

Connecting Nature-based Solutions (NbS) and Spatial Approach for More Effective Multi-disaster Mitigation in Palangka Raya

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1. Multi-hazards Profile in Palangka Raya

a. Palangka Raya as the capital city of Central Kalimantan and connecting hub for the new IKN

Palangka Raya City is the capital of Central Kalimantan Province, with an area of 2,853.12 km². The total population is 266,020 people, and the average population density is 93.24 people/km² (Palangka Raya City Central Bureau of Statistics/BPS, 2020). After regional autonomy in 2001, Palangka Raya City has five sub-districts, namely: Pahandut, Sabangau, Jekan Raya, Bukit Batu, and Rakumpit sub-districts.

As one of the cities on the island of Kalimantan, Palangka Raya is one of the hubs for the prospective Nusantara Capital City/Ibu Kota Nusantara (IKN), which has a location in East Kalimantan. Palangka Raya is also the economic center for the region in southern Kalimantan. However, the city is often affected by disasters dominated by hydrometeorological disasters that cause various physical, economic, and social losses.

b. Drought and Fire Hazards during Dry Season

Palangka Raya City suffers from drought and fire hazards, especially during the dry season. Based on the Environmental Support and Capacity Study of Palangka Raya City in 2021 (Environment Department Of Palangka Raya City, 2021), Palangka Raya City in the years perioding from 2001–2020 was drier than in 1961–1980.

In addition, the incidence of forest fires is also one of the conditions that have a major impact on air quality in Palangka Raya City.

The Air Quality Index shows the air quality condition based on carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), surface ozone (O₃), and particulate matter (PM₁₀). Figure 2 shows the number of days divided into good, moderate, unhealthy, very unhealthy, and hazardous air quality in Palangka Raya City in 2017–2020. These numbers show the same conditions as the fire events. Palangka Raya became one of the cities with the highest risk in 2019 (Cahyono et al., 2021), which is also indicated by the long duration of hazardous air quality in Palangka Raya City. From the figure 1 below, it can be surmised that 2019 had the highest number of fires with 1,161 fires recorded. These fires contributed to poor regional air quality as well as public health. The forest and land fires in Palangkaraya caused thick haze, significantly reducing visibility and air quality. The incident was part of a season of forest and land fires that swept across Indo-

Number of Hotspot in Palangkaraya

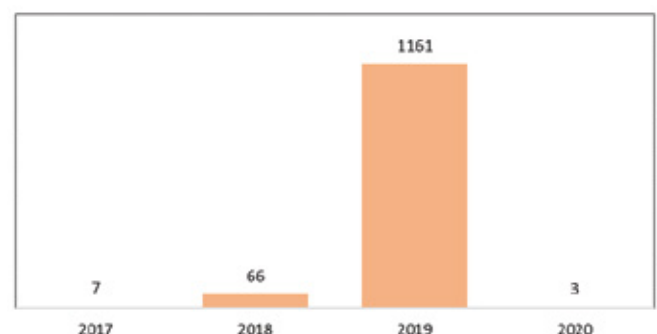


Figure 1 Palangka Raya Hotspots 2017–2020 (MODIS MCD14ML)

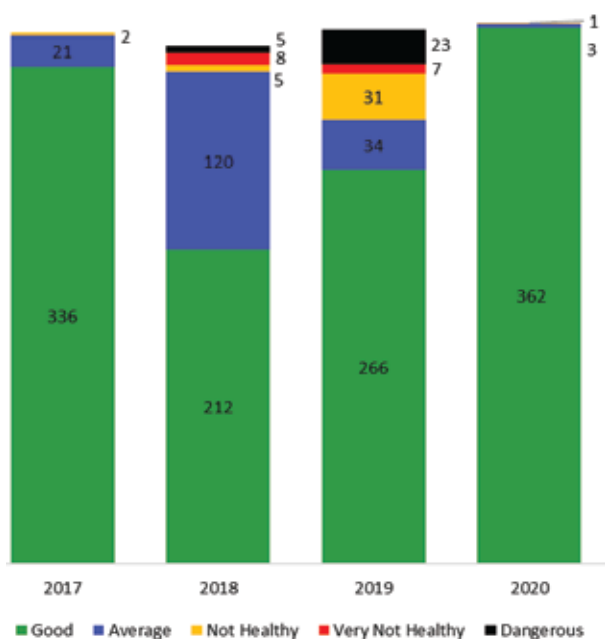


Figure 2 Graph of Air Quality Index (Indeks Kualitas Udara/IKU) in Palangka Raya 2017-2020 (DLH Palangka Raya, 2021)

Forest and land fires in Palangka Raya City occur every year. As of July 2023, there were at least 63 fire incidents in Palangka Raya City (Palangka Raya City Government, 2023). The data also shows that 30.38 hectares of land were burned in various sub-districts. This data shows that Palangka Raya City has a serious



Figure 3 Incidence and extent of forest and land fires in Palangka Raya city

c. Flooding in Rainy Season

In addition to forest and land fires, Palangka Raya also has a high risk of flooding. Flooding is generally triggered by moderate to high-intensity rainfall conditions and Palangka Raya’s location.

Table 1 shows Palangka Raya’s high flood potential in every sub-district except Rakumpit. The flood hazard in Palangka Raya City generally comes from inundation and overflow flooding (DLH Kota Palangka Raya, 2021). Overflow flooding is generally at greater risk in settlements located near the Kahayan and Rungan Rivers, which morphologically constitute the floodplain. A major flood in April 2023 occurred in 13 urban villages in four sub-districts, affecting 421 people (Triwibowo, 2023).

Table 1 Flood Hazard Potential in Palangka Raya (KRB Palangka Raya, 2023)

No	District	Flood Hazard	
		Area (Ha)	Class
1	Bukit Batu	40.314	High
2	Jekan Raya	28,753	High
3	Pahandut	8,973	High
4	Rakumpit	85,199	Moderate
5	Sebangau	44.073	High
Palangka Raya		207,312	High

Palangka Raya is characterized by an abundance of peaty organic plains exhibiting diminished soil productivity, primarily due to the prevalence of organosol soils characterized by an exceptionally low pH level. The region’s water sources, encompassing both surface water and groundwater reservoirs, while visually appealing, exhibit suboptimal quality rendering them inadequate for potable purposes. The topography is dominated by wide river valleys and undulating plains with rocks that are less able to absorb and drain water, resulting in a high flood hazard.

d. More Effects during ENSO as a Proxy of Climate Change

El Niño Southern Oscillation (ENSO), as a climate anomaly, could pose further risks in various multi-disaster, especially in tropical countries. Figure 3 shows the distribution of fire density hotspots per 1 km² area in Kalimantan. Hotspots are distributed mostly in the central area of Kalimantan, where Palangka Raya is located. The ENSO effect usually occurs mainly in August, September, and October during the dry season (Santika et al., 2020; Zahra et al., 2023). This temporal distribution can support more specific disaster management strategies within the period.

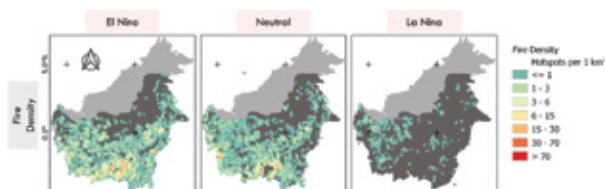


Figure 4 Map of Hotspots during El Niño, La Niña, and Neutral

Besides intensifying fire occurrences, ENSO can affect flood hazards. La Niña makes higher rainfall during the rainy season, hence, more water input to the watershed and river. Floods in November 2021 and 2022 happened during the La Niña period, according to Oceanic Niño Index (NOAA, 2023). This climate anomaly becomes a real threat to Palangka Raya during the dry and rainy seasons, but the risk can be mitigated.

2. Existing Regional Disaster Mitigation Strategy in Palangka Raya

a. Palangka Raya Regional Governmental Actions

As elaborated in the previous section, high level of multidisaster risk in Palangka Raya City does not go unnoticed and the city government has taken several policy measures in disaster risk reduction. Palangka Raya City Government has made several efforts to support disaster risk management in Palangka Raya City.

In the field of environment, the government, through the Department of Environment, prepared an Environmental Support and Capacity Study/Daya Dukung dan Daya Tampung Lingkungan Hidup (DDDTLH) Technical Guideline, which contains a strategic study of the resources and the various capabilities of these resources in supporting the needs in Palangka Raya. In 2023, the government, through the Regional Disaster Management Agency/Badan Penanggulangan Bencana Daerah (BPBD) of Palangka Raya City, prepared a Disaster Risk Assessment/Kajian Risiko Bencana (KRB) document, which contains studies and outputs in the form of recommendations in accordance with the National Disaster Management Plan 2020-2024.

The recommendations in the Palangka Raya KRB have outlined a detailed plan of strategies and actions to be taken by the city government. Apart from the institutional aspect, BPBD recommends that future Regional Spatial Plan/Rencana Tata Ruang Wilayah (RTRW) regulations consider disaster threat information and disaster risk reduction (DRR) principles. The regulation is expected to be used as a reference in the implementation of land use and building construction regulations that consider DRR principles in Palangka Raya City. This regulation is closely related to the specific strategies written in the KRB points, some of which are:

1. Risk Assessment and Integrated Planning (Map review and update, disaster risk assessment);
2. Thematic Handling of Disaster Prone Areas (Review of RTRW, strengthening communities with the Disaster Resilient Village (Des-tana) indicators);
3. Increased Effectiveness of Disaster Prevention and Mitigation (Implementation of bio-pore infiltration wells, protection of water catchment areas, river restoration, slope strengthening, peatland management, optimization and implementation of surface water management, revitalization of reservoirs/tanks, ponds, and city parks).

These recommendations generally require studies and applications that are closely related to the concepts of spatial and Nature-based Solutions (NbS).

3. Nature-based Solutions Implementation in Palangka Raya City

a. Basic concepts and examples of NbS

Nature-based solutions (NbS) are actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and actively, simultaneously providing human well-being and biodiversity benefits (Emmanuelle Cohen-Shacham et al., 2016). NbS use nature itself to tackle the challenges. The NbS approach simultaneously coincides with hydrometeorological risk in a specific community. On the other hand, climate change adaptation aims to help people by reducing their exposure to hazardous events such as storms and droughts or both, preparing them for such events. For example, carbon dioxide emissions can be reduced by protecting or restoring forests. Forest restoration can help reduce the risk of droughts. It supports the infiltration process as input for aquifers to provide water resources and, as a result, prevent drought in communities.

b. Previous Work and Research in Palangka Raya related to NbS

The government has made efforts through various plans related to Nature-based Solutions. Recently, the Government of Palangka Raya, through the Department of Environment of Palangka Raya City, conducted a Focus Group Discussion (FGD) on Strategic and Internal Issues of the Peat Ecosystem Protection and Management Plan/Rencana Perlindungan Ekosistem Gambut (RPPEG) of Palangka Raya City in 2023 (Government of Palangka Raya City, 2023). In addition, there are also studies on the concept of green economy in the development of nature tourism and traditional arts (Anden., 2022) and open-space cities to mitigate flooding (Permana and Ludang, 2019).

The Peat and Mangrove Restoration Agency (BRGM) has also made efforts in peat restoration. Since 2018, the Central Kalimantan Environment Agency has built 2,500 units of boreholes and 1,250 units of canal blocking. Meanwhile, through the assignment mechanism to the National Park, 100 canal blocks, 1,500 boreholes and 15 canal fill points were built for the rewetting program (Palangka Raya City, 2021). By 2023, BRGM also plans to restore 69,745 hectares for Central Kalimantan (BRGM, 2023).

4. Challenges in Prioritizing and Implementing NbS as a DRR Effort

a. Challenge: Why is Palangka Raya still prone to hydrometeorological disasters?

Some actions have been taken as nature-based solutions in Palangka Raya, from big projects such as peatland restoration to small-scale capacity building. Nevertheless, there has been little reflection on the effectiveness of focusing on restoration (Dohong et al., 2018). Some actions have been small-scale trials, and the restoration techniques have included canal blocking, seedling transplantation, and promotion of seed dispersal.

Thus, some researchers suggested appropriate land use policy by reforming the technical effectiveness of specific restoration methods (Dohong et al., 2018). The various efforts that have been given to the environment have partly resulted in the return of the peat ecosystem. However, hydrometeorological disasters such as floods and fires still occur in Palangka Raya to this day. Regulations from the government are still concentrated on the larger area, while the implementation in smaller areas (in a village or district) is still met with challenges as the areas often fail to meet the disaster management standards effectively.

The progress of a nature-based solution also needs to be seen through further analysis of the connection between particular areas.

Location analysis is vital to find specific nature-based solutions projects, especially on the interconnection between each location, from physical to socio-economic features. This analysis is beneficial for the monitoring and evaluation process, so the efforts for nature can significantly impact disaster reduction.

b. Spatial approach related to NbS to hydrometeorological disasters?

The spatial approach could answer some barriers in nature-based solutions application for disaster mitigation, especially when we need to analyze its causes and impacts. The spatial approach can provide maps as communication tools for disaster mitigation and regulation and the media for investment in different areas.

There are several tools for enhancing the mitigation of disaster-related problems to NbS. One example is Graphab which provides methods to map links between urban green spaces. Linkages in protected areas and forest reserves within Palangka Raya could be modeled with specific species groups. Integrated valuation of ecosystem services and tradeoffs (InVEST) provides models to map and value ecosystem services. It is highly beneficial in disaster management as it provides economic valuation in different regions. InVEST tools commonly use hydrological or process-based models.

Several studies also use participatory mapping to get qualitative analysis within a spatial area. Maps of residents' landscape values, development preferences, and perceived environmental concerns can be obtained by participatory mapping. One method is the public participation GIS (PPGIS) which has successfully mapped economic and environmental values; one example was conducted at Tioman Island, Malaysia (Lechner et al., 2020). Combining spatial planning with scenario analysis has also been implemented in decision-making.

Some outputs are maps of risk, areas of development priority, locations for nature-based solutions, and hard infrastructure regional planning. It has several methods; one of them is Spatial Multi-Criteria Evaluation (SMCE).

c. Benefits of using the spatial approach in mitigation

- i. Make different priorities for each location. Having the ability to discern and strategically allocate distinct priorities for each sub-region is essential, driven not solely by potential risks but also by comprehensive valuation considerations. This ability entails a nuanced understanding of the unique attributes and challenges of each area, allowing for a holistic approach to decision-making that balances both the potential hazards and the inherent value that each location holds.
- ii. Mitigation can be effectively implemented Using the spatial approach to conduct disaster mitigation strategy has been implemented before; however, implementation based on NbS analysis is still limited. By including the NbS in spatial analysis, the government can precisely know the priorities locations from the physical and socio-economic conditions and ecological valuation. As a result, disaster mitigation can be effectively implemented with the principle of 'back to nature'. Accordingly, this method relates to Palangka Raya's environmental features as its strategic location for implementing nature-based solutions. In addition, it also supports the goals of governmental planning, as stated in KRB Palangka Raya.

d. Benefits of using the spatial approach in future region capacity

More research and studies on spatial analysis and nature-based solutions also act as opportunities for Palangka Raya. Through studies, maps as general outputs can be produced to gain investment in nature protection. These investments can benefit Palangka Raya in implementing nature-based solutions.

It will open further studies related to biomass and carbon sequestration, which could help Palangka Raya to be involved in the carbon market. Protecting nature also contributes to community resilience for water resources. Thus, supportive actions from the government, local stakeholders, industries, and communities are essential to implement nature-based solutions for resilience, and it can start with more analysis and studies on spatial characteristics in Palangka Raya.

Disclaimer

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