are urbanized (Weier et al., 2000). The produced NDVI index for pre- and post-period is then compared to analyze the significant spatial vegetation loss and growth. To create the difference in NDVI for pre- and post-construction, we subtract the NDVI index from the post-construction period. A binary indicator is used to signal a significant vegetation health change between the two periods. A threshold of 0.1 in the NDVI index is used to indicate a significant difference. The relatively low threshold is employed to account for the fact that the construction of IKN has yet to be fully realized, and therefore, a higher threshold value would not be appropriate. The binary indicator for a significant loss and gain is then used to calculate the area of crucial biodiversity regions and both direct and indirect construction sites of IKN by masking the layer with the polygons that were created in section 3.2. The NDVI index and the binary significant vegetation loss and gain composite image are then exported to QGIS for the final visualization.

4 Results

Figure 1. shows NEVI indices for pre- and post- IKN construction. In the west south the designated IKN city as highlighted within the red-dashed square, we can see where the construction of the city progresses the most., There are also significant losses in the mid-to-upper boundaries of the region—this could be explained due to the massive amount of deforestation and groundwork excavations to build road networks (WRM, 2023). Although much of the significant losses in vegetation health could be linked to the construction of the city due it's apparent proximity—the assumption may not hold true when extended to key biodiversity regions situated further than the central of the IKN construction.

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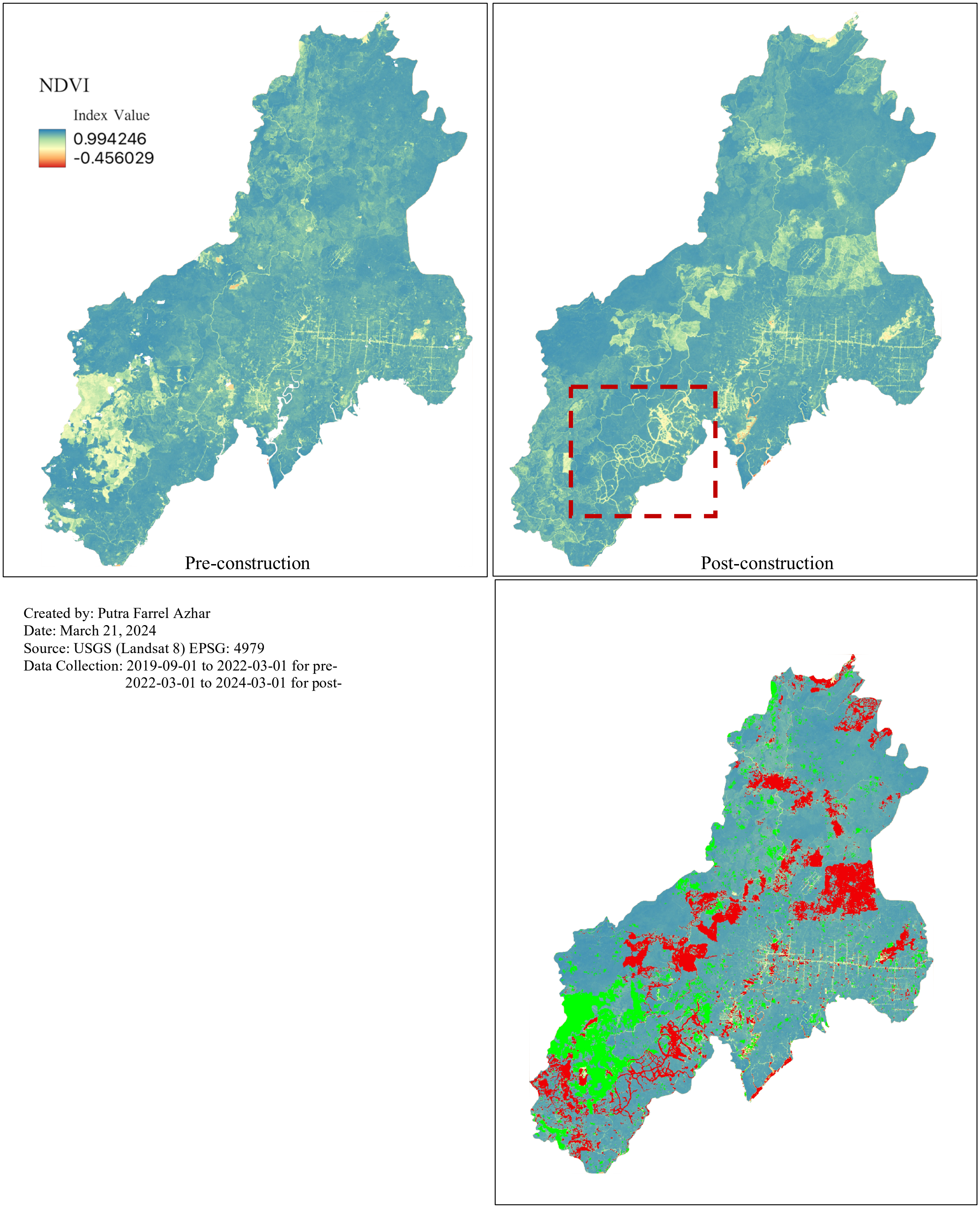
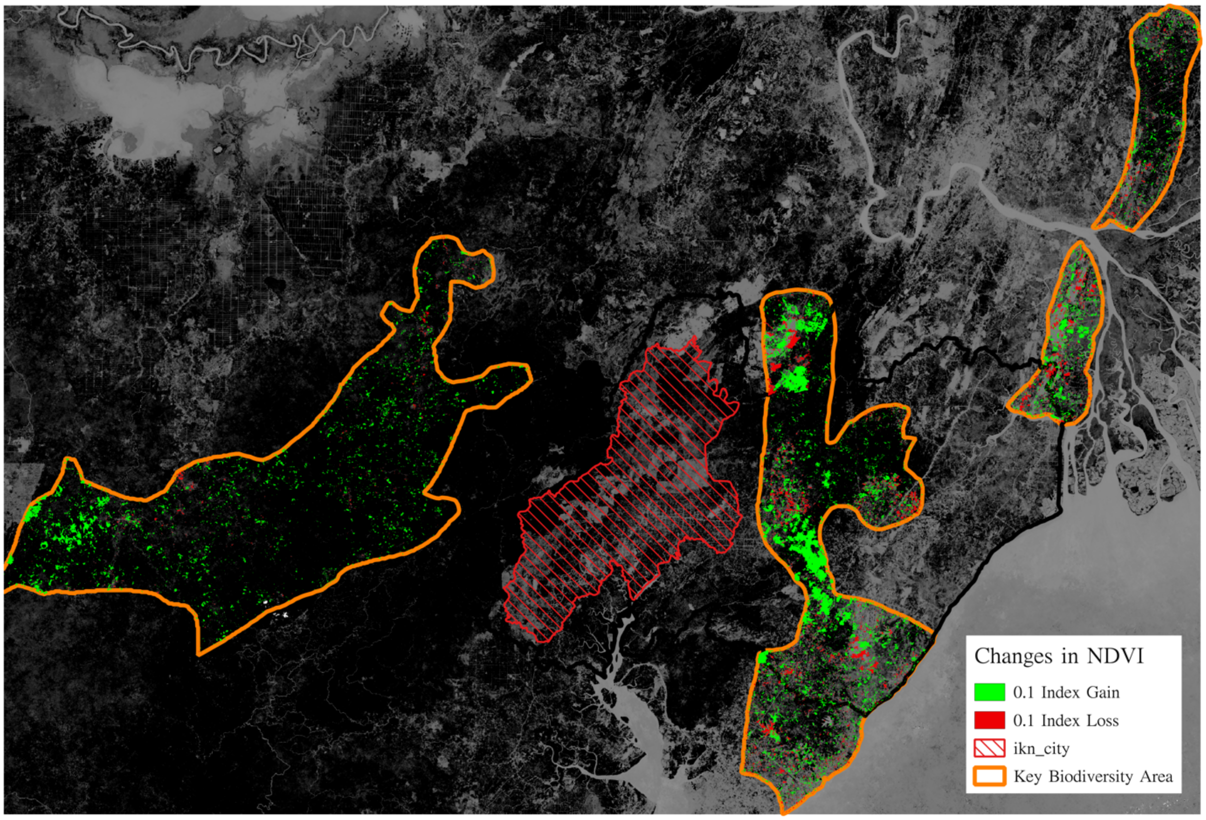
Figure 1. NDVI — IKN City



Created by: Putra Farrel Azhar
Date: March 21, 2024
Source: USGS (Landsat 8) EPSG: 4979
Data Collection: 2019-09-01 to 2022-03-01 for pre-
2022-03-01 to 2024-03-01 for post-

Figure 2. Significant NDVI Loss & gain in Key Biodiversity Area



Created by: Putra Farrel Azhar
Date: March 21, 2024
Source: USGS (Landsat 8) EPSG: 4979
Data Collection: 2019-09-01 to 2022-03-01 for pre-
2022-03-01 to 2024-03-01 for post-

In Figure 2. we can see that there is not much significant vegetation loss compared to the direct regions of IKN. Instead, when comparing the change in NDVI pre- and post- construction period, there has been an increase in significant vegetation health. When calculating the total changes in NDVI by the two regions, there are approximately 71,548,092 sq meter and 57,360,410 sq meter of significant vegetation loss for the direct IKN region and key biodiversity area, respectively. Moreover, there are approximately 195,191,206 sq meter of lands with a significant increase in NDVI across all the key biodiversity regions. Direct IKN region have a comparatively lower rate of 54,216,645 sq meter of lands with a significant increase in NDVI. Although the aggregate estimate for these growth and loss is as expected, when zooming in into the distribution of growth, the key biodiversity area that is closest to the direct IKN region appear to have an increase in vegetation health rather than a loss. When looked into the temporal changes in average NDVI, both regions exemplify similar level of indices with the exception of the March 2023 drought that is appears to be a singular shock that bounce back in the months ahead (WWF, 2023).

5 Conclusion

Using satellite imagery data, this paper highlights the remote sensing tools to approximate the impact of the new city towards key biodiversity regions. Although the causal chain that the closer key biodiversity regions are with direct IKN construction sites is a plausible inference, the result from this study suggest otherwise. This does not mean that the closer these regions are with the IKN construction the higher growth for vegetation health, the result simply indicates that the reduce vegetation health based on the proximity of the construction does not present a viable approach to signal any adverse impact—there are other omitted variables that is not included in this study and therefore this result should be taken with cautious. Nevertheless, this study provides the grounding framework for future researcher to conduct the effects of the construction of IKN towards the surrounding ecological areas.

Reference

World Wildlife Fund (WWF). (n.d.). Borneo and Sumatra. Retrieved from https://www.worldwildlife.org/places/borneo-and-sumatra

Rachman, A. (2022, October 30). Indonesia is Still Moving its Capital to Nusantara Despite Rising Public Opposition. Retrieved from https://globalvoices.org/2022/10/30/indonesia-is-still-moving-its-capital-to-nusantara-despite-rising-public-opposition/

Dungey, G. (2022, April 12). Study: Most Biodiversity Hotspots Lack Formal Protection in Borneo and Sumatra. Retrieved from https://news.mongabay.com/2022/04/study-most-biodiversity-hotspots-lack-formal-protection-in-borneo-and-sumatra/

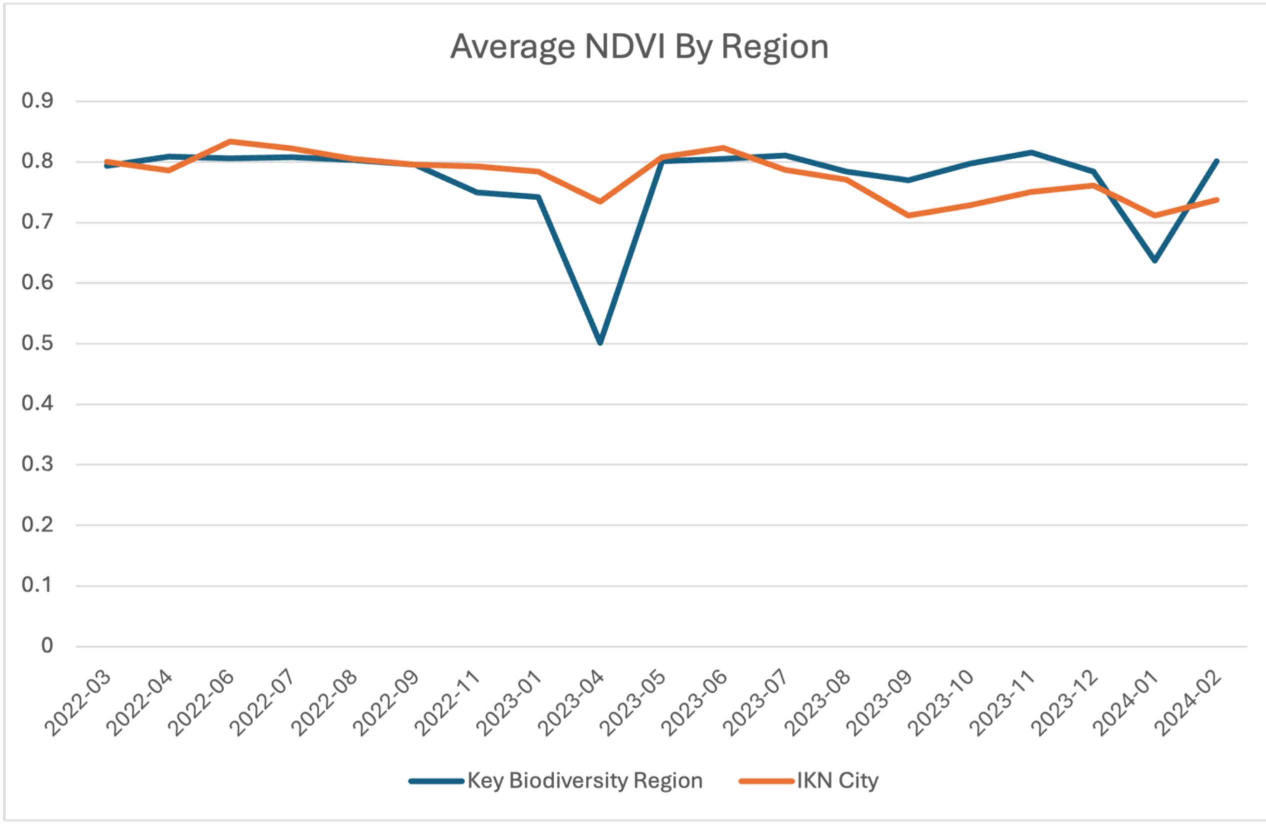
Weier, J & Herring, D. (2000, August 30). Measuring Vegetation (NDVI & EVI). Retrieved form https://earthobservatory.nasa.gov/features/MeasuringVegetation \

Teo, H.C., Lechner, A.M., Sagala, S., & Campos-Arceiz, A. (2020, November 09). Environmental Impacts of Planned Capitals and Lessons for Indonesia's New Capital. Retrieved from https://doi.org/10.3390/land9110438

World Rainforest Movement (WRM). (2023, January 16). New Capital Cities, Deforestation and Social Apartheid: Parallels Between Brazil and Indonesia. Retrieved from https://www.wrm.org.uy/bulletin-articles/new-capital-cities-deforestation-and-social-apartheid-parallels-between-brazil-and-indonesia

World Water Forum. (2023, February 15). BMKG: Parts of Indonesia Will Experience Low-intensity Rainfall, Beware of Drought Potential. Retrieved from https://worldwaterforum.org/blog/news-3/bmkg-parts-of-indonesia-will-experience-low-intensity-rainfall-beware-of-drought-potential-27#blog_content

Appendix I: Average NDVI by Region



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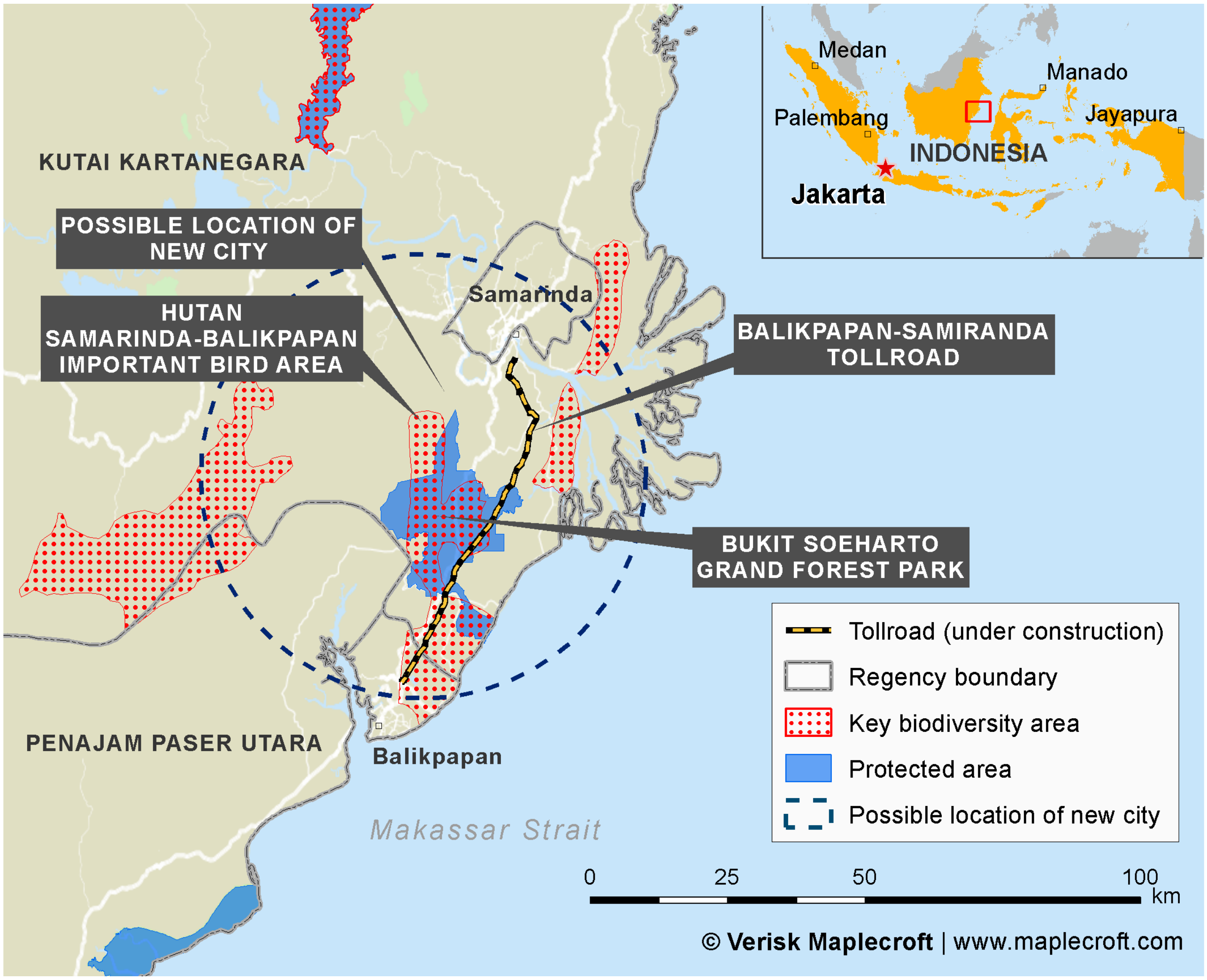
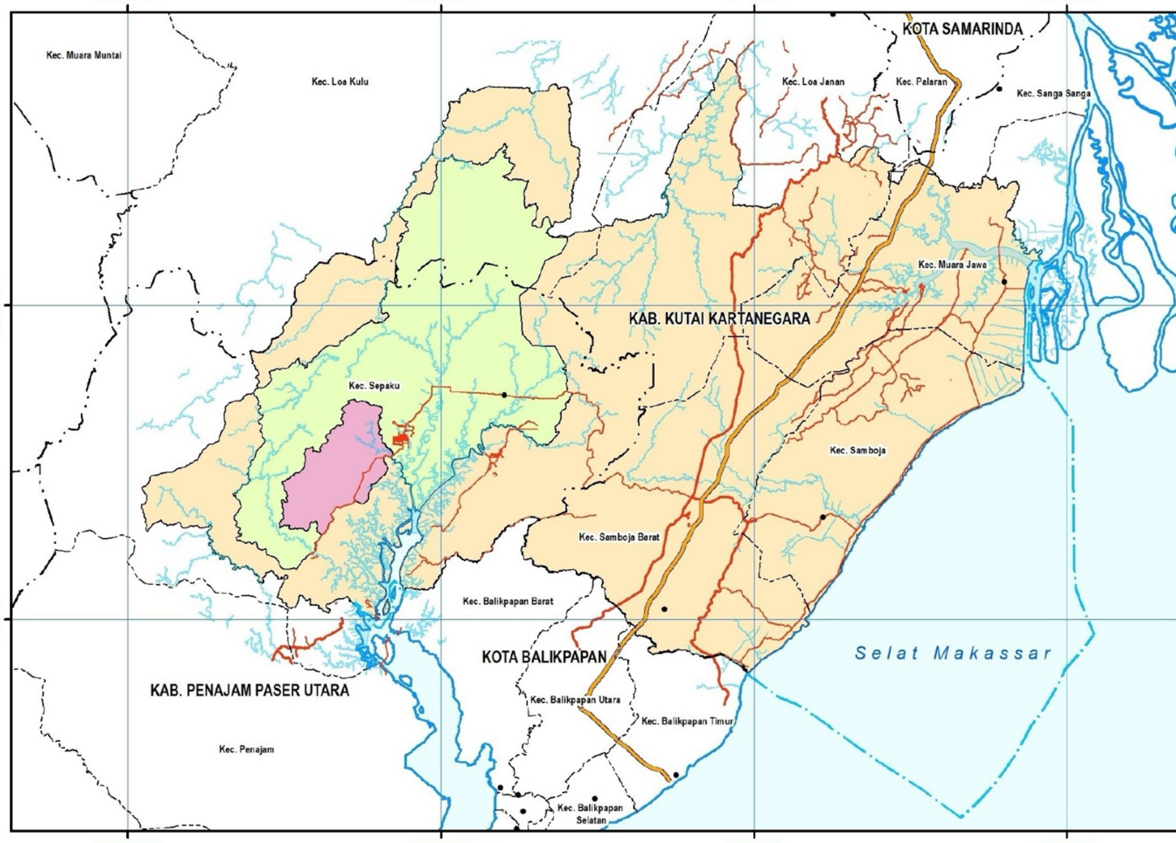
Data Collection: 2019-09-01 to 2022-03-01 for pre-
2022-03-01 to 2024-03-01 for post-

Appendix II: Key Biodiversity Regions Diagram



Appendix III: IKN Administrative Region Map

PETA DELINEASI KAWASAN STRATEGIS NASIONAL IBU KOTA NEGARA



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SKALA 1:600.000

0 5 10 20 30 km

Proyeksi : Mercator
Sistem Grid : Graticule (Geografis)
Datum Horizontal : WGS-84

DAFTAR NAMA PULAU DI IBU KOTA NUSANTARA

No.	Nama Pulau	Koordinat	
		Bujur	Lintang
1	Pulau Benawa Besar	116° 43' 36,00" BT	01° 05' 13,99" LS
2	Pulau Batupayau	116° 43' 05,12" BT	01° 05' 52,43" LS
3	Pulau Jawang	116° 44' 30,99" BT	01° 01' 21,00" LS
4	Pulau Sabut	116° 43' 36,99" BT	01° 02' 49,37" LS

DAFTAR KOORDINAT TITIK TERLUAR IBU KOTA NUSANTARA

No.	Batas	Koordinat	
		Bujur	Lintang
1	Utara	117° 00' 20,102" BT	00° 38' 20,578" LS
2	Timur	117° 18' 25,590" BT	01° 06' 32,773" LS
3	Barat	116° 31' 31,180" BT	01° 00' 14,822" LS
4	Selatan	117° 11' 51,546" BT	01° 15' 31,780" LS

KETERANGAN :

Ibu Kota Kecamatan

Batas Wilayah

- Batas Kabupaten
- Batas Kecamatan
- Batas Kewenangan Pengelolaan Sumber Daya Alam di Laut Ibu Kota Negara

Perairan

- Garis Pantai
- Sungai

Perhubungan

- Jalan Tol
- Jalan Arteri
- Jalan Kolektor
- Jalan Lokal

Kawasan Strategis Nasional Ibu Kota Negara

- Kawasan Pengembangan IKN (KP-IKN)
- Kawasan IKN
- Kawasan Inti Pusat Pemerintahan (KIPP)

SUMBER DATA :

1. Peta Rupabumi Indonesia skala 1:5.000 Kabupaten Penajam Paser Utara dan sekitarnya serta Peta Rupabumi Indonesia skala 1:5.000 Kabupaten Kutai Kartanegara dan sekitarnya tahun 2019 yang telah melalui proses generalisasi
2. Batas wilayah administrasi Kabupaten Penajam Paser Utara dengan Kabupaten Kutai Kartanegara berdasarkan Permendagri Nomor 121 Tahun 2019 dan Kabupaten Kutai Kartanegara dengan Kota Balikpapan berdasarkan Permendagri Nomor 30 Tahun 2017
3. Batas wilayah administrasi desa definitif Kabupaten Kutai Kartanegara dan batas wilayah administrasi desa indikatif BIG edisi tahun 2022

REFERENSI :

1. Undang-Undang Nomor 3 Tahun 2022 tentang Ibu Kota Negara
2. Peraturan Pemerintah Nomor 13 Tahun 2017 tentang Perubahan atas Peraturan Pemerintah Nomor 26 Tahun 2008 tentang Rencana Tata Ruang Wilayah Nasional
3. Batas Perairan Kalimantan Timur dalam Peraturan Daerah Provinsi Kalimantan Timur Nomor 1 Tahun 2016 tentang Rencana Tata Ruang Wilayah Provinsi Kalimantan Timur Tahun 2016-2036
4. Batas Tahura Bukit Soeharto dalam SK Menteri Kehutanan Nomor 1231/2017 tentang Kawasan Hutan Provinsi Kalimantan Timur dan Kalimantan Utara
5. Batas DAS di Wilayah Sungai Mahakam dalam Keputusan Presiden Nomor 12 Tahun 2012 tentang Penetapan Wilayah Sungai
6. Batas IUPHHK PT ITCHI Hutani Manunggal dalam SK. 184/Kpts-II/1996, Kementerian Lingkungan Hidup dan Kehutanan