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Analysis of Clouding and Extinguishing Forest and Land Fires in Lumut Maju Village, Lumut Sub-district, Central Tapanuli Regency

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ABSTRACT
Forest and land fires are a recurring environmental threat in many parts of Indonesia. This study aims to analyze the level of fire vulnerability and the effectiveness of fire suppression efforts in Lumut Maju Village, Lumut Sub-district, Central Tapanuli Regency, North Sumatra Province. The analysis was conducted using a Geographic Information System (GIS)-based spatial approach with ArcGIS Software. The results indicate that most areas in Lumut Maju Village exhibit moderate to high levels of fire vulnerability, influenced by topographic conditions, land cover, human activities, and climatic factors. The implementation of fire suppression highlighted the importance of team preparedness, adequate equipment, and rapid response in controlling fires, despite challenges such as difficult terrain and limited water sources. GIS-based fire vulnerability mapping proved effective in supporting mitigation strategies and informed decision-making. Active community participation and strong coordination among stakeholders are essential to enhance sustainable forest and land fire prevention and control efforts.

Keyword: Forest Fire, Spatial Analysis, GIS, Lumut Maju Village, Fire Mitigation

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1. Introduction

Lumut Maju is one of the villages in Lumut Sub-district, Central Tapanuli Regency, North Sumatra Province. The village is located on the west coast of Sumatra Island, directly adjacent to the Indian Ocean. Geographically, this area has landscape characteristics in the form of lowlands, hills, and quite extensive forest areas, and has the potential for natural resources such as agricultural products, fisheries, and forestry. In addition, its strategic location on the western Sumatra causeway makes Lumut Maju one of the areas with high potential for local economic development and tourism. However, the village also faces various challenges, such as limited infrastructure, the potential for natural disasters such as floods and landslides, and issues of environmental damage due to human activities such as land clearing and unsustainable resource exploitation.

Forest and land fires are one of the most common environmental problems and are considered so important that they have become a local and global concern. Every year the problem of forest fires tends to increase. This is due to the increase in illegal logging activities, land conservation for settlements, farming, large-scale plantations, the development of plantations that are more prone to fire, as well as climatic conditions that

support forest and land fires such as low rainfall periods. Forest fires in Indonesia can be identified through hotspot information. Hotspot data provides an indication of the number and extent of burned forest areas. The

Hotspot data can be combined with climate data so that the relationship can be analyzed. Climatic factors such as air temperature, rainfall, radiation, and wind speed can be drivers of forest and land fire occurrence of forest and land fires because they can affect the level of dryness of the region [1].

Forest fires are often unplanned and can be triggered by natural and human activities, leading to the destruction of vegetated areas and ecosystems. This destruction can have long-term effects on biodiversity and climate change. Early detection of hotspots is critical as it can significantly reduce the risk of larger forest and land fires. This study emphasizes the importance of monitoring these hotspots to prevent widespread destruction. Forest fires have significant impacts on various environmental, economic and social aspects. Environmentally, fires result in ecosystem damage, loss of biodiversity, and increased greenhouse gas emissions that exacerbate climate change. Integrated mitigation efforts need to be carried out through strengthening monitoring systems, public education, and law enforcement [2].

The phenomenon of fires that occur in forests and land is one of the unplanned disasters in natural areas. Three main problems for the environment such as global warming, climate change, water pollution and ocean acidification and loss of biodiversity. In addition, the problem of forest and land fires also causes human health problems, decreased economic activity, and political stability. It is also important to create a map of forest and land fire disaster prone areas to map areas with fire threats according to their level of vulnerability. All parties involved must consider the risk of fire when making plans to extinguish forest and land fires [3].

Forest fires can cause a decrease or even loss of biodiversity, such as loss of vegetation structure, destruction of animal habitats, death of soil microorganisms, damage to water management functions that cause runoff and erosion, decreased carbon sequestration and the emergence of floods and droughts. In general, forest fires occur due to the presence of heat, fuel, and oxygen/air as the fire triangle. Light to heavy fuels such as trees, bollards and branches in dry conditions can burn, although they are slow in burning but produce high heat. Meanwhile, light materials such as grass, teak leaf debris, and bamboo burn very easily [4].

The objectives of the community service activity entitled "Fire Vulnerability Analysis and Extinguishing in Lumut Village" are as follows and Extinguishing in Lumut Maju Village, Lumut Subdistrict, Central Tapanuli Regency" is to determine the level of fire vulnerability in Lumut Maju Village, Lumut Subdistrict, Central Tapanuli Regency through spatial analysis using Geographic Information Systems (GIS). The benefits of this community service activity are to determine the level of fire vulnerability in Lumut Maju Village, Lumut Sub-district, Central Tapanuli Regency through spatial analysis using Geographic Information Systems (GIS) which supports efforts to mitigate forest and land fires and sustainable environmental management planning.

2. Methods

This community service activity entitled "Analysis of Fire Vulnerability and Extinguishing in Lumut Maju Village, Lumut Sub-district, Central Tapanuli Regency" was carried out on Wednesday to Tuesday, July 02 to July 08, 2025 in Lumut Maju Village, Lumut Sub-district, Central Tapanuli Regency, North Sumatra, Indonesia. The tools used are cellphones, laptops, Google Earth Engine, ArcGIS 10.8 and stationery, hand tools, monilog cars, slip on units, machines and equipment. The materials used were the fire vulnerability map of Lumut Sub-district and SHP Indonesia.

There are some activity procedures, namely:

1. Departure to the fire location
   The activity implementation team departed for Lumut Maju Village, Lumut Sub-district, Central Tapanuli District, as the location according to the predetermined schedule. This departure was carried out by taking into account the readiness of personnel, equipment, and logistics needed during the activity.
2. Briefing the team
   Upon arrival at the location, a briefing session was conducted by the field coordinator to all team members. This briefing included an explanation of the objectives of the activity, field conditions, potential fire risks, and work safety procedures that must be followed during the activity.

3. Division of tasks according to teams
   After the briefing, the division of tasks was carried out to all team members according to the predetermined teams. This division aims to ensure the effective implementation of activities in the field, with each team having specific roles, including supervision, suppression, documentation and logistics.
4. Extinguishing the fire
   Core activities in the form of firefighting are carried out in accordance with applicable procedures, using available firefighting equipment. The team worked in a coordinated manner to control and extinguish the fire, taking into account aspects of personnel safety, environmental sustainability, and documentation of activity results for evaluation purposes.

3. Result and Discussion

The results obtained from the activity "Fire Vulnerability Analysis and Extinguishing in Lumut Maju Village, Lumut village, Central Tapanuli district" can be seen in Figure 1 and Figure 2.

Figure 1. Fire Extinguishing in Lumut Maju Village

Figure 2. Site conditions before and after fire extinguishing

Based on the results of spatial analysis conducted through Geographic Information System (GIS)-based mapping, the map layout of fire vulnerability and incidence in Lumut Maju Village, Lumut Subdistrict, Central Tapanuli District can be seen in Figure 3. Approximately 5,000 hectares of burned area. With this map layout, mitigation efforts, countermeasures, and fire prevention strategy planning can be carried out in a more targeted and accurate data-based manner.

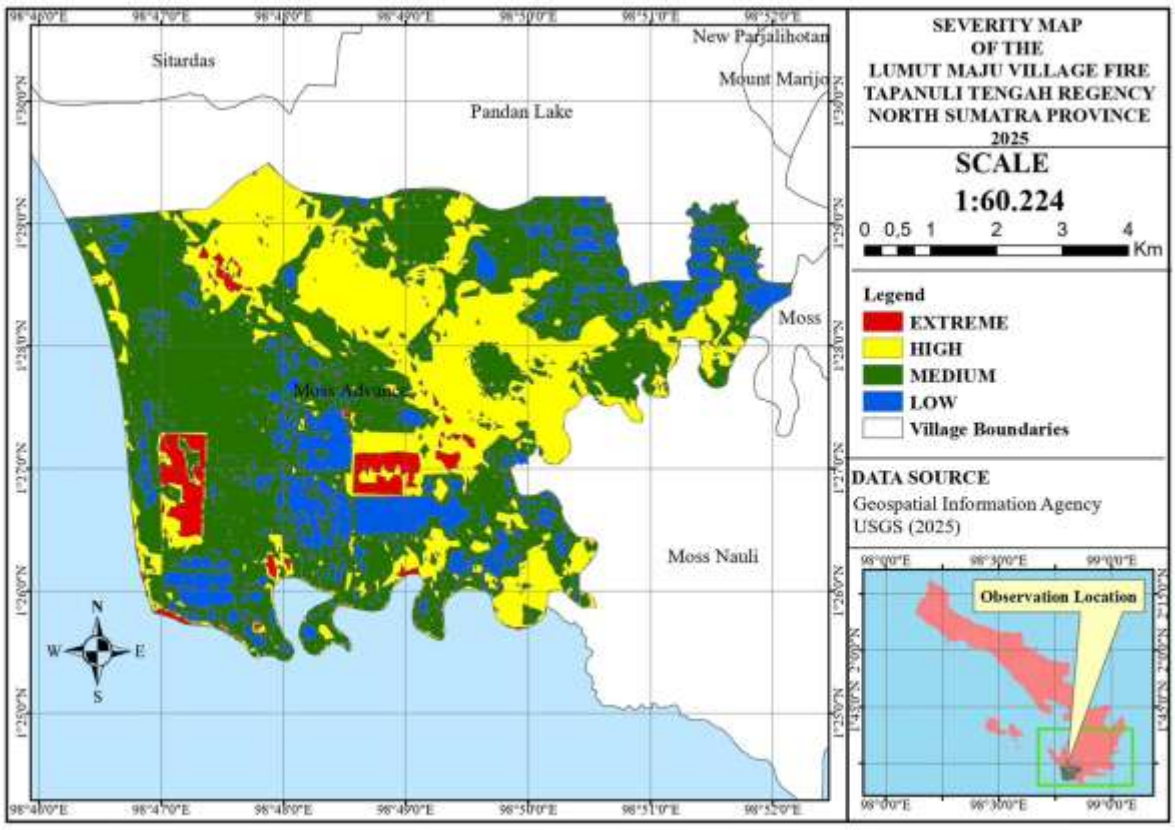

Figure 3. Fire Severity Map of Lumut Maju Village

Based on the results of fieldwork in Lumut Maju Village, Lumut Sub-district, Central Tapanuli Regency, it is known that this area has varying levels of forest and land fire vulnerability. This was obtained through spatial analysis by utilizing vulnerability map data and data processing using Geographic Information System (GIS) software, namely ArcGIS 10.8 and Google Earth Engine. The fire severity map shows that parts of Lumut Maju Village fall into the medium to high category, which means that special attention is needed in fire prevention and management efforts. This level of vulnerability is influenced by topographic conditions, land cover, and the intensity of human activities in the surrounding area. Therefore, regular monitoring and mitigation strategies tailored to local characteristics are required. Community involvement is also key in reducing fire risk through educative and participatory approaches.

Factors causing fire vulnerability in this area are strongly influenced by climatic conditions, vegetation types, and human activities such as land clearing and shifting agriculture systems. Other factors that influence forest fire vulnerability include the presence of combustible fuels, extreme weather conditions, and human activities such as illegal land burning. A long dry season accompanied by low humidity and wind increases the risk of fire spread. In addition, the presence of natural fuels such as leaf litter, dry grass and young flammable vegetation increases the likelihood of fire. This is consistent with [5] statement that land cover such as shrubs and shifting cultivation are highly susceptible to fire, especially during prolonged dry seasons.

Forest and land fires have a significant impact on biodiversity loss in the affected areas. Rapidly spreading fires not only destroy ecosystem-supporting vegetation, but also cause faunal mortality. It can be seen in Figure 4 that species such as snakes and centipedes, which play an important role in maintaining ecosystem balance through controlling pest populations and recycling organic matter, become highly vulnerable to fire (Figure 4). These fires cause significant environmental damage, including pollution and biodiversity loss, as well as economic losses for communities dependent on forest resources. Loss of microhabitats due to the destruction of leaf litter, topsoil and understory vegetation leaves many species without shelter or food sources. The loss of these species leads to the disruption of the food chain.

food and long-term degradation of ecosystem function. In the long term, the recovery of these animal populations will take a long time, and some species may be permanently lost from fire-affected areas.

Figure 4. Burned Centipede and Snake

The implementation of fire suppression during the activity also showed that the preparedness of the team and equipment played an important role in controlling the fire. Fire suppression is carried out using tools such as water pumping machines and light extinguishing equipment. Obstacles in the field such as difficult access, hot weather, and limited water sources are challenges in the implementation of this activity. The extinguishing activities carried out on site show the importance of rapid response and adequate equipment. As explained by

[6] the effectiveness of firefighting is highly dependent on team readiness, training, and access to disaster management infrastructure. In addition, coordination between team members and effective communication are important factors in ensuring activities run smoothly. The use of technology such as monitoring drones or surface temperature sensors can also improve accuracy in determining the location of hotspots.

In addition, the utilization of hotspot data and early warning systems is crucial in reducing the impact of fires. With this mapping and spatial analysis, it is hoped that relevant parties such as local governments, local communities, and conservation organizations can work together to develop appropriate mitigation strategies. Educating the public about the dangers and prevention of fires is also key to reducing future fire incidents. [7] stated that satellite-based monitoring systems can help map critical locations and provide accurate information for quick decision-making on the ground. The data can be combined with climate information such as temperature, humidity and rainfall to predict fire potential more accurately. Continuous implementation of this system can improve preparedness at the local level. In addition, policy and funding support from the government is needed to strengthen fire monitoring infrastructure.

The importance of hotspot monitoring and early detection systems is also highlighted in this discussion. Hotspot data provides important initial information for determining vulnerable locations and designing effective control strategies. As stated by Saharjo and Hasanah (2023), the combination of hotspot data with climate data can identify areas that are highly at risk of fire. With this monitoring system, preventive action can be taken more quickly before the fire spreads and is difficult to control. The data generated also helps in allocating suppression resources more efficiently. In areas such as Lumut Maju Village that have diverse terrain, an early detection system can be an effective solution to reduce delays in response on the ground. In addition, the integration of technologies such as temperature sensors, thermal cameras, and drone monitoring can complement this system.

Media campaigns serve as public communication tools that simplify technical information into messages that are easily understood by the general public (Figure 5). Forest fire mitigation efforts need to combine spatial approaches and risk communication to drive participatory prevention. Participatory campaigns, such as early firefighting technical training and fire suppression simulations, can foster a sense of collective responsibility in protecting the environment. In addition, the involvement of community leaders, youth and farmer groups in the socialization program will strengthen the message and ensure sustainable understanding. This strategy not

only reduces the practice of land clearing by burning, but also build a culture of fire prevention based on community awareness and self-reliance.

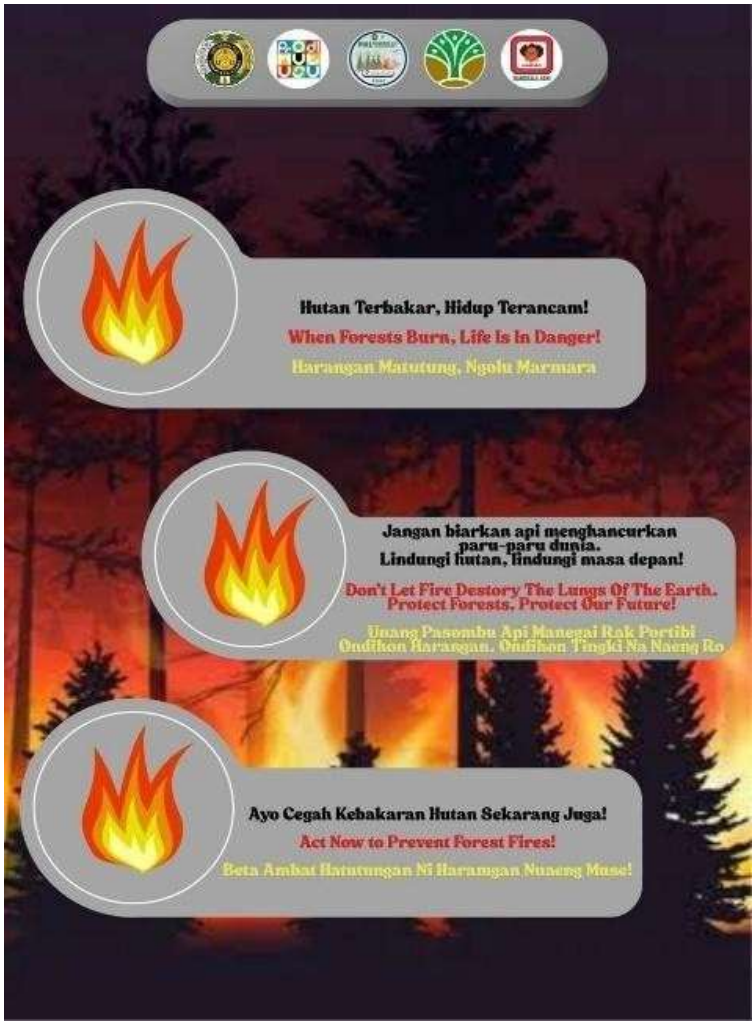

Figure 5. Fire Prevention Poster

The results of the publication of forest and land fire prevention activities on online media can be seen in Table 1. It is presented to provide information that is easily accessible to the wider community. This publication includes documentation of fire suppression activities in Lumut Maju Village, Lumut Sub-district, Central Tapanuli District. The presentation of information through online media aims to increase public awareness of the importance of fire prevention while encouraging the active participation of various parties in preserving the environment. This publication is expected to be an educational tool as well as an inspiration for the community in adopting environmentally friendly behavior and supporting collective fire suppression efforts.

Table 1. Fire Prevention Publications on Social Media Platforms

No	Publication	Link/Publication
1	YouTube	https://youtube.com/shorts/k0hB5xLJCw0?si=2hDWK1Gm-yPtsrch

4. Conclusion

Lumut Maju Village in Lumut Sub-district, Central Tapanuli Regency has a varying level of forest and land fire vulnerability, from moderate to high, as analyzed through Geographic Information Systems (GIS). The main factors that cause fire vulnerability in this area include climatic conditions, land cover type, human activities such as land clearing, and fire risk. land cover types, human activities such as land clearing, and the presence of natural combustible fuels. The fire suppression conducted demonstrated the importance of team preparedness, equipment and rapid response in tackling fires, despite challenges such as difficult access and

limited water sources. The hotspot monitoring system and climate data are helpful in early detection of potential fires and mapping fire-prone areas to support more effective mitigation strategies. Active community participation and coordination between parties are key aspects in efforts to prevent and control forest and land fires sustainably in this region.

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