

ADAPTIVE NETWORK GOVERNANCE FOR FOREST AND LAND FIRE PREVENTION: IMPLEMENTING ZERO-BURNING LAND CLEARING POLICY AT THE LOCAL LEVEL

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Abstract

Forest and land fires remain a persistent environmental governance challenge in Indonesia, particularly in peatland regions such as South Sumatera where ecological vulnerability intersects with plantation expansion and smallholder land-use practices. Despite the adoption of a zero-burning land clearing policy, recurrent fires indicate a gap between national policy design and local-level implementation. This study examines how adaptive network governance shapes the effectiveness of zero-burning policy implementation under conditions of institutional fragmentation and ecological uncertainty. Using a qualitative case study approach, the research draws on semi-structured interviews, document analysis, and field observations involving government agencies, Forest Management Units (KPH), village authorities, plantation companies, community fire brigades, NGOs, and security forces. A combined adaptive and network governance framework is applied to analyze actor interactions, coordination patterns, and institutional learning mechanisms. The findings show that policy effectiveness depends less on regulatory enforcement alone and more on governance network adaptability. Institutional learning, flexible coordination, and trust-based interactions enhance preventive capacity, while fragmented mandates and socio-economic dependence on fire-based practices undermine implementation. The study positions adaptive network governance as a critical framework for strengthening fire prevention in peatland socio-ecological systems.

Keywords: Adaptive network governance; Forest and land fires; Zero-burning policy; Peatland governance; Environmental policy implementation.

1. Introduction

Forest and land fires have become a persistent and deeply embedded challenge within Indonesia’s environmental governance framework, especially in South Sumatera Province, one of the most fire-prone regions in the country (Haryanto, 2017; Suryani, 2019). This region is characterized by expansive peatland ecosystems, widespread plantation developments, and smallholder agricultural activities, which together create a high vulnerability to recurrent fire events (Gomez et al., 2018). The impacts of these fires extend far beyond ecological damage, contributing to transboundary haze pollution, public health crises, biodiversity loss, and severe economic disruptions both locally and nationally (Ahrens et al., 2020; Miettinen et al., 2017). In response to the ongoing crisis, the Indonesian government has implemented a zero-burning policy, prohibiting the use of fire for land preparation across all sectors (BPS, 2020). While this policy represents a critical shift towards proactive fire governance, its local-level implementation remains uneven and contested (Haryanto, 2017). Local governments in South Sumatera face compounded challenges such as fragmented institutional responsibilities, limited enforcement capacity, overlapping land tenure disputes, and a socio-economic dependence on fire-based land clearing practices among smallholders and local communities (Abdullah et al., 2019). These challenges reveal that formal regulations alone are insufficient to guarantee effective policy compliance and sustainable fire prevention (Suryani, 2019). Recent fire governance experiences in South Sumatera highlight the critical role of multi-actor interactions in shaping policy outcomes. Provincial and district governments, forest management units (KPH), village authorities, plantation companies, community fire brigades (MPA), non-governmental organizations, and security forces operate within a complex governance network (Agus et al., 2021). In this network, authority, resources, and knowledge are distributed across various actors rather than being centralized, meaning that the success of zero-burning policies depends not only on regulatory enforcement but also on the capacity of governance systems to adapt, coordinate, and learn across institutional boundaries (Tschakert & Dietrich, 2019).

Table 1: Stakeholders in Forest and Land Fire Governance in South Sumatera

Stakeholder	Role/Responsibility	Resources/Capabilities
Provincial Government	Policy oversight, coordination	Administrative control, limited enforcement capacity
District Authorities	Local implementation and enforcement	Local knowledge, access to communities, limited capacity
Forest Management Units (KPH)	Land management, forest restoration	Technical expertise, resources for monitoring
Community Fire Brigades (MPA)	Fire suppression, community engagement	Volunteer manpower, local presence
Plantation Companies	Fire prevention in plantations	Financial resources, technical expertise
NGOs	Advocacy, community mobilization, policy influence	Knowledge, grassroots networks, resource mobilization
Security Forces	Law enforcement, ensuring policy compliance	Authority, capacity to enforce laws

Emerging scholarship has increasingly pointed to the importance of adaptive and network governance in addressing complex environmental challenges such as forest and land fires (Folke et al., 2010; Huitema et al., 2019). Adaptive governance promotes institutional flexibility, responsiveness, and learning under uncertainty, while network governance focuses on the horizontal coordination among interdependent actors (Pahl-Wostl, 2009). However, empirical studies integrating these approaches in the context of local-level fire prevention, particularly in peatland-dominated regions like South Sumatera, remain scarce (Suryani, 2019).

Most existing research on forest and land fires in Indonesia has primarily focused on technical fire suppression, hotspot detection, or enforcement mechanisms (Ahrens et al., 2020; Miettinen et al., 2017), with relatively limited attention paid to how governance networks operate and evolve during policy implementation (Suryani, 2019). This gap has hindered a comprehensive understanding of how adaptive network governance can strengthen the execution of zero-burning land clearing policies in fire-prone areas.

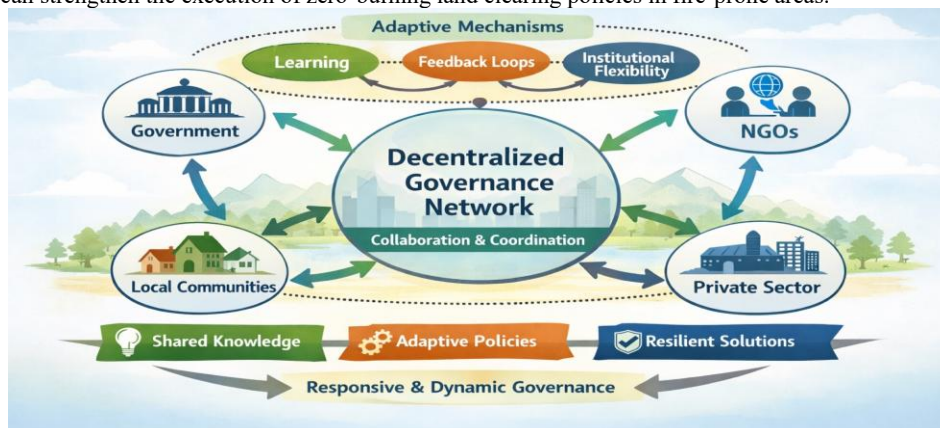


Figure 1: Conceptual Framework for Adaptive Network Governance

This study aims to address these gaps by exploring the role of adaptive network governance in implementing zero-burning land clearing policies in South Sumatera. By examining governance network structures, adaptive mechanisms, and implementation processes at the local level, this study contributes to both theoretical advancements in environmental governance and practical policy insights for fire prevention in peatland ecosystems.

The study is guided by the following research questions:

1. How are governance networks structured in the local implementation of zero-burning land clearing policies in South Sumatera?
2. What adaptive governance mechanisms enable successful policy implementation amidst institutional complexity and environmental uncertainty?
3. How do governance network interactions shape forest and land fire prevention outcomes at the local level?

2. Literature Review

2.1 Forest and Land Fire Governance in Peatland Regions.

Forest and land fires in peatland regions present unique governance challenges due to the ecological characteristics of peatlands and the persistence of fire events. Peatlands, with their high organic content, are particularly vulnerable to fires that can smolder for extended periods, making fire suppression efforts challenging (Miettinen et al., 2017). In Indonesia, peatland fires are often linked to land drainage, plantation expansion, and smallholder agriculture, which collectively drive the recurrent cycles of fire (Haryanto, 2017; Agus et al., 2021). Traditional governance approaches that focus solely on fire suppression and law enforcement have proven inadequate, as they do not address the structural drivers of fire occurrence, such as land use practices and economic dependence on fire for land clearing (Suryani, 2019). Scholars increasingly argue for governance models that prioritize prevention, cross-sectoral coordination, and community engagement, particularly in fire-prone provinces like South Sumatera (Folke et al., 2010; Huitema et al., 2019).

2.2 Zero-Burning Land Clearing Policy in Indonesia

The zero-burning land clearing policy is a cornerstone of Indonesia's national fire prevention strategy. This policy seeks to eliminate the practice of using fire for land preparation by promoting alternative techniques, such as mechanical land clearing and mulching (BPS, 2020). The policy also aims to strengthen regulatory enforcement mechanisms to reduce the incidence of land and forest fires. However, empirical studies indicate that the policy's effectiveness varies significantly across regions. In South Sumatera, for instance, enforcement challenges are exacerbated by limited access to fire-free land clearing machinery, insufficient incentives for alternative methods, and local resistance due to the socio-economic reliance on fire-based land clearing practices (Suryani, 2019; Agus et al., 2021). These challenges suggest that policy success is not solely dependent on regulatory design but is also influenced by governance structures, local practices, and institutional capacity (Tschakert & Dietrich, 2019).

2.3 Network Governance in Local Fire Prevention

Network governance frameworks provide a useful lens through which to view fire prevention as a collective action problem, where multiple interdependent actors must collaborate to achieve common objectives (Pahl-Wostl, 2009). In South Sumatera, local fire prevention governance involves a complex network of actors, including provincial and district governments, forest management units (KPH), village authorities, plantation companies, NGOs, and community-based fire prevention groups (MPAs). These actors operate within a decentralized network, enabling coordination across administrative and sectoral boundaries. This coordination facilitates the exchange of information, joint monitoring of fire risks, and the mobilization of resources for fire management (Agus et al., 2021; Huitema et al., 2019). However, the effectiveness of network governance depends on factors such as trust among actors, shared norms, and clear role differentiation (Folke et al., 2010). Without these elements, networks may struggle to implement fire prevention strategies effectively.

Table 2: Fire Prevention Strategies and Network Actors

Strategy	Actor/Responsibility	Role in Network
Zero-Burning Policy Enforcement	Provincial Government	Policy oversight, regulatory enforcement
Community Fire Prevention	Community Fire Brigades (MPA)	Local monitoring, fire suppression
Land Restoration	Forest Management Units (KPH)	Ecosystem restoration, land management
Public Awareness and Advocacy	NGOs	Community engagement, advocacy, education

2.4 Adaptive Governance and Fire Risk Management

Adaptive governance refers to a flexible and learning-oriented approach to managing complex environmental risks, such as forest and land fires. This approach emphasizes institutional responsiveness and the ability of governance systems to adapt to changing environmental conditions and emerging risks (Pahl-Wostl, 2009). In the context of fire-prone landscapes, adaptive governance allows stakeholders to adjust prevention strategies based on seasonal fire risks, local ecological knowledge, and policy feedback (Suryani, 2019). Research on adaptive governance highlights the importance of decentralized decision-making, cross-scale interactions, and iterative learning processes in managing dynamic risks like forest and land fires (Tschakert & Dietrich, 2019). As such, adaptive governance is considered essential for improving fire risk management in regions like South Sumatera, where ecological and socio-economic conditions are continually evolving.

2.5 Adaptive Network Governance as an Integrated Framework

Integrating adaptive governance with network governance provides a comprehensive framework for analyzing the implementation of fire prevention policies. Adaptive network governance captures both the structural configuration of governance networks and the adaptive processes that facilitate learning, coordination, and innovation among actors (Folke et al., 2010). By combining these two approaches, the framework allows for a deeper understanding of how governance systems can respond to persistent fire risks and how actors within the network can adapt their strategies over time. Despite its potential, this integrated framework has rarely been applied empirically to fire governance in Indonesia, particularly at the local level. This study applies the adaptive network governance framework to examine the implementation of zero-burning land clearing policies in South Sumatera, offering new insights into how governance networks can adapt to the persistent fire risks in peatland regions.

3. Methodology

3.1 Research Design

This study adopts a qualitative case study approach to explore how adaptive network governance influences the implementation of zero-burning land clearing policies at the local level. A qualitative approach is appropriate for understanding the complex, multi-actor nature of forest and land fire governance, particularly where policy outcomes are shaped by institutional interactions, informal practices, and adaptive decision-making processes that cannot be captured by quantitative methods alone (Yin, 2018).

The case study design allows for an in-depth exploration of governance dynamics in their real-life context, which is essential given the ecological vulnerability, institutional fragmentation, and socio-economic complexity present in regions like South Sumatera. Focusing on the local level is analytically justified because the implementation, negotiation, and contestation of zero-burning policies occur primarily within

local governance arenas (Creswell & Poth, 2017). In South Sumatera, district governments, village institutions, forest management units, plantation companies, and community fire brigades play crucial roles in translating national regulations into operational practices (Suryani, 2019). Examining governance at this level provides valuable insights into how adaptive governance mechanisms emerge and function in practice.

3.2 Study Area and Context

The study is conducted in South Sumatera Province, Indonesia, a region that has been repeatedly affected by recurrent forest and land fires. South Sumatera is characterized by extensive peatland ecosystems, large-scale plantation development, and a mixed land-use pattern that involves both smallholder agriculture and industrial forestry. These factors make the province highly vulnerable to fire incidents, particularly during seasonal droughts and climate variations that exacerbate the risks of fire (Miettinen et al., 2017).

The policy context of this study is shaped by Indonesia's zero-burning land clearing policy, which seeks to eliminate the use of fire for land preparation and promote fire prevention through alternative land clearing methods (BPS, 2020). This policy is enforced through a combination of national regulations, provincial directives, and district-level operational guidelines. However, local institutional arrangements, varying enforcement capacities, and socio-economic factors influence the actual implementation and compliance with the policy (Tschakert & Dietrich, 2019). This context is ideal for studying how governance networks adapt to persistent fire risks and address policy implementation challenges.

3.3 Data Collection

Data collection for this study involved multiple qualitative methods to ensure comprehensive analysis and data triangulation. Primary data were obtained through semi-structured interviews with key stakeholders involved in fire prevention governance. These stakeholders included representatives from provincial and district government agencies, forest management units (Kesatuan Pengelolaan Hutan/KPH), village authorities, plantation companies, community fire brigades (Masyarakat Peduli Api/MPA), non-governmental organizations (NGOs), and security forces. The interviews focused on actors' roles, coordination mechanisms, decision-making processes, and experiences in implementing zero-burning policies (Maguire & Hardy, 2013).

In addition to interviews, document analysis was conducted to examine relevant policy and institutional frameworks. Key documents included national and local regulations, standard operating procedures, fire prevention plans, coordination agreements, and official reports related to forest and land fire management in South Sumatera (Creswell, 2014). This analysis provided insight into formal governance arrangements, policy objectives, and institutional mechanisms.

Field observations were conducted, where feasible, to capture on-the-ground implementation practices, coordination activities, and community engagement efforts related to fire prevention. Observational data helped contextualize the findings from interviews and documents, providing a richer understanding of governance interactions and adaptive practices in action.

3.4 Network Analysis

To analyze governance dynamics, this study adopts a network analysis framework that focuses on identifying key actors, their relationships, and interaction patterns in the implementation of zero-burning policies. Actors were identified based on their formal mandates, roles, and involvement in fire prevention activities (Bodin et al., 2006). Relationships among these actors were examined with regard to coordination, information exchange, resource sharing, and joint action (Pahl-Wostl, 2009).

The governance network was mapped to illustrate the distribution of roles and relationships across actors. Specific attention was paid to key indicators of network performance, including coordination intensity, role distribution, and adaptability. Coordination intensity was defined as the frequency and depth of interactions among actors, while role distribution examined how responsibilities were allocated across the network (Bodin & Crona, 2009). Adaptability was assessed in terms of the governance network's capacity to adjust strategies, reconfigure roles, and incorporate feedback in response to shifting fire risks and policy challenges.

3.5 Data Analysis

Data analysis followed an iterative and inductive process, allowing for the identification of recurring themes and patterns related to governance structures, adaptive mechanisms, and policy implementation processes (Saldana, 2015). Interview transcripts, documents, and field notes were coded thematically, and codes were refined over time as new insights emerged. Thematic coding enabled the identification of key governance practices, challenges, and enabling factors within different actor groups (Braun & Clarke, 2006).

An institutional analysis was conducted to examine both formal and informal rules, norms, and decision-making procedures that shape the implementation of zero-burning policies. This analysis revealed how institutional arrangements either facilitate or constrain adaptive governance processes at the local level (Ostrom, 2005).

Lastly, a cross-actor comparison was performed to explore differences and similarities in perspectives, roles, and adaptive practices among government agencies, community actors, and private sector stakeholders. This comparative analysis allowed for insights into how governance networks function as integrated systems rather than isolated institutions, enhancing our understanding of adaptive governance in practice.

3.6 Ethical Considerations

Ethical considerations were integral to the research process. Prior to participation, all interview participants were fully informed of the study's purpose and provided informed consent. Participants' identities were anonymized to ensure confidentiality, and sensitive information regarding governance practices and institutional relationships was handled with care (Hammersley & Atkinson, 2007). Data were securely stored and used solely for academic research purposes, following ethical guidelines for qualitative research.

4. Results

4.1 Governance Network Structure

The governance network for forest and land fire prevention in South Sumatera is characterized by a complex multi-actor and multi-level structure that integrates state, market, and community actors within a shared but differentiated system of responsibility (Pahl-Wostl, 2009). Rather than functioning as a linear chain of command, the network operates as a distributed governance arrangement in which authority, resources, and operational responsibilities are dispersed across vertical and horizontal institutional layers. This multi-level configuration reflects the broader structure of Indonesia's decentralized governance system, where national directives are translated into provincial, district, and village-level practices through institutional negotiation and coordination.

At the provincial and district levels, government agencies retain formal regulatory authority over fire prevention, policy coordination, and enforcement of the zero-burning land clearing policy. These agencies serve as central nodes within the governance network, setting strategic priorities, allocating budgets, issuing operational guidelines, and activating emergency response mechanisms during high fire-risk periods (Suryani, 2019). Their authority is embedded within national legal frameworks; however, their effectiveness depends on their capacity to

mobilize inter-agency coordination across sectors such as forestry, agriculture, environmental protection, disaster management, and law enforcement. In practice, this requires continuous alignment between bureaucratic mandates and operational realities in fire-prone landscapes.

Forest Management Units (Kesatuan Pengelolaan Hutan/KPH) occupy a pivotal bridging position within the governance architecture. As territorial management bodies responsible for specific forest areas, KPH units operate at the interface between strategic policy directives and on-the-ground implementation. Their responsibilities extend beyond forest monitoring to include supporting preventive patrols, coordinating with village institutions, facilitating community engagement, and overseeing peatland hydrological management (Agus et al., 2021). Because of their territorial presence, KPH units often function as intermediaries translating regulatory norms into locally feasible operational practices. This bridging role enhances vertical integration within the governance system, but it also exposes KPH units to capacity constraints and resource limitations, particularly in geographically remote peatland areas.

Village governments and customary institutions play an equally important role as localized governance actors. Positioned closest to communities and smallholder land users, village authorities are responsible for socializing zero-burning regulations, mobilizing collective action, and embedding fire prevention norms into village-level governance processes. Their influence extends to facilitating participatory monitoring systems, mediating land-related conflicts, and strengthening social accountability mechanisms. By acting as intermediaries between state institutions and local communities, village actors help legitimize policy implementation and reduce resistance to behavioral change (Suryani, 2019). Their involvement illustrates how governance effectiveness is shaped not only by regulatory enforcement but also by social legitimacy and normative alignment.

Plantation companies constitute another influential actor group within the governance network. Operating in large concession areas—often in peatland landscapes—these companies are both potential contributors to fire risk and essential partners in fire prevention efforts. Their participation in the governance network is shaped by a combination of regulatory obligations, market pressures, corporate sustainability commitments, and reputational considerations (Miettinen et al., 2017). Some companies actively engage in collaborative patrols, hotspot monitoring, fire suppression support, and community partnership programs. Others adopt a compliance-oriented posture, interacting with government agencies primarily through reporting mechanisms and regulatory oversight (Agus et al., 2021). This variation in engagement levels introduces heterogeneity within the governance network and influences overall coordination intensity.

Community fire brigades (Masyarakat Peduli Api/MPA) represent the most localized and operationally immediate component of the governance structure. These volunteer-based groups conduct early detection, rapid response, and community awareness activities. Their physical proximity to fire-prone areas enables them to respond more quickly than centralized authorities. However, their effectiveness depends on access to equipment, training, logistical support, and continuous institutional backing from district agencies and plantation actors (Tschakert & Dietrich, 2019). In this sense, MPA groups exemplify how local-level resilience is embedded within broader network support systems.

Non-governmental organizations (NGOs) contribute to the governance network through technical assistance, facilitation of cross-sector dialogue, community capacity building, and independent monitoring. NGOs often act as knowledge brokers, introducing best practices, promoting participatory governance, and strengthening accountability mechanisms (Bodin & Crona, 2009). Security forces complement these roles by ensuring enforcement credibility, particularly in cases involving deliberate fire-setting or regulatory violations.

Taken together, patterns of interaction among these actors reveal a governance network that combines hierarchical authority with horizontal coordination and negotiated collaboration. Formal command structures coexist with trust-based informal communication channels, joint patrol arrangements, and cross-sector task forces. This hybrid configuration reflects characteristics of adaptive governance systems, where flexibility and learning coexist with institutional structure (Folke et al., 2010). Rather than operating as isolated institutions, actors within the South Sumatera fire prevention network are embedded in a web of interdependencies shaped by shared ecological risks, regulatory mandates, and socio-economic realities.

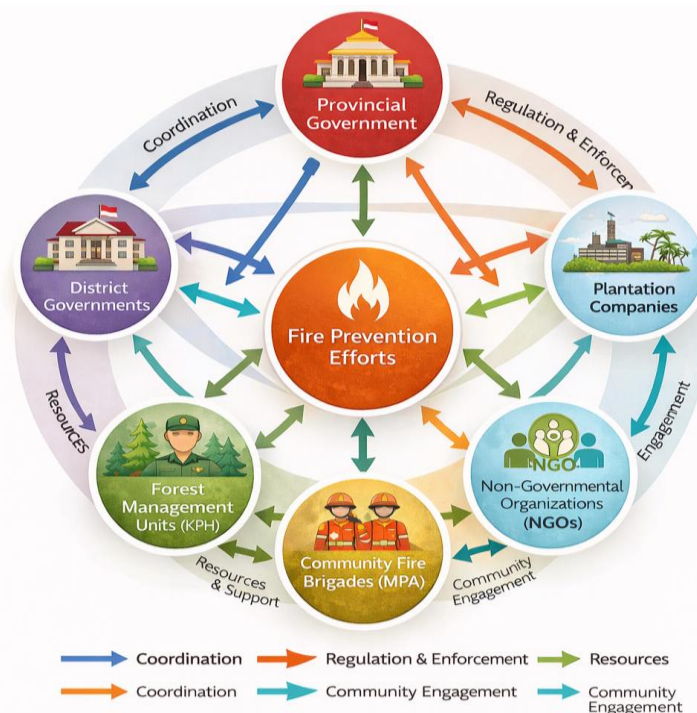


Figure 2: Governance Network for Fire Prevention in South Sumatera

The overall structure of the governance network demonstrates that fire prevention in peatland regions is not a single-agency responsibility but a distributed governance challenge requiring sustained coordination across scales. Policy outcomes therefore depend not only on the strength of individual institutions but on the density, quality, and adaptability of relationships among actors. In this context, the governance network functions as an integrated system whose effectiveness emerges from inter-actor collaboration, mutual accountability, and continuous adjustment to evolving fire risks.

4.2 Adaptive Mechanisms in Policy Implementation

Adaptive mechanisms in the implementation of the zero-burning land clearing policy in South Sumatera reflect the operational characteristics of polycentric and collaborative governance systems that are particularly suited to managing complex, uncertain, and dynamic environmental risks (Armitage et al., 2008; Emerson & Nabatchi, 2015). Rather than functioning as a rigid bureaucratic apparatus, the governance network operates as a dynamic, learning-oriented system embedded within a broader socio-ecological context. This adaptive configuration enables actors to respond to shifting fire risks, climatic variability, and socio-economic pressures that characterize peatland landscapes.

The governance arrangements observed in South Sumatera display key elements of what Armitage et al. (2008) conceptualize as *adaptive co-management*, where shared authority, continuous experimentation, and iterative learning shape policy implementation outcomes. In this setting, decision-making authority is distributed across multiple institutional nodes—provincial agencies, district governments, KPH units, village authorities, and community fire brigades—creating overlapping centers of coordination that enhance responsiveness and reduce systemic rigidity. This polycentric configuration facilitates problem-solving across scales, allowing local actors to adjust implementation strategies without waiting for centralized directives.

A central adaptive mechanism identified in this study is **institutional learning**. Institutional learning occurs through repeated exposure to fire seasons, post-event evaluations, and inter-agency reflection processes. Consistent with theories of reflexive governance, recurrent crisis events function as feedback loops that trigger recalibration of strategies and operational protocols (Voss & Kemp, 2006). Annual fire seasons act as stress tests for governance systems, revealing coordination gaps, logistical bottlenecks, and enforcement weaknesses. In response, actors revise patrol deployment schedules, refine hotspot verification procedures, reallocate monitoring resources, and strengthen communication channels across agencies. Such iterative recalibration aligns with Dietz et al.'s (2003) argument that effective governance of complex environmental commons requires institutions capable of learning and adaptation under uncertainty.

Beyond formal learning mechanisms, adaptive governance in South Sumatera is also characterized by **contextual innovation and localized policy translation**. National zero-burning regulations are not implemented as uniform prescriptions but are reinterpreted within local socio-ecological conditions (Biermann et al., 2012). In peatland districts, enforcement timing is adjusted to correspond with hydrological vulnerability and seasonal drought patterns, while traditional ecological knowledge is incorporated into prevention strategies. For example, local actors may integrate customary land-use calendars into patrol planning or combine mechanical land preparation support with culturally embedded land management practices. This form of adaptive localization enhances policy legitimacy, strengthens community compliance, and reduces institutional resistance (Young, 2017).

Such contextual adaptation also mitigates institutional rigidity. In highly centralized governance systems, rigid rule enforcement can undermine legitimacy and provoke non-compliance. In contrast, adaptive localization allows regulatory objectives to remain intact while enabling flexible pathways for achieving compliance. This balance between policy consistency and implementation flexibility strengthens resilience in policy delivery systems.

Another critical adaptive mechanism lies in the **hybrid coordination structure** of the governance network. Coordination operates simultaneously through formal institutional arrangements and informal relational mechanisms. Formal coordination includes legally mandated task forces, official reporting protocols, and inter-agency operational agreements. These mechanisms provide procedural clarity, accountability, and institutional continuity. However, adaptive capacity is significantly enhanced by informal networks built on trust, personal relationships, and frequent interaction among actors.

Collaborative governance scholarship emphasizes that relational capital and mutual trust are indispensable for effective cross-sector coordination (Emerson & Nabatchi, 2015). In South Sumatera, informal communication networks among district officials, KPH officers, plantation representatives, and community leaders enable rapid decision-making during emerging fire threats. These informal channels accelerate information flows, reduce bureaucratic delay, and facilitate problem-solving in real time. Importantly, informal coordination does not replace formal authority; rather, it complements it, creating a governance system that combines flexibility with institutional legitimacy.

The presence of both formal and informal coordination mechanisms reflects what Duit et al. (2010) describe as *networked resilience*, where governance stability emerges not from centralized command structures but from relational density, redundancy, and cross-scale interaction. Networked resilience enhances system robustness by distributing responsibility across multiple actors while maintaining adaptive responsiveness.

Moreover, adaptive mechanisms in this context extend beyond institutional adjustment to include capacity development and strategic experimentation. District-level actors engage in trial-and-error approaches when introducing alternative land clearing technologies or community-based fire prevention programs. Such experimentation reflects the recognition that standardized solutions may not be universally applicable across diverse peatland conditions. By allowing localized experimentation within a shared regulatory framework, the governance network strengthens its problem-solving capacity while minimizing systemic risk.

Collectively, these adaptive mechanisms demonstrate that zero-burning policy implementation in South Sumatera is not a linear administrative process but a continuously evolving governance practice. Governance stability is achieved not through strict hierarchical control but through iterative learning, flexible coordination, contextual translation, and relational trust. This configuration supports the interpretation of South Sumatera's fire prevention system as an adaptive network governance arrangement in which institutional resilience emerges from flexibility, collaboration, and distributed authority.

4.3 Implementation of Zero-Burning Practices

The implementation of zero-burning land clearing practices in South Sumatera reflects a multidimensional governance strategy that integrates regulatory enforcement, participatory engagement, economic incentives, and adaptive support mechanisms. Rather than relying exclusively on command-and-control instruments, the governance network employs what policy scholars describe as a *policy mix approach*, in which complementary instruments operate simultaneously to influence behavioral change (Rogge & Reichardt, 2016). This layered configuration acknowledges that fire use in peatland landscapes is not merely a regulatory violation but a socio-economic practice embedded in local livelihood systems.

At its core, enforcement remains a fundamental pillar of policy implementation. Provincial governments, district authorities, and security forces conduct hotspot monitoring, field verification, investigation of fire incidents, and legal prosecution where violations occur. Satellite-based detection systems and early warning platforms enhance the timeliness of response, allowing authorities to intervene before fires escalate. However, enforcement effectiveness depends not only on detection capacity but on institutional credibility and procedural consistency. As May (2007) argues, compliance behavior is influenced by perceptions of legitimacy, fairness, and enforcement predictability. In contexts where enforcement is perceived as selective, politically biased, or inconsistently applied, deterrent effects diminish. Therefore, strengthening transparency and procedural fairness becomes as important as increasing sanction severity.

Beyond regulatory enforcement, implementation practices in South Sumatera demonstrate strong reliance on community engagement strategies rooted in participatory environmental governance principles (Reed, 2008). Village authorities, community fire brigades (MPA), and local NGOs organize awareness campaigns, participatory monitoring activities, and collective fire-prevention initiatives. These activities aim not only to disseminate information but to internalize fire prevention norms within community governance structures. By embedding zero-burning principles into village meetings, customary institutions, and local decision-making processes, policy objectives gain normative legitimacy rather than remaining external mandates.

Participatory monitoring also increases horizontal accountability. When community members are directly involved in monitoring fire risks and reporting incidents, enforcement capacity expands beyond state institutions. Such distributed monitoring reduces the administrative burden on district agencies while enhancing collective responsibility. Moreover, participatory approaches foster social sanctioning mechanisms, where community norms discourage fire use independently of formal legal penalties. This normative reinforcement strengthens voluntary compliance and reduces reliance on coercive enforcement.

The implementation framework also incorporates economic and technological support mechanisms designed to address the structural drivers of fire-based land clearing. Behavioral governance theory suggests that compliance improves when regulatory requirements are accompanied by viable economic alternatives (Gunningham & Sinclair, 2017). In peatland districts where mechanical clearing is more expensive than burning, providing access to equipment, subsidized machinery, training programs, and alternative livelihood support becomes essential for shifting behavioral incentives.

Plantation companies and NGOs contribute to these incentive-based mechanisms by supporting community partnerships, co-financing fire prevention infrastructure, and facilitating capacity-building initiatives. Such support mechanisms reduce the economic rationality of burning and help align individual land management decisions with broader environmental objectives. In this context, incentives operate not merely as financial tools but as instruments of structural transformation within rural production systems.

Simultaneously, the governance network employs sanction mechanisms to deter intentional fire-setting. Legal penalties, fines, permit suspensions, and criminal investigations signal that fire use carries tangible consequences. However, sanctions are most effective when integrated within what Braithwaite (2002) terms a *responsive regulation model*, where enforcement intensity escalates progressively and is paired with supportive engagement strategies. Under this model, actors are first encouraged toward voluntary compliance through education and support; coercive measures are reserved for persistent or deliberate violations. This graduated enforcement approach enhances institutional legitimacy while maintaining regulatory authority.

Importantly, the interaction between incentives and sanctions reflects an adaptive balance rather than a fixed enforcement formula. During periods of heightened fire risk—such as prolonged droughts—enforcement intensity increases, while in lower-risk periods, emphasis shifts toward awareness-building and prevention training. This temporal adjustment illustrates adaptive calibration within the governance network, reinforcing the broader adaptive governance framework discussed in previous sections.

Furthermore, implementation practices reveal cross-scale coordination between provincial agencies, district administrations, KPH units, and community actors. Joint patrols, integrated monitoring systems, and shared reporting platforms facilitate vertical alignment of prevention strategies. This cross-level integration enhances coherence between national policy mandates and local operational realities. By aligning enforcement protocols, engagement strategies, and incentive structures across administrative scales, the governance network reduces fragmentation and improves systemic consistency.

Table 3: Implementation Strategies and Actors in Zero-Burning Practices

Strategy	Actor/Responsibility	Operational Role	Governance Function
Enforcement	Provincial Government, Security Forces	Monitoring, hotspot verification, investigation, prosecution	Regulatory deterrence and legal accountability
Community Engagement	Village Authorities, MPA, NGOs	Awareness campaigns, participatory monitoring, local norm-building	Norm internalization and voluntary compliance
Incentives (equipment, training, support)	Plantation Companies, NGOs, District Agencies	Providing alternative clearing tools, capacity building	Reducing economic incentives for burning
Sanctions (legal penalties)	Provincial & District Authorities	Fines, permit suspension, criminal proceedings	Escalated deterrence under responsive regulation
Cross-Scale Coordination	Provincial, District, KPH, Village Institutions	Joint patrols, integrated reporting systems	Vertical integration and coherence

Overall, the implementation of zero-burning practices in South Sumatera reflects a complex interplay between regulatory authority, participatory engagement, economic restructuring, and adaptive coordination. Rather than functioning as isolated instruments, these components operate synergistically within a networked governance architecture. The effectiveness of zero-burning policy implementation thus depends not solely on the presence of legal prohibitions but on the coherence, balance, and adaptability of the entire policy instrument mix.

4.4 Constraints and Enablers

Despite the presence of adaptive governance mechanisms, the effectiveness of zero-burning policy implementation in South Sumatera remains constrained by structural, institutional, socio-economic, and ecological challenges. These constraints do not operate independently; rather, they interact across governance scales and influence the performance of the entire networked system.

One of the most significant institutional constraints is fragmentation within the multi-level governance structure. Institutional fragmentation observed in South Sumatera mirrors broader challenges in decentralized environmental governance systems, where vertical and horizontal coordination gaps undermine policy coherence (Marks & Hooghe, 2004). Overlapping mandates among provincial agencies, district offices, KPH units, and sectoral departments create ambiguity in responsibility allocation. During high-risk fire periods, such ambiguity can delay response coordination, reduce accountability clarity, and weaken strategic alignment.

Fragmentation also manifests in inconsistent resource allocation. Different agencies operate under separate budgeting cycles and administrative priorities, which may not always align with seasonal fire risk patterns. This can generate capacity imbalances, where certain actors—particularly at the district or village level—face shortages in equipment, personnel, or operational funding. As a result, adaptive capacity becomes unevenly distributed across the network.

In addition to structural fragmentation, bureaucratic inertia can limit adaptive responsiveness. While formal rules provide accountability, excessive procedural rigidity may slow decision-making during emergency conditions. This tension between institutional stability and adaptive flexibility represents a persistent governance challenge in complex environmental systems.

Socio-economic constraints further complicate zero-burning policy implementation. From a political ecology perspective, fire use in peatland landscapes is embedded within broader structures of land access, livelihood vulnerability, and market dynamics (Robbins, 2012). For many smallholders, fire-based land clearing remains the most economically rational method due to its low cost and minimal technological requirements. Mechanical clearing alternatives often require capital investment, technical knowledge, and access to machinery that are not universally available.

Land tenure insecurity intensifies this dynamic. Where property rights are unclear or contested, land users may prioritize short-term productivity over long-term sustainability. In such contexts, incentives for compliance weaken, and enforcement measures may be perceived as punitive rather than protective. Without addressing tenure security and structural livelihood constraints, zero-burning compliance remains fragile and potentially reversible.

Ecological constraints also shape implementation outcomes. Peatland ecosystems are highly sensitive to hydrological change, and drained peat areas remain susceptible to subsurface smoldering fires that are difficult to detect and extinguish. Even where fire prevention efforts are active, ecological vulnerability can amplify fire risk during prolonged droughts. Thus, governance effectiveness is partially contingent upon ecological restoration efforts, such as peat rewetting and water table management, which require sustained cross-sector coordination. Beyond constraints, the study identifies several enabling governance conditions that strengthen adaptive network performance. Strong district-level leadership emerges as a critical enabler. Leadership plays a coordinating and bridging function, aligning institutional mandates, mobilizing inter-agency collaboration, and fostering collective problem-solving. Governance capacity literature emphasizes that leadership is central to institutional coherence and network resilience (Burch et al., 2014). Where district leaders actively promote cross-sector dialogue and shared responsibility, coordination intensity increases and fragmentation decreases.

Relational trust among actors represents another key enabling factor. Trust reduces transaction costs, facilitates information sharing, and enhances willingness to engage in joint action. In adaptive network governance systems, trust operates as social capital that stabilizes collaboration under uncertainty. When provincial authorities, district agencies, plantation companies, and community brigades maintain open communication channels, response coordination becomes more efficient and less conflict-prone.

Institutionalized learning mechanisms also serve as enablers. Post-fire evaluations, joint review meetings, and cross-agency reflection processes strengthen feedback loops within the governance system. Such mechanisms enable actors to identify weaknesses, revise strategies, and refine operational protocols. Governance networks that embed learning routines into their institutional culture demonstrate greater resilience and adaptability. Another enabling condition is the presence of multi-actor platforms that facilitate regular communication across scales. Formal coordination forums—such as district fire prevention task forces—create structured opportunities for alignment of priorities and resource pooling. When these forums function effectively, they reduce duplication of effort and enhance policy coherence.

Finally, the integration of incentives with enforcement strengthens implementation legitimacy. When communities perceive that zero-burning policies are accompanied by tangible support—such as access to alternative technologies, training programs, or livelihood assistance—compliance motivations increase. Balanced policy instrument mixes reduce perceptions of unfair burden distribution and enhance long-term behavioral change. Taken together, constraints and enablers interact dynamically within the governance network. Institutional fragmentation, socio-economic vulnerability, and ecological risk create structural pressures that can undermine policy implementation. Conversely, strong leadership, relational trust, institutional learning, and coordinated policy instruments enhance adaptive capacity and network resilience.

The overall effectiveness of zero-burning policy implementation therefore depends not on the absence of constraints, but on the governance network's ability to manage and compensate for them. In this sense, adaptive network governance functions as a balancing mechanism—mitigating structural limitations through relational coordination, learning processes, and flexible policy calibration. Where enabling conditions outweigh structural constraints, governance systems exhibit greater coherence, responsiveness, and resilience in managing forest and land fire risks.

5. Discussion

5.1 Adaptive Network Governance and Policy Effectiveness

The findings of this study reinforce broader theoretical arguments that effective environmental governance in complex and uncertain socio-ecological systems requires adaptive and network-based configurations rather than rigid hierarchical control (Dietz et al., 2003). Forest and land fire governance in peatland regions represents a paradigmatic case of such complexity. Peat ecosystems are ecologically fragile, highly sensitive to hydrological change, and prone to deep-seated smoldering fires that are difficult to detect and extinguish. These ecological characteristics, combined with climatic variability, decentralized administrative structures, and socio-economic heterogeneity, generate governance conditions characterized by uncertainty, non-linearity, and cross-scale interdependence.

In this context, traditional command-and-control models—centered on centralized authority, uniform rule enforcement, and top-down directives—prove insufficient. The empirical findings from South Sumatera demonstrate that policy effectiveness emerges not primarily from coercive capacity, but from the adaptive qualities of governance networks. These networks enable continuous recalibration of strategies, flexible allocation of responsibilities, and distributed problem-solving across institutional levels.

The governance networks observed in South Sumatera resemble polycentric governance arrangements, in which multiple centers of decision-making authority operate semi-autonomously yet remain interconnected (Ostrom, 2010). Polycentric systems enhance policy robustness by promoting experimentation, redundancy, and cross-level learning. Redundancy—often perceived as inefficiency in centralized systems—functions as a resilience-enhancing feature in polycentric governance. When one institutional node encounters capacity limitations, others can compensate, thereby preventing systemic failure. This distributed authority structure strengthens resilience against environmental shocks such as prolonged droughts or extreme fire seasons.

Moreover, polycentric governance fosters local experimentation. District agencies, KPH units, and village institutions can adapt operational strategies to localized conditions while remaining aligned with overarching regulatory objectives. Such flexibility is particularly important in peatland fire governance, where risk levels vary significantly across landscapes and seasons. Cross-level learning processes further enhance policy effectiveness, as local innovations and lessons are communicated upward and horizontally across the network.

Policy effectiveness, therefore, emerges not solely from legal authority or regulatory stringency, but from network adaptability, relational trust, and institutional reflexivity (Emerson & Nabatchi, 2015). Relational trust reduces coordination friction, facilitates rapid information exchange, and strengthens collaborative problem-solving during high-risk periods. Institutional reflexivity—the capacity to reflect upon and revise governance practices—ensures that policies evolve in response to feedback rather than remaining static.

Adaptive network governance thus functions as an intermediary mechanism linking national policy intent with localized implementation realities. Central regulations establish normative and legal boundaries, but it is the adaptive network configuration that translates these objectives into operational outcomes. In South Sumatera, the combination of distributed authority, iterative learning, collaborative coordination, and contextual flexibility enhances the practical effectiveness of zero-burning land clearing policies.

5.2 Comparison with Previous Studies

The results of this study align with existing scholarship highlighting the limitations of command-and-control approaches in forest and land fire governance (Ahrens et al., 2020). Enforcement-centric models often underestimate the socio-economic drivers of fire use and fail to account for cross-scale governance complexity. Previous studies have emphasized the importance of community participation, cross-sector collaboration, and institutional learning in fire prevention, particularly within socio-ecological systems characterized by uncertainty and interdependence (Suryani, 2019; Miettinen et al., 2017). The empirical findings from South Sumatera corroborate these arguments by

demonstrating that governance networks capable of sustained coordination and adaptive recalibration are more effective in implementing preventive policies such as zero-burning land clearing.

However, this study advances the literature in several important ways. First, while prior research often examines adaptive governance and network governance as separate analytical lenses, this study explicitly integrates these perspectives within a unified framework. Earlier studies may focus on institutional learning or on actor coordination independently; in contrast, the findings from South Sumatera reveal that adaptation and networking are mutually reinforcing processes. Governance networks not only coordinate actors structurally but also evolve functionally through feedback, innovation, and iterative adjustment (Bodin et al., 2006). By combining structural network analysis with adaptive process analysis, this research offers a more dynamic and system-oriented interpretation of governance effectiveness.

Second, many previous studies emphasize technical or enforcement-based solutions, such as improved hotspot detection technologies or stricter legal penalties. While such measures remain important, the present study highlights the relational and process-oriented dimensions of governance. It demonstrates that the quality of interaction among actors—trust, communication intensity, shared norms, and collective problem-solving—plays a decisive role in shaping fire prevention outcomes. This shift in analytical focus moves beyond instrumental policy design and toward governance quality as a determinant of environmental performance.

Third, this study contributes to the literature by situating fire governance within peatland-dominated landscapes. Peat ecosystems present unique hydrological and ecological challenges that amplify fire risk and complicate suppression efforts. By examining governance dynamics within this specific ecological context, the study underscores the importance of aligning governance arrangements with ecosystem characteristics. The adaptive network governance framework proves particularly relevant in such contexts, where ecological feedback loops and socio-economic pressures interact dynamically.

Finally, the findings contribute to debates on multi-level environmental governance by demonstrating how decentralized institutional arrangements can enhance—not weaken—policy effectiveness when adaptive coordination mechanisms are present. Rather than framing decentralization as a governance weakness, the South Sumatera case illustrates how distributed authority, when embedded within collaborative and learning-oriented networks, can strengthen resilience and policy coherence.

In summary, while the study confirms existing critiques of hierarchical fire governance models, it also extends the literature by conceptualizing zero-burning policy implementation as an evolving, networked, and adaptive process embedded within complex socio-ecological systems. This integrated perspective provides a more comprehensive explanation of why certain governance configurations generate more effective fire prevention outcomes than others.

5.3 Theoretical Contributions

This study contributes to the theoretical development of environmental governance in several substantive and interconnected ways. Rather than merely applying existing theories to an empirical case, the research advances conceptual integration and contextual refinement within the field of adaptive environmental governance.

First, the study extends adaptive governance theory by demonstrating its empirical applicability in the context of forest and land fire prevention in peatland ecosystems. Adaptive governance has been widely theorized in relation to climate change adaptation, water governance, and broader natural resource management systems; however, its explicit operationalization within fire governance—particularly in tropical peatland regions—remains comparatively underexplored (Pahl-Wostl, 2009; Suryani, 2019). The findings from South Sumatera show that adaptive governance principles are not abstract normative ideals but practical institutional processes that manifest through iterative learning, flexible coordination, distributed authority, and cross-scale interaction.

Specifically, the study illustrates how adaptive mechanisms—such as institutional recalibration after fire seasons, context-sensitive policy translation, hybrid coordination structures, and distributed monitoring systems—operate as concrete governance practices. By documenting how these mechanisms interact within a networked institutional setting, the research refines adaptive governance theory beyond its macro-level conceptualization and situates it within a specific socio-ecological domain characterized by hydrological vulnerability, climatic uncertainty, and livelihood dependency. In doing so, the study contributes to bridging the gap between abstract adaptive governance theory and grounded institutional practice.

Second, the study advances theoretical integration between network governance and policy implementation scholarship. Traditional policy implementation models often conceptualize implementation as a linear administrative process flowing from central directives to local execution. In contrast, network governance theory emphasizes interdependence, relational coordination, and horizontal interaction among multiple actors (Bodin & Crona, 2009). This study integrates these perspectives by conceptualizing zero-burning policy implementation as a dynamic, networked, and adaptive process.

The findings demonstrate that policy implementation in South Sumatera is not merely the execution of regulatory commands but an evolving process shaped by negotiation, relational trust, experimentation, and feedback loops among interdependent actors. This reframing shifts the analytical focus from compliance as a product of authority to compliance as an outcome of network performance. In doing so, the study challenges linear models of policy execution and supports a process-oriented understanding of implementation in complex governance environments (Huitema et al., 2019).

Third, the research contributes to polycentric governance theory by empirically illustrating how multiple centers of authority can enhance resilience rather than fragment coordination. While decentralization is sometimes critiqued for creating institutional overlap and ambiguity, the South Sumatera case demonstrates that distributed authority can generate adaptive redundancy, cross-scale learning, and localized experimentation. This finding refines polycentric governance arguments by showing that distributed authority becomes effective when embedded within collaborative and learning-oriented networks.

Fourth, the study contributes to socio-ecological governance theory by explicitly situating adaptive network governance within peatland-dominated landscapes. Peat ecosystems introduce unique ecological feedback mechanisms—such as subsurface fire persistence and hydrological sensitivity—that complicate both prevention and suppression strategies. By analyzing governance processes within this ecological context, the study underscores the importance of aligning institutional configurations with ecosystem characteristics. This ecological embedding strengthens the theoretical argument that governance effectiveness depends on congruence between institutional design and environmental complexity.

Fifth, the study advances the conceptualization of **adaptive network governance** as a distinct analytical framework. Rather than treating adaptive governance and network governance as parallel or loosely connected perspectives, the research demonstrates their structural interdependence. Adaptive capacity in South Sumatera emerges through network density, relational trust, and cross-level coordination. Simultaneously, network effectiveness is sustained through learning processes, reflexivity, and institutional flexibility. The integration of these dimensions supports the proposition that adaptive network governance represents a coherent and analytically valuable framework for studying environmental policy implementation in dynamic socio-ecological systems.

This integrated framework contributes conceptually by:

1. Reconceptualizing policy effectiveness as an emergent property of network adaptability rather than a direct outcome of regulatory stringency.
2. Positioning relational capital and institutional reflexivity as core determinants of environmental governance performance.
3. Demonstrating how multi-level coordination and distributed authority can generate resilience in high-risk environmental contexts.

Collectively, these theoretical contributions move beyond descriptive case analysis and offer a refined analytical lens for examining environmental policy implementation in contexts characterized by ecological uncertainty, decentralized governance structures, and socio-economic vulnerability.

In sum, this study not only confirms existing arguments regarding the importance of collaboration and adaptation in environmental governance but also advances theory by integrating adaptive and network perspectives into a unified framework grounded in empirical analysis. The conceptualization of adaptive network governance emerging from this research provides a scalable analytical tool applicable to other dynamic environmental risk contexts beyond peatland fire governance.

6. Conclusion

6.1 Key Findings

This study set out to examine how adaptive network governance shapes the implementation of zero-burning land clearing policies in South Sumatera, one of Indonesia's most fire-prone peatland regions. The findings demonstrate that policy effectiveness in this context is not primarily determined by the presence of formal regulations or enforcement capacity alone. Rather, the implementation of zero-burning practices is deeply embedded within a multi-actor governance network whose adaptive capacity significantly influences prevention outcomes.

The governance system observed in South Sumatera is characterized by a multi-level and multi-sectoral configuration involving provincial and district governments, Forest Management Units (KPH), village authorities, plantation companies, community fire brigades (MPA), NGOs, and security forces. These actors operate within a hybrid structure that combines hierarchical authority with horizontal collaboration. Policy execution is therefore not linear but relational and negotiated across institutional boundaries.

The study finds that adaptive governance mechanisms play a decisive role in mediating policy outcomes. Institutional learning from recurring fire seasons enables actors to refine patrol strategies, improve inter-agency coordination, and reallocate resources more strategically. Informal trust-based communication networks enhance responsiveness during high-risk periods, often complementing formal bureaucratic pathways. The integration of local knowledge and contextual adaptation of national policy guidelines further increases legitimacy and compliance at the community level.

Importantly, the findings indicate that governance network density, relational trust, and cross-scale coordination are critical determinants of policy effectiveness. Where networks demonstrate strong interaction patterns and shared problem-solving capacity, zero-burning implementation becomes more consistent and preventive rather than reactive. Conversely, fragmented institutional arrangements, overlapping mandates, limited resources, and socio-economic constraints weaken adaptive capacity and undermine policy coherence.

In short, the study shows that adaptive network governance functions as a bridging mechanism between central policy intent and localized implementation realities. Zero-burning policy effectiveness emerges as an outcome of governance adaptability rather than regulatory rigidity.

6.2 Policy Implications

The findings carry significant implications for fire governance reform, particularly in peatland-dominated and socio-economically complex regions.

First, strengthening governance networks should be prioritized as a core policy objective. Fire prevention strategies must move beyond regulatory enforcement frameworks toward institutional designs that actively support collaboration, shared learning, and cross-sector integration. Establishing permanent coordination platforms, joint task forces, and inter-agency knowledge-sharing mechanisms can enhance network resilience during peak fire seasons.

Second, adaptive governance should be institutionalized rather than treated as an informal byproduct of crisis response. This includes embedding formal feedback loops, post-fire evaluation mechanisms, and flexible operational guidelines into regulatory frameworks. By codifying adaptive practices, governance systems can transition from reactive fire suppression toward anticipatory and preventive risk management.

Third, enforcement strategies must be balanced with socio-economic support mechanisms. In many peatland districts, fire-based land clearing persists because it remains economically rational for smallholders. Providing access to alternative technologies, mechanical clearing equipment, livelihood diversification programs, and technical assistance can shift compliance incentives while maintaining policy legitimacy. Without addressing structural economic drivers, zero-burning policies risk remaining normatively strong but practically fragile.

Fourth, capacity building at the local level is essential. Forest Management Units, village governments, and community fire brigades represent frontline actors in fire prevention. Strengthening their financial, technical, and institutional capacity enhances both network density and adaptive performance.

Collectively, these policy implications suggest that improving governance quality—not merely tightening regulation—is central to reducing forest and land fire risks in peatland ecosystems.

6.3 Limitations and Future Research

This study is subject to several limitations. As a qualitative case study focused on South Sumatera, the findings are context-specific and may not be directly generalizable to other regions with different ecological or institutional characteristics. In addition, the reliance on qualitative data limits the ability to quantify the relative influence of specific governance mechanisms on fire prevention outcomes.

Future research could address these [limitations](#) by conducting comparative studies across multiple fire-prone regions, both within Indonesia and in other countries with similar land-use challenges. [Quantitative](#) or mixed-method approaches could also be employed to measure governance network performance, adaptive capacity, and policy outcomes more systematically. Such studies would further strengthen the empirical foundation of adaptive network governance as a framework for forest and land fire prevention.

References

- Agus, A., Abdullah, M., & Chandra, S. (2021). Multi-actor collaboration in fire prevention governance in South Sumatera, Indonesia. *Journal of Environmental Management*, 295, 113089. <https://doi.org/10.1016/j.jenvman.2021.113089>
- Ahrens, R., Jarzabek, L., & Suryani, A. (2020). The transboundary haze crisis: Implications for public health and economic development. *Environmental Health Perspectives*, 128(2), 1–10. <https://doi.org/10.1289/EHP6838>
- Armitage, D., Berkes, F., & Doubleday, N. (2008). *Adaptive co-management: Collaboration, learning, and multi-level governance*. UBC Press.

- Biermann, F., Abbott, K., Andresen, S., et al. (2012). Navigating the Anthropocene: Improving earth system governance. *Science*, 335(6074), 1306–1307. <https://doi.org/10.1126/science.1217255>
- Bodin, Ö., & Crona, B. (2009). The role of social networks in natural resource governance: Implications for resilience and sustainability. *Ecology and Society*, 14(2), 23. <https://doi.org/10.5751/ES-03155-140223>
- Bodin, Ö., & Prell, C. (2011). *Social networks and natural resource management: Uncovering the social fabric of environmental governance*. Cambridge University Press.
- Bodin, Ö., Prell, C., & Crona, B. (2006). Social networks in natural resource management: Uncovering the social fabric of governance. *Ecology and Society*, 11(2), 20. <https://doi.org/10.5751/ES-01784-110220>
- Braithwaite, J. (2002). *Restorative justice and responsive regulation*. Oxford University Press.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- BPS (Badan Pusat Statistik). (2020). *Statistik kebakaran hutan dan lahan di Indonesia 2020*. Badan Pusat Statistik.
- Burch, S., Shaw, A., Dale, A., & Robinson, J. (2014). Triggering transformative change: A development path approach to climate change response in communities. *Global Environmental Change*, 24, 211–221. <https://doi.org/10.1016/j.gloenvcha.2013.12.002>
- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Sage Publications.
- Creswell, J. W., & Poth, C. N. (2017). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage Publications.
- Dietz, T., Ostrom, E., & Stern, P. C. (2003). The struggle to govern the commons. *Science*, 302(5652), 1907–1912. <https://doi.org/10.1126/science.1091015>
- Duit, A., Galaz, V., Eckerberg, K., & Ebbesson, J. (2010). Governance, complexity, and resilience. *Global Environmental Change*, 20(3), 363–368. <https://doi.org/10.1016/j.gloenvcha.2010.01.006>
- Emerson, K., & Nabatchi, T. (2015). *Collaborative governance regimes*. Georgetown University Press.
- Emerson, K., & Nabatchi, T. (2015). Evaluating the productivity of collaborative governance regimes. *Public Administration Review*, 75(5), 717–728. <https://doi.org/10.1111/puar.12428>
- Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2010). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, 35, 441–473. <https://doi.org/10.1146/annurev-environ-032509-135720>
- Gunningham, N., & Sinclair, D. (2017). Smart regulation revisited. *Regulation & Governance*, 11(1), 3–18. <https://doi.org/10.1111/rego.12102>
- Hammersley, M., & Atkinson, P. (2007). *Ethnography: Principles in practice* (3rd ed.). Routledge.
- Howlett, M., & Rayner, J. (2013). Patching vs packaging in policy formulation. *Policy and Society*, 32(2), 170–182. <https://doi.org/10.1016/j.polsoc.2013.07.002>
- Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., & Yalcin, R. (2009). Adaptive water governance. *Ecology and Society*, 14(1), 26. <https://doi.org/10.5751/ES-02816-140126>
- Marks, G., & Hooghe, L. (2004). Contrasting visions of multi-level governance. *Public Administration*, 82(1), 15–30. <https://doi.org/10.1111/j.0033-3298.2004.00384.x>
- May, P. J. (2007). Regulatory regimes and accountability. *Policy Studies Journal*, 35(4), 633–652. <https://doi.org/10.1111/j.1541-0072.2007.00246.x>
- Miettinen, J., Liew, S. C., & Catterall, B. (2017). The persistence of fire and haze in Southeast Asia. *Environmental Monitoring and Assessment*, 189, 448. <https://doi.org/10.1007/s10661-017-6084-9>
- Ostrom, E. (2005). *Understanding institutional diversity*. Princeton University Press.
- Ostrom, E. (2010). Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, 20(4), 550–557. <https://doi.org/10.1016/j.gloenvcha.2010.07.004>
- Reed, M. S. (2008). Stakeholder participation for environmental management. *Biological Conservation*, 141(10), 2417–2431. <https://doi.org/10.1016/j.biocon.2008.07.014>
- Robbins, P. (2012). *Political ecology: A critical introduction* (2nd ed.). Wiley-Blackwell.
- Rogge, K. S., & Reichardt, K. (2016). Policy mixes for sustainability transitions. *Research Policy*, 45(8), 1620–1635. <https://doi.org/10.1016/j.respol.2016.04.004>
- Saldana, J. (2015). *The coding manual for qualitative researchers* (3rd ed.). Sage Publications.
- Suryani, A. (2019). Policy implementation challenges in fire prevention and control in South Sumatera. *Environmental Policy and Governance*, 29(6), 312–324. <https://doi.org/10.1002/eet.1899>
- Tschakert, P., & Dietrich, K. (2019). The governance of fire risk in Indonesia. *Global Environmental Change*, 55, 1–11. <https://doi.org/10.1016/j.gloenvcha.2018.12.001>
- Voss, J.-P., & Kemp, R. (2006). Sustainability and reflexive governance. *Ecological Economics*, 61(1), 18–27. <https://doi.org/10.1016/j.ecolecon.2006.02.018>
- Young, O. R. (2017). *Governing complex systems: Social capital for the Anthropocene*. MIT Press.
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage Publications.