Model of collaborative for forest and land fire prevention and management in Ogan Komering Ilir regency South Sumatra Province Indonesia

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Abstract

Forest and land fires are recurring environmental problems in Indonesia, especially in areas with peatland ecosystems such as Ogan Komering Ilir (OKI) Regency, South Sumatra. Although prevention efforts have been made, limited resources in terms of personnel, equipment, and early monitoring systems remain obstacles in managing forest and land fires. Therefore, a collaborative model involving various stakeholders such as local governments, communities, plantation companies, academics, and environmental organizations is necessary to improve the effectiveness of fire prevention and response. This study employs a qualitative method, focusing on an in-depth understanding of forest and land fire prevention strategies through collaboration among five sectors within the Penta Helix model, using the Ansel & Gash approach as an analytical framework. The findings indicate that forest and land fires constitute a serious environmental issue requiring cooperation among government, industry, communities, academics, and the media. The primary challenges in fire mitigation include weak law enforcement, lack of trust among actors, and unsustainable land clearing practices. The main strategy is based on regulatory and bureaucratic approaches, with the government acting as policy coordinator, industry as the technical implementer, academics as research providers, the media as shapers of public opinion, and the community as the primary actor at the local level. The success of mitigation efforts depends on cross-sector coordination, raising awareness, implementing monitoring technologies, and adopting community-based approaches to ensure the sustainability of forest and land fire prevention.

Keywords: Collaboration models, Forest and land fires, Prevention and Management of Forest and Land Fires.

1. Introduction

Forest and land fires in Indonesia are a phenomenon that occurs periodically and has a very large environmental impact [1]. Forest and land fires occur almost every year in South Sumatra Province, including in Ogan Komering Ilir (OKI) Regency [2]. Forest and land fires are predominantly caused by humans in Indonesia, both negligence and deliberate actions by humans [3]. In addition, communities and plantation companies carry out burning when clearing land because it is considered a cheap and effective method [4]. Forest and land fires impact health problems due to haze, disrupt economic activities, and cause ongoing environmental damage [5, 6].

Prevention efforts have been made, but there are still obstacles such as limited personnel, equipment, and suboptimal early monitoring systems. Therefore, a collaborative model is needed that involves various stakeholders, such as the government, communities, plantation companies, academics, and the media [7]. This model involves mapping areas prone to forest and land fires using satellite-based technology and sensors for early detection [8, 9]. Increasing community capacity in land management without burning through education and training programs [10, 11] and cooperation with plantation companies in implementing sustainable land management standards [12, 13]. In addition, the roles of task forces and volunteers in early detection and rapid extinguishing need to be optimized in order to reduce the impact of fires more effectively [14].

Strengthening policies and law enforcement against illegal land burning practices is also an important aspect in this collaborative model [15]. With a participatory approach, technology, and sustainable policies, it is hoped that efforts to prevent and control forest and land fires in Ogan Komering Ilir Regency can be more effective and have a positive impact on the environment and community welfare. Therefore, it is necessary to develop a model for handling forest and land fires that can serve as a guideline in public policy-making.

2. Literature Review
Global and National Trends in Forest and Land Fire Prevention and Mitigation

Globally, the trend in forest and land fire mitigation has shifted from a focus on extinguishing fires to integrated proactive prevention [16]. This paradigm emphasizes the importance of multi-party collaboration involving the government, private sector, academics, and the international community [17]. The use of technologies such as remote sensing and geographic information systems has become the global standard for early detection and comprehensive fire risk analysis [18]. At the national level, Indonesia has adopted a similar strategy with a strong emphasis on prevention through integrated patrols and peat ecosystem restoration. The central and regional governments are now orchestrating the involvement of Manggala Agni, TNI, Polri, and fire-conscious communities in one integrated command. Strengthening law enforcement against perpetrators of burning and improving land governance are priorities in the current national policies. Recent studies have highlighted innovations in community-based approaches, such as strengthening the Independent Fire-Caring Village program, which has proven effective in suppressing fire incidents at the site level. Additionally, the implementation of weather modification technology to rewet peatlands before the extreme dry season is being intensified. This approach demonstrates the synergy between modern science and active community participation in forest and land fire disaster mitigation.

Latest Technological Innovations for Forest and Land Fire Monitoring and Early Detection

The use of high-resolution satellite technology, such as Sentinel and Landsat, is now the backbone of monitoring. As you can understand, this data is processed with artificial intelligence to analyze hotspots precisely, distinguish fires from other heat anomalies, and predict the direction of spread. This innovation allows teams in the field to receive much more accurate and faster early warnings. The use of drones or unmanned aircraft equipped with thermal cameras has revolutionized aerial patrols in remote areas. This technology is able to detect hotspots under forest canopies or in peatlands before the fire grows large and becomes visible to the naked eye. In addition, the installation of wireless sensors in peatlands provides real-time soil moisture and temperature data to the command post.

All data from satellites, drones, and ground sensors are now integrated into a single digital dashboard platform. Systems such as Sipongi Karhutla and locally developed mobile applications enable stakeholders to access integrated information quickly [8]. This facilitates coordinated decision-making and more efficient and effective deployment of

extinguishing resources in the field. The active role of the community and local wisdom in mitigating forest and land fires is significant. The involvement of the Fire Aware Community (MPA) is at the forefront of mitigating forest and land fires at the local level. As observed, this group is formed from local villagers with in-depth knowledge of their area. They play a vital role in conducting routine patrols, raising awareness about fire dangers, and serving as an initial response team before assistance from formal institutions arrives at the location.

Local wisdom in land management [19] has proven effective in significantly reducing the risk of fires. Practices such as creating natural firebreaks, a no-burn crop rotation system, and land use by planting fire-resistant commodities are real examples. This tradition, if you notice, is starting to be revived and integrated into modern mitigation programs to maintain ecological balance and prevent disasters. The synergy between local community knowledge and scientific data is key to the success of the collaborative model. The community provides field information that is not captured by satellites, such as social conditions and location accessibility. This collaboration, you need to know, allows validation of technological data and ensures that the prevention strategies designed are not only technically effective but can also be accepted and implemented by the community.

Development and Implementation of an Adaptive Multi-Party Collaboration Model

A recent study in Ogan Komering Ilir showed the development of an adaptive collaboration model as the key to success. This model, as you can understand, forms a regular communication forum involving local government, plantation companies, environmental NGOs, and community representatives. Its flexibility allows prevention and response strategies to be dynamically adjusted based on current conditions in the field. The implementation of this model is realized through integrated patrols that combine personnel and equipment from various parties. You need to know, resources such as company-owned fire towers and local community knowledge are integrated into daily planning. The existence of a joint post and periodic evaluation mechanisms ensures that responses to hotspots can be carried out quickly, coordinated, and on target.

3. Material and Methods

This study uses a qualitative method because it focuses on an in-depth understanding of land and forest fire prevention strategies through collaboration between five sectors in the Penta Helix model [16] with the Ansell and Gash [17] as an analytical framework. The type of research used is a case study because this study specifically examines the implementation of Penta Helix in the context of Ogan Komering Ilir Regency (OKI). This study employs a phenomenological approach and a descriptive-exploratory approach. The phenomenological approach is used to determine the direct experiences and perspectives of informants regarding land fires. The descriptive-exploratory approach is used to assess the synergy between actors in Penta Helix applied in OKI.

Data collection techniques include in-depth interviews with key informants from five Penta Helix sectors, namely government, academia, industry, society, and the media. Additionally, Focus Group Discussions (FGDs) were conducted to explore perspectives and joint solutions among actors. Field observations were also carried out to directly observe efforts to prevent and respond to land fires in OKI, supported by documentation and literature studies of regulations, regional policies, and reports related to land fires.

Table 1.
List of Questions.

Aspect	Research Questions
Starting Conditions	▪ What is the history of cooperation among actors in fire prevention?
	▪ Are there differences in resources, interests, or incentives among actors?
	▪ What was the initial level of trust before collaboration began?
Institutional Design	▪ Do regulations support the involvement of all actors in the Penta Helix model?
	▪ What are the rules of engagement in this collaboration?
	▪ Is the decision-making process transparent?
Collaborative Process	Trust-Building
	▪ What obstacles arise in building trust among actors?
	▪ What factors influence the increase or decrease of trust?
	Face-to-Face Dialogue
	▪ How frequently do actors meet and communicate?
	▪ Is face-to-face dialogue effective in resolving conflicts and fostering mutual understanding?
	▪ How is the quality of negotiation within the collaboration forum?
	Shared Understanding
	▪ Do all actors share the same vision and mission?
	▪ How do they define land fire problems and their solutions?
	▪ Are there differences in perspectives that hinder collaboration?
	Commitment to Process
	▪ How committed are actors to implementing fire prevention programs?
	▪ Do all actors feel a shared responsibility?

	▪ To what extent are they open to exploring joint solutions?
	Intermediate Outcomes
	▪ Are there small successes ("small wins") that reinforce trust?
	▪ Have any collective strategies been developed?
	▪ How is data collected and utilized to support collaboration?
Facilitative Leadership	▪ Who plays the leadership role in this collaboration?
	▪ How does the leader ensure effective coordination?
	▪ Is the leader capable of empowering all actors to collaborate?
Outcomes	▪ Has this collaboration led to a reduction in land and forest fires?
	▪ How sustainable is this collaboration in the long term?
	▪ Are there lessons that can be applied to other regions?

3.1. Research Location

This research was conducted in Ogan Komering Ilir (OKI) Regency, South Sumatra Province. Ogan Komering Ilir (OKI) Regency has become a highly vulnerable area for forest and land fire cases in South Sumatra Province. Forest and land fires (karhutla) in South Sumatra are a recurring problem, with the worst incidents occurring in Ogan Komering Ilir (OKI) Regency. South Sumatra has experienced forest and land fires (karhutla) since 1967, with recurring incidents in 1997-1998, 2006, 2015, and 2019. In 2023, 32,000 hectares of land were recorded as burned, with Ogan Komering Ilir (OKI) Regency being the most severely affected location, having 3,969 hotspot points (63.7% of the total in South Sumatra).

3.2. Key Informants

Key informants in forest and land fire management include various stakeholders. The government sector comprises the Environment and Forestry Service, the Regional Disaster Management Agency, the Agriculture and Plantation Service, the Police, and the Indonesian Army. The academic sector includes environmental and forestry experts from universities. The industrial sector consists of palm oil plantation companies and Industrial Plantation Forests. The community comprises traditional leaders, farmers, forest farmer groups, and NGOs. The media includes local and national mass media journalists.

4. Results and Discussion

Forest and land fires in Ogan Komering Ilir, South Sumatra Province, are often caused by the clearing of new land for agriculture or plantations, which is done by burning. Natural factors such as El Niño also play a role in exacerbating the occurrence of fires. Forest and land fires in Ogan Komering Ilir, South Sumatra, are a complex issue and require comprehensive handling. Prevention, risk mitigation, and fire management must be carried out collaboratively by various parties to reduce the negative impact of forest and land fires.

Table 2.
Interview Results with The Roles of Industry, Government, Society, Academics, and the Media.

Aspect	Industry	Government	Community	Academia	Media
Starting Conditions	Strict regulations drive collaboration, resources are available, and initial trust is low.	Regulations exist, enforcement is weak, funded by national/local budgets, and initial trust is fairly high.	Relies on land, traditional tools, and initial trust is low.	Research-based data, limited implementation, and trust is fairly high.	Information disseminator, limited data access, low trust.
Institutional Design	Regulations mandate involvement, operational standards exist, but transparency is lacking.	National & local regulations, slow bureaucracy, and transparency need improvement.	Lacks understanding of burning regulations, minimal transparency.	Contributes to research, but is underrepresented in decision-making.	Freedom of information law supports access, but limitations remain.
Trust-Building	Accusations of causing fires are an obstacle; trust improves with mitigation efforts.	Weak law enforcement, trust increases with consistent regulations.	Negative stereotypes, trust rises if solutions align with the local economy.	Often seen as theoretical, trust improves when research is practical.	Resistance to negative reporting, trust increases with objective news.
Face-to-Face Dialogue	Regularly in industry-government forums, negotiations on mitigation costs.	Coordination forums exist, but decisions are slow.	Dialogues occur but with a subordinate role.	Engaged in academic discussions, less involved in policymaking.	More frequent discussions during major fire incidents, fewer in policy forums.
Shared Understanding	Same vision (fire prevention), different prevention methods.	Same vision, but implementation varies.	Small fires are seen as traditional management, conflicting with regulations.	Research-based definitions but difficult to implement in practice.	Focus on transparency, but data access remains limited.
Commitment to Process	Committed to reducing fires, depends on regulatory incentives & public pressure.	Commitment exists, but often administrative.	Committed to solutions that do not disrupt the local economy.	Commitment through research & education.	Committed through reporting & policy advocacy.
Intermediate Outcomes	Hotspot monitoring technology is being implemented.	Coordination among actors has improved.	Greater awareness of fire impacts.	Increase in solution-based research.	Investigative reporting drives transparency.
Facilitative Leadership	The government is the primary leader, and industry plays a technical role.	The government serves as the main coordinator.	Community leaders play a role in local implementation.	Academia builds data-driven understanding.	Media shapes public opinion & accountability.
Outcomes (Collaboration Results)	Fires in industrial areas have decreased, but community land management remains a challenge.	Illegal fires persist, and policies need improvement.	Awareness has increased, but implementation is difficult.	Scientific studies have increased, supporting evidence-based policies.	Transparency in reporting & mitigation has improved.

The table below illustrates the roles and challenges faced by various stakeholders in mitigating forest and land fires (karhutla). Each aspect in the table reflects the initial conditions, institutional design, efforts to build trust, and the level of commitment of each actor in the mitigation process. Additionally, this table highlights the intermediate outcomes achieved and the role of leadership in facilitating cross-sector collaboration. Understanding the dynamics of the roles of industry, government, society, academics, and the media is essential for developing more effective and sustainable fire mitigation strategies. Forest and land fire prevention involves various main actors, namely industry, government, community, academics, and media. Each actor has a strategic role and faces challenges that must be addressed for fire mitigation to be effective. Industry possesses the technology and resources for fire prevention but is often suspected of being the main cause of fires due to unsustainable land management practices. The government acts as a regulator and policy facilitator but often encounters bureaucratic obstacles and weak law enforcement in controlling illegal burning activities.

5. Discussion

Forest and land fires in South Sumatra have become an annual recurring disaster. This event should be predictable and mitigable by the central and regional governments, especially by key stakeholders, namely land-use permit holders. The position paper of the Indonesian Forum for the Environment (Walhi) South Sumatra states that the facts show that land-based permit holders such as HTI, plantations, and mining operations are the main causes of forest and land fires in South Sumatra.

The position paper document explains that 8.3 million hectares of South Sumatra are controlled by HTI companies, covering 1.4 million hectares; palm oil plantation companies, covering 1.2 million hectares; and more than 700 thousand hectares controlled by mining enterprises.

5.1. Model of Collaborative for Forest and Land Fire Prevention and Mitigation

The collaborative model for forest and land fire prevention and mitigation describes the roles and interactions of various stakeholders, including government, industry, community, academics, and media. This collaboration aims to create an effective and sustainable mitigation strategy through regulation, technology, research, and information dissemination. With good coordination, this model can increase the effectiveness of forest and land fire prevention and mitigation systematically.
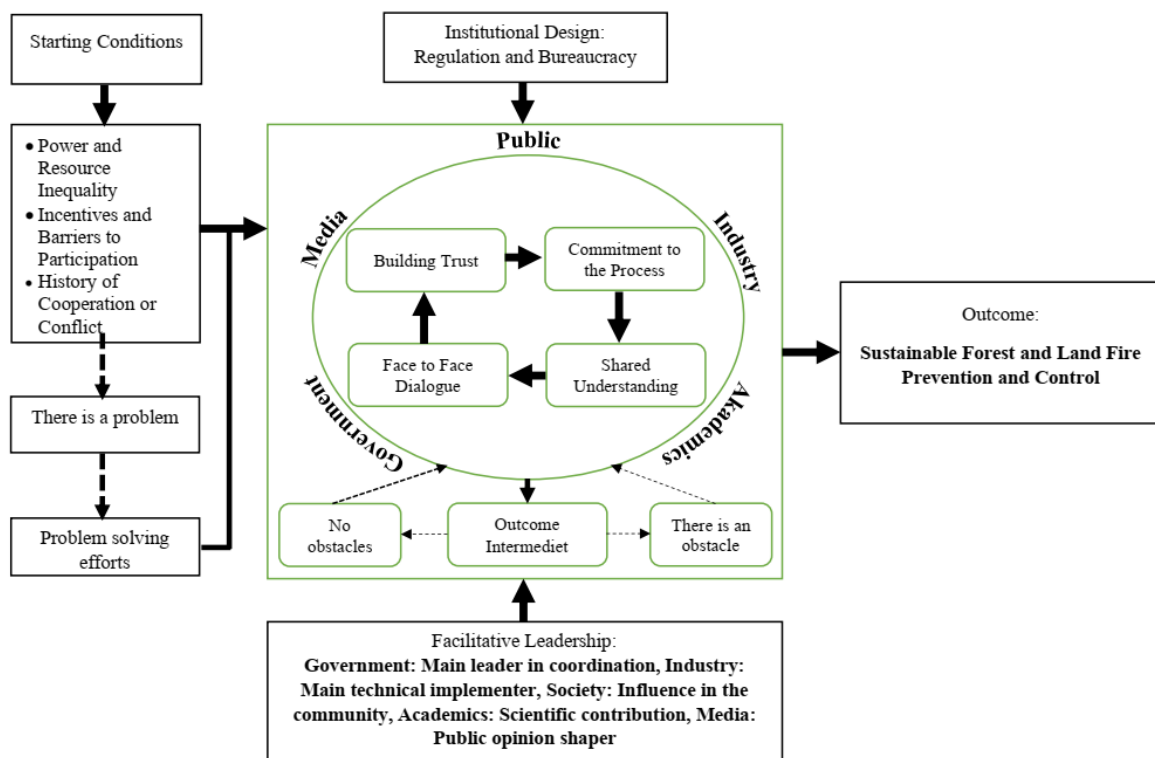

Figure 1.
Sustainable Forest and Land Fire Prevention and Mitigation Model.

This figure illustrates the process of resolving forest and land fire problems sustainably through a regulation-based and bureaucratic approach. Initial problems arise due to imbalances in power and resources, incentives, and obstacles in participation, as well as a history of cooperation or conflict that has occurred. This requires a resolution effort that involves various parties in society, including government, industry, academics, and the media. In the process, the media plays a role in building trust through face-to-face dialogue, while the industry demonstrates commitment to the resolution process. Academics contribute by providing a scientifically based understanding, while the community influences the process within the community.

If this process runs smoothly, it will produce intermediate outcomes that support the achievement of the main objective, namely, sustainable forest and land fire prevention and mitigation. However, if there are obstacles, an evaluation and adjustment of the strategy are needed. In this approach, the government plays the role of the main leader in coordination, industry as the main technical implementer, academics as providers of scientific contributions, the media as shapers of public opinion, and the community as an influential party in the community. Through this cross-sector collaboration, it is hoped that the resulting solutions can be effective and sustainable.

The majority of the community works as traditional farmers, involving land burning, often in conflict with environmental regulations [18]. Academics play a role in providing data-based research to support science-based policies, but they are less involved in the decision-making process and implementation in the field [19, 20]. Meanwhile, the media functions as a public watchdog and disseminator of information on fires and mitigation policies, but often faces limited access to information and challenges in maintaining the credibility of news reporting [21].

One of the main challenges in this collaboration is the lack of trust among actors. Industry is often accused of causing fires, the government is criticized for weak law enforcement, and the community is frequently considered the primary perpetrator of land burning. Academics are often viewed as too theoretical without applicable solutions, while the media faces resistance from those who are negatively portrayed [22, 23].

Coordination efforts have been made through multi-stakeholder dialogue, but decision-making is often hampered by bureaucracy. Industry and government tend to focus on regulation and operational efficiency, while communities view small fires as part of traditional practices. Academics are trying to offer data-based solutions, and the media plays a role in increasing transparency of policies and implementation in the field [24].

However, challenges in managing community land and illegal fires remain major obstacles. Therefore, more effective, transparent policies and closer coordination between actors are needed to ensure the sustainability of fire mitigation efforts. Community-based approaches that actively involve communities in fire prevention have proven to be more effective and need to be strengthened in long-term mitigation strategies [25, 26].

Forest and land fires are a serious environmental problem, especially in tropical areas such as Indonesia. The causes include human activities, such as land clearing by burning, as well as natural factors such as prolonged droughts due to El Niño [27]. The impacts include ecosystem damage, high carbon emissions, and public health problems due to smoke [28].

The success of this approach depends on cross-sector collaboration and trust among stakeholders. Face-to-face dialogue is essential for building shared commitment and reducing potential conflicts. If implemented effectively, this mechanism can produce long-term solutions for better land management, especially in peat areas that are prone to fires [29].

In addition to strict regulations, forest and land fire mitigation also requires ecosystem conservation strategies and the implementation of monitoring and early detection technologies. Support from various parties, including international institutions, is essential to ensure the effectiveness and sustainability of these efforts [30, 31].

6. Policy Recommendations and Further Research Directions

Based on the findings, local governments are recommended to institutionalize multi-stakeholder collaboration forums into local regulations. You need to understand that this legal basis will ensure the sustainability of the program through a definite budget allocation and clear division of roles. The policy must also strengthen incentives for high-achieving villages and sanctions for parties who neglect their prevention obligations. Furthermore, there needs to be a policy to formally integrate local wisdom into landscape-based spatial planning. You need to know that community knowledge about hydrological conditions and local vegetation types is crucial data. Regulations that accommodate this will ensure that mitigation strategies are not only technically effective but can also be accepted and implemented sustainably by local communities. For further research, you can focus on the long-term effectiveness of CSR programs in changing community and corporate behavior. In addition, research on the development of fire prediction models that integrate dynamic climate data with local socio-economic factors is also very much needed. This research will provide a stronger scientific basis for future adaptation strategies.

7. Conclusion

Forest and land fires are a serious environmental problem that requires collaboration among various actors, including government, industry, community, academics, and media. The main challenges in fire mitigation are weak law enforcement, lack of trust between actors, and unsustainable land clearing practices. A regulatory and bureaucratic approach is the main strategy, with the government as policy coordinator, industry as technical implementer, academics as research providers, media as public opinion shapers, and the community as a key actor at the community level. The success of mitigation depends on cross-sector coordination, awareness raising, application of monitoring technology, and a community-based approach to ensure the sustainability of karhutla prevention.

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