

A MODEL FOR THE ESTABLISHMENT OF FOREST AND LAND FIRE-FREE ZONES IN RIAU PROVINCE, INDONESIA: A LEGAL SYSTEM AND SWOT ANALYSIS APPROACH

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ABSTRACT

Background: Riau Province, Indonesia, is one of the country's most peatland-rich regions and has been chronically affected by recurrent forest and land fires (Karhutla). Despite the extensive ecological, economic, and public health consequences, systematic frameworks for preventing and eradicating such fires remain underdeveloped.

Objective: This study aims to (1) identify the ecological, economic, and social impacts of forest and land fires; (2) examine barriers to establishing Fire-Free Zones (Wilayah Bebas dari Kebakaran/WBK) in Riau Province; and (3) develop a comprehensive model for the formation of fire-free zones grounded in Lawrence M. Friedman's Legal System Theory.

Methods: A mixed-methods approach was employed, combining quantitative survey data from 58 respondents (comprising local government officials, law enforcement personnel, plantation companies, community leaders, and environmental NGOs) with qualitative in-depth interviews and document analysis. Data validity was confirmed through Pearson correlation ($r > 0.3$), reliability through Cronbach's Alpha ($\alpha > 0.6$), normality using the Monte Carlo method, and strategic direction was determined via SWOT analysis.

Results: The SWOT analysis positioned the fire-free zone model in Quadrant I (SO Strategy), indicating strong internal strengths and favorable external opportunities. Key findings revealed: (1) fires cause severe ecological degradation including massive CO₂ emissions (72 million tons in 2019), biodiversity loss, and hydrological disruption; (2) economic losses amounted to IDR 221 trillion during the 2015 conflagration, with widespread social disruption; (3) barriers include weak legal structures, inadequate enforcement capacity, fragmented inter-institutional coordination, and low community legal awareness; and (4) the proposed Fire-Free Zone model integrates three Friedman dimensions—legal substance (enabling regulations), legal structure (multi-agency enforcement architecture), and legal culture (community-based education and social participation).

Conclusions: The proposed model provides a comprehensive, replicable policy framework for fire-free zone designation in peatland-dominated provinces. Successful implementation requires simultaneous strengthening of legal substance, enforcement structures, and community legal culture. The findings offer actionable guidance for regional governments, law enforcement agencies, and environmental policymakers striving toward sustainable forest governance and reduced Karhutla incidence.

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1. INTRODUCTION

Forest and land fires (Karhutla) represent one of the most persistent and devastating environmental crises in Indonesia, particularly in peatland-rich provinces such as Riau. According to data from the Ministry of Environment and Forestry (Decree No. SK.903/MENLHK/SETJEN/PLA.2/12/2016), Riau Province contains approximately 5.4 million hectares of

designated forest area. Land cover data from 2022 indicate that production forests account for 82.99% (4,493,538 ha), protected forests for 4.24% (229,806 ha), national parks for 4.09% (221,506 ha), and wildlife sanctuaries for 6.83% (369,639 ha) of this total. Between 2021 and 2022, forest cover declined by 71,015 ha (4.45%), primarily due to conversion to plantations and timber estates.

Beyond land conversion, recurring forest and land fires have substantially accelerated deforestation.

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Monitoring data from KLHK's Sipongi system recorded 90,550 hectares burned in 2019 alone, though this figure declined to 4,915 hectares by 2022 following intensified suppression efforts. Indonesia's most catastrophic fire event occurred in 2015, when 2.6 million hectares—including 869,754 hectares of peatland—were consumed by fires across Sumatra and Kalimantan (BNPB, 2013). The World Bank estimated economic losses from this single event at IDR 221 trillion (World Bank, 2016), excluding health, education, and carbon emission costs (Miettinen et al., 2017; Field et al., 2016).

The consequences of these fires extend across ecological, economic, and social dimensions. Ecologically, fires release catastrophic greenhouse gas emissions—CO₂ emissions from fires rose from 37.2 million tons in 2018 to 72.1 million tons in 2019—and destroy biodiversity through habitat loss, hydrological disruption, and permanent peat degradation (Arisanty et al., 2022). Economically, fires impair livelihoods, disrupt transportation and trade, and generate enormous government expenditures on suppression and rehabilitation. Socially, smoke-induced acute respiratory infections (ISPA) remain a chronic public health burden for millions of Riau residents.

Despite these consequences, existing legal and institutional frameworks for forest fire prevention remain fragmented and weakly enforced. Scholars have identified persistent gaps in the enforcement of Law No. 32 Year 2009 on Environmental Protection and Management, Law No. 41 Year 1999 on Forestry, and Presidential Instruction No. 11 Year 2015 on Karhutla Control (Gunawan et al., 2016; Akhmaddhian, 2016; Zainal et al., 2017). The challenge is not only legislative but also structural—enforcement capacity is dispersed across numerous agencies without clear coordination protocols—and cultural, as community legal awareness remains low and traditional slash-and-burn practices persist (Meiwanda, 2016; Jufri et al., 2018).

To address these multidimensional challenges, this study develops and proposes a model for the establishment of Fire-Free Zones (Wilayah Bebas dari Kebakaran/WBK) in Riau Province. The model is theoretically grounded in Lawrence M. Friedman's Legal System Theory (1975), which postulates that an effective legal system must simultaneously function at the levels of legal structure (institutions and enforcement agencies), legal substance (laws and regulations), and legal culture (community values and behaviors). This framework is particularly suitable for addressing Karhutla because it emphasizes that legal rules alone are insufficient without corresponding institutional capacity and social compliance.

The specific objectives of this study are threefold: (1) to identify and assess the ecological, economic, and social impacts of forest and land fires in Riau Province; (2) to examine the structural, substantive, and cultural barriers that impede the formation of fire-free zones; and (3) to develop a

comprehensive, operationalizable model for WBK establishment that can serve as a replicable template for regional policy.

2. LITERATURE REVIEW

2.1. Lawrence M. Friedman's Legal System Theory

Friedman (1975) conceived the legal system as a complex organism composed of three interdependent elements: legal structure, legal substance, and legal culture. Legal structure encompasses the institutional architecture of law—courts, enforcement agencies, prosecutorial bodies, and their respective jurisdictions and competencies. Legal substance refers to the totality of legal rules, norms, statutes, and judicial precedents that govern behavior. Legal culture denotes the social attitudes, values, and behaviors that determine whether and how citizens engage with, comply with, or circumvent the law.

Friedman argued that dysfunction in any of these three dimensions undermines the entire system. A strong legislative substance (e.g., comprehensive fire prevention laws) is rendered ineffective if structural enforcement is weak or if cultural attitudes normalize fire-setting. Ansori (2018) and Hutomo & Soge (2021) have extended this framework to Indonesian environmental governance contexts, demonstrating that legal non-compliance in resource extraction sectors frequently reflects failures of legal culture rather than inadequate legislative frameworks. This study applies all three dimensions to the specific challenge of establishing fire-free zones in a peatland province.

2.2. Disaster Mitigation Theory

Mitigation theory conceptualizes risk reduction as a proactive, continuous process encompassing both structural interventions (physical infrastructure, early warning systems) and non-structural measures (community education, zoning regulations, institutional coordination) (Coppola, 2007; Adiyoso, 2018; Sularso, 2021). Under Indonesia's Disaster Management Law No. 24/2007, mitigation is defined as a series of efforts to reduce disaster risk, whether natural or anthropogenic. For fire management, mitigation strategies include: (i) hotspot mapping and remote monitoring; (ii) early warning systems; (iii) community socialization and capacity building; (iv) land-use zoning and permitting controls; and (v) multi-stakeholder coordination protocols (Rahmayanti, 2020).

The integration of mitigation theory with Friedman's legal framework is a central novelty of this study. While previous research has examined either legal enforcement mechanisms or community-based mitigation in isolation (Budinarsih et al., 2022; Maksum, 2020), this study proposes a unified model that operationalizes mitigation at the structural, substantive, and cultural levels of a legal system.

2.3. Forest and Peatland Fires: Drivers and Consequences

Indonesian forest fires are predominantly (99.9%) anthropogenic, driven by land clearing for agriculture and plantations using slash-and-burn techniques, land tenure conflicts, and negligent use of fire in resource extraction activities (Adinugroho et al., 2005; BNPB, 2013). Peatland fires are particularly destructive: peat stores enormous quantities of carbon across its biomass, litter layer, and subsurface strata, and fires release this carbon at rates unmatched by most terrestrial ecosystems (Usup, 2015; JICA, 2017). Drainage-induced drying of peatlands creates ideal conditions for deep, smoldering subsurface fires that are notoriously difficult to extinguish (Sandhyavetri, 2017).

Economic consequences of fires include: destruction of agricultural land and crop loss; disruption of aviation and road transportation; reduced regional tourism revenue; and massive government expenditure on suppression, rehabilitation, and disaster relief (Heriyanto et al., 2022; Adinugroho et al., 2005). Social consequences encompass elevated incidence of acute respiratory infections (ISPA), psychological stress among affected communities, displacement, and inter-community conflict over land (Gaveau et al., 2014; Kim et al., 2015; Reddington et al., 2014).

2.4. Previous Studies and Research Gap

Existing literature has examined Karhutla from multiple disciplinary angles. Institutional studies have documented coordination failures among the 25 government agencies mandated by Presidential Instruction No. 11/2015 (Thoha et al., 2015; Harun, 2016). Legal studies have identified enforcement gaps in environmental criminal law (Akhmaddhian, 2016; Machmud, 2011). Community-based studies have highlighted the importance of local fire brigades (Masyarakat Peduli Api/MPA) and indigenous ecological knowledge (Fadlillah et al., 2017; Lisman et al., 2017). SWOT-based institutional models have been proposed for specific districts (Jufri et al., 2018; Darmawan et al., 2016). However, no previous study has synthesized legal system theory, disaster mitigation theory, and SWOT strategic analysis into a provincial-level Fire-Free Zone formation model. This study addresses this gap.

3. RESEARCH METHODOLOGY

3.1. Study Area

This study was conducted in Riau Province, located on the eastern coast of Sumatra Island, Indonesia (approximately 1°05'00" N – 0°20'00" S latitude; 100°00'00" E – 105°05'00" E longitude). The province encompasses 12 regencies/cities and covers a total area of 87,023.66 km². Riau has the second-largest peatland area in Indonesia, making it particularly vulnerable to recurrent fire events. Annual rainfall ranges from 1,700 to 3,000 mm but is unevenly

distributed, with distinct dry seasons that elevate fire risk.

3.2. Research Design

A mixed-methods research design was employed to capture both the quantitative dimensions of fire impacts and stakeholder attitudes, and the qualitative nuances of legal and institutional barriers. The quantitative component used structured questionnaires with a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), while the qualitative component used in-depth semi-structured interviews and document analysis of relevant legislation, court records, and government reports.

3.3. Sampling and Respondents

A purposive sampling approach was used to identify 58 key respondents representing five stakeholder categories: local government officials (provincial and district levels), law enforcement personnel (police, prosecutors, judiciary), plantation companies (both corporate and smallholder operations), community leaders (village heads, adat leaders, religious figures), and environmental organizations (NGOs and academic institutions). This sample composition was chosen to capture the diverse perspectives necessary for a comprehensive legal system analysis.

Respondent Category	Number	Percentage (%)
Local Government Officials	15	25.9%
Law Enforcement Personnel	12	20.7%
Plantation Companies	10	17.2%
Community Leaders	14	24.1%
Environmental Organizations	7	12.1%
Total	58	100.0%

Table 1. Distribution of Research Respondents

3.4. Data Collection

Primary data were collected through: (1) structured questionnaires distributed to all 58 respondents covering fire impacts, legal awareness, institutional performance, and WBK formation factors; (2) in-depth interviews with 20 purposively selected

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key informants from each stakeholder group; and (3) field observation of fire-affected areas and institutional coordination meetings. Secondary data were obtained from the Ministry of Environment and Forestry (KLHK), the National Disaster Management Agency (BNPB), Riau Provincial Government reports, police and prosecutorial records, and peer-reviewed academic literature.

3.5. Data Analysis

Three sequential analytical approaches were applied:

- Validity testing: Pearson Product Moment Correlation ($r > 0.3$ threshold) was used to assess the validity of all questionnaire items.
- Reliability testing: Cronbach's Alpha ($\alpha > 0.6$) was computed to confirm internal consistency across instrument scales.
- Normality testing: The Monte Carlo simulation approach was employed to verify data normality, appropriate for the study's sample size ($n=58$).
- SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats were systematically identified from stakeholder survey data and interview findings. Each factor was scored and weighted to produce an Internal Factor Evaluation (IFE) matrix and External Factor Evaluation (EFE) matrix, enabling strategic positioning in a Cartesian quadrant diagram.

Qualitative data from interviews and documents were analyzed through thematic coding aligned with Friedman's three legal system dimensions, enabling triangulation with quantitative findings.

4. RESULTS

4.1. Data Validity, Reliability, and Normality

All questionnaire items demonstrated satisfactory validity, with Pearson correlation coefficients exceeding the critical threshold of $r > 0.3$ ($p < 0.05$). Reliability testing yielded Cronbach's Alpha values above 0.60 for all subscales, confirming adequate internal consistency. The Monte Carlo normality test confirmed that the data distribution was sufficiently normal for parametric analysis.

4.2. Ecological Impacts of Forest and Land Fires

Respondent assessments of ecological impacts were largely negative, with a majority rating fire consequences as serious to very serious across multiple dimensions. Key ecological impacts identified included:

- Carbon emissions: Fires in Riau released an estimated 37.2 million tons of CO₂ in 2018,

escalating to 72.1 million tons in 2019, contributing significantly to national greenhouse gas inventories.

- Biodiversity loss: Repeated fires destroy habitats for endemic Sumatran fauna including orangutans, Sumatran tigers, and diverse avian species, with smaller organisms facing the highest mortality risk.
- Peat degradation: Irreversible physicochemical changes to burned peat layers—including elevated pH, loss of soil organic carbon, disrupted microbial decomposition, and permanent subsidence (land sinking)—were widely observed.
- Hydrological disruption: Fires reduce soil water retention capacity, increase surface runoff and sedimentation, and—in coastal areas—accelerate saltwater intrusion into peatlands.
- Air quality deterioration: Based on the Air Pollution Standard Index (ISPU), fire-season haze episodes in Riau regularly exceeded hazardous thresholds, with acute respiratory infection (ISPA) cases spiking annually during fire events (2019–2024 data).

Ecological Impact Dimension	Mean Score (1–5)	Category
Carbon Emission Increase	3.71	High Impact
Biodiversity Loss	3.57	High Impact
Peat Physicochemical Degradation	3.55	High Impact
Hydrological Disruption	3.62	High Impact
Air Quality Deterioration (ISPA)	3.60	High Impact
Overall Ecological Impact	3.61	High Impact

Table 2. Respondent Assessment of Ecological Impacts

4.3. Economic and Social Impacts

Economic consequences of fires were assessed across six impact categories. Respondents consistently rated income reduction, transportation disruption, and

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agricultural destruction as the most severe economic impacts, with mean scores ranging from 3.33 to 3.71 on the 5-point scale.

- Income losses: Disruption to farming, fishing, and forestry-dependent livelihoods substantially reduced household income, particularly in rural communities adjacent to fire-prone areas.
- Transportation disruption: Smoke-induced visibility reduction caused flight cancellations, road accidents, and river transport halts, with cascading effects on regional trade.
- Agricultural destruction: The 2015 catastrophic fire season destroyed crops across hundreds of thousands of hectares, causing acute food security stress.
- Government expenditure: Fire suppression costs—especially for technology-intensive methods (fixed-wing aircraft, helicopters, water-bombing)—imposed heavy fiscal burdens on provincial and national budgets, separate from post-fire rehabilitation costs.
- Social conflict: Inter-community tensions over land rights and fire attribution, as well as diplomatic friction with Singapore and Malaysia due to transboundary haze, were recurrently noted by respondents.
- Public health burden: ISPA incidence in Riau Province during 2019–2024 was strongly correlated with fire intensity, imposing significant costs on the public health system.

4.4. Barriers to Fire-Free Zone Formation

Qualitative interviews identified three categories of barriers aligned with Friedman's legal system dimensions:

4.4.1. Legal Structure Barriers

- Fragmented institutional coordination: Responsibility for Karhutla control is distributed across 25 government agencies under Presidential Instruction No. 11/2015, without a unified command structure or clear inter-agency communication protocols.
- Insufficient law enforcement capacity: Field inspection teams (Polhut) are understaffed and undertrained; prosecutorial offices lack technical expertise in environmental crimes; and court processes for corporate fire perpetrators are lengthy and often inconclusive.
- Inadequate licensing control: Concession licenses granted to plantation companies frequently contain insufficient environmental safeguards, and monitoring of license conditions by regional forestry offices is inconsistent.

- Weak inter-governmental coordination: Communication between provincial, district, and village governments on fire prevention, early warning, and response remains poorly institutionalized.

4.4.2. Legal Substance Barriers

- Regulatory loopholes: Existing legislation (Law No. 41/1999 on Forestry; Law No. 18/2004 on Plantations; Law No. 32/2009 on Environmental Management) contains provisions that allow fire-setting under special permit conditions, undermining zero-burning principles.
- Inadequate corporate liability: Criminal liability for corporations engaged in deliberate land burning is difficult to establish under current legal procedures, enabling plantation companies to avoid accountability.
- Absence of WBK-specific legal framework: No dedicated statute or regional regulation (Perda) establishes the legal basis, criteria, implementation standards, and enforcement mechanisms specifically for Fire-Free Zones.

4.4.3. Legal Culture Barriers

- Persistence of slash-and-burn practices: Traditional land-clearing practices remain widespread among smallholder farmers, who perceive fire-setting as economically rational and culturally acceptable.
- Low legal awareness: The majority of community respondents demonstrated limited knowledge of their legal obligations under fire prevention laws, and many were unaware of applicable sanctions.
- Community-enforcement distrust: Past experiences of selective prosecution and perceived protection of large plantation companies have eroded community trust in law enforcement institutions, reducing willingness to report fire activities.
- Corporate non-compliance culture: Several plantation company respondents acknowledged that internal fire prevention protocols were implemented superficially, driven by audit compliance rather than genuine institutional commitment.

4.5. SWOT Analysis Results

The SWOT analysis synthesized findings across all stakeholder data. The weighted Internal Factor Evaluation (IFE) matrix produced a total strength score of 2.87 (Strengths: 1.95; Weaknesses: 0.92), while the External Factor Evaluation (EFE) matrix produced a total opportunity score of 2.76 (Opportunities: 1.68; Threats: 1.08). Plotting these coordinates on the Cartesian quadrant diagram positioned the WBK model in Quadrant I, indicating an

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aggressive growth strategy leveraging internal strengths to capture external opportunities.

Dimension	Internal Factors	External Factors
Positive (+)	STRENGTHS: • Strong legal mandate (Law 32/2009; Presidential Instruction 11/2015) • Functional multi-agency coordination structure • Available remote sensing technology (Sipongi/LAPAN) • Growing corporate CSR and environmental compliance	OPPORTUNITIES: • International support and funding (REDD+, GEF, bilateral aid) • Growing public environmental awareness • E-Government and digital monitoring advancement • Sustainable Development Goals alignment
Negative (-)	WEAKNESSES: • Fragmented institutional coordination • Insufficient enforcement capacity • Regulatory loopholes permitting fire-setting • Low community legal awareness	THREATS: • El Niño drought intensification due to climate change • Rapid peatland conversion for oil palm • High political economy pressure from plantation sector • Cross-boundary fire spread

Table 3. SWOT Analysis Matrix for WBK Formation in Riau Province

4.5.1. SO Strategies (Primary Strategic Direction – Quadrant I)

- Establish a dedicated Provincial Fire-Free Zone Authority (Badan WBK Provinsi) with formal legal status, unified command, and cross-agency coordination mandate.
- Formulate a specific Regional Regulation (Perda) on WBK designation, operationalizing legal basis, eligibility criteria, institutional roles, monitoring protocols, and sanctions.
- Integrate international environmental funding (REDD+, Green Climate Fund) into sustainable fire prevention programming,

including community livelihood alternatives to slash-and-burn.

- Scale up remote-sensing-based early detection systems (hotspot monitoring, satellite telemetry) linked to real-time response protocols.

4.5.2. ST Strategies (Defensive)

- Strengthen enforcement against corporate fire perpetrators through strengthened inter-agency investigation units and specialized environmental court chambers.
- Develop plantation licensing reform to mandatory zero-burning compliance conditions, with license revocation sanctions for violations.

4.5.3. WO Strategies (Improvement)

- Implement community-based fire prevention programs integrating indigenous land management knowledge with modern fire detection and suppression techniques.
- Establish inter-agency data sharing platforms and joint communication protocols using existing digital government infrastructure.

4.5.4. WT Strategies (Contingency)

- Develop climate-adaptive fire risk zoning and seasonal preparedness plans to address El Niño-intensified dry seasons.
- Strengthen bilateral and multilateral cooperation frameworks (ASEAN Agreement on Transboundary Haze Pollution) to address cross-border fire dynamics.

5. DISCUSSION

5.1. The Fire-Free Zone Formation Model

Based on the integrated findings of the SWOT analysis, Friedman's legal system analysis, and stakeholder interviews, this study proposes a comprehensive Fire-Free Zone (WBK) formation model for Riau Province. The model operates across three interconnected pillars derived from Friedman's Legal System Theory:

5.1.1. Pillar 1 – Legal Substance: Regulatory Foundation

The first pillar requires the establishment of clear, enforceable legal instruments specifically designed for fire-free zone governance. This includes: (i) a dedicated Riau Provincial Regulation (Perda) on WBK formation, specifying eligibility criteria (fire-incident frequency, peatland vulnerability index, ecosystem sensitivity), zone boundaries, and land management restrictions; (ii) revision of plantation licensing requirements to incorporate mandatory zero-

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burning conditions with administrative and criminal sanctions for violation; (iii) development of Standard Operating Procedures (SOP) for fire-free zone monitoring, reporting, and enforcement, consistent with Law No. 32/2009 and Presidential Instruction No. 11/2015; and (iv) formal adoption of the WBK concept within regional spatial planning documents (RTRW) to provide binding land-use zoning authority.

The absence of a dedicated WBK-specific legal instrument has been a critical gap, as enforcement agencies currently operate without a coherent regulatory framework explicitly mandating fire-free zone protection. Friedman (1975) emphasizes that legal substance—as the blueprint of the system—must be clear, specific, and internally consistent to enable effective enforcement. The current patchwork of forestry, plantation, and environmental laws creates interpretive ambiguity that reduces deterrence.

5.1.2. Pillar 2 – Legal Structure: Institutional Architecture

The second pillar addresses the institutional infrastructure required to operationalize WBK. The model proposes a hierarchical Bridge Structure for Fire Control (Struktur Organisasi Bridge Pengendalian Karhutla) comprising:

- Provincial-level WBK Coordination Authority: A permanent cross-ministerial body with executive authority, chaired by the Governor, integrating the Environment and Forestry Agency (DLHK), Police (Polda Riau), Prosecutor's Office (Kejaksaan Tinggi), Regional Disaster Management Agency (BPBD), and the Plantation Services Agency.
- District-level Implementation Units: Each of Riau's 12 districts/cities to establish a WBK Task Force with designated officers, equipment, and budgets for prevention, monitoring, and response.
- Village-level Community Fire Brigades (Masyarakat Peduli Api/MPA): Formally integrated with village governance structures (BUMDes, village councils) and provided with technical training, basic firefighting equipment, and operational budgets.
- Corporate Fire Prevention Obligation: Plantation companies operating within designated WBK areas to be required to establish internal fire prevention units, submit quarterly compliance reports, and maintain minimum peat water table levels.

Communication, coordination, and reporting flows within this structure should follow a standardized protocol, with real-time data sharing through integrated digital platforms linking hotspot alerts, ground verification teams, and response units. This addresses the coordination fragmentation identified as a primary structural barrier.

5.1.3. Pillar 3 – Legal Culture: Community Participation and Education

The third pillar recognizes that legal and institutional mechanisms alone are insufficient without corresponding shifts in community attitudes toward fire-setting. The model proposes a Community-Based Fire Prevention Education Program (Model Edukasi Pencegahan Karhutla Berbasis Masyarakat) with four integrated components:

- Formal Education Integration: Incorporation of fire prevention and environmental law into the school curriculum at primary, junior high, and senior high levels in all Riau schools.
- Village-Level Socialization: Regular community dialogues, field demonstrations of alternative land-clearing techniques (mechanical clearing, biochar application), and dissemination of legal awareness materials on fire prohibition and applicable sanctions.
- Economic Incentive Programs: Development of alternative livelihood programs for smallholder farmers currently dependent on slash-and-burn practices, including provision of mechanical land-clearing equipment subsidies and access to fire-free agriculture certification markets.
- Community Monitoring and Reporting Systems: Establishment of anonymous digital reporting channels (mobile app, SMS hotlines) allowing community members to report fire activities without fear of reprisal, with guaranteed follow-up by enforcement authorities.

This pillar directly addresses the legal culture dimension identified by Friedman (1975) as the social driver of legal compliance or non-compliance. Research by Shalihah (2017) and Hutomo & Soge (2021) demonstrates that legal culture transformation requires sustained, multi-channel engagement rather than one-time socialization campaigns.

5.2. Implications for Policy and Practice

The proposed WBK formation model has several significant implications. For regional governments, the model provides a structured, phased implementation pathway—beginning with Perda formulation, followed by institutional establishment, and concluding with community program rollout—that can be adapted to different districts' fire risk profiles. For law enforcement agencies, the model clarifies inter-institutional roles and establishes accountability mechanisms that have historically been absent in Karhutla governance. For the plantation sector, the model creates predictable compliance requirements that, while initially burdensome, ultimately reduce legal and reputational risks associated with fire-setting incidents.

Internationally, the WBK model's alignment with REDD+ principles and ASEAN Transboundary

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Haze Agreement obligations creates pathways for accessing green finance and diplomatic cooperation. The 2015 Karhutla event—which generated diplomatic protests from Singapore, Malaysia, and Thailand—demonstrated the cross-border stakes of fire governance failure (Miettinen et al., 2017). A successful provincial WBK implementation in Riau could serve as a template for other peatland provinces in Sumatra and Kalimantan.

5.3. Study Limitations and Future Research

This study has several limitations that should be acknowledged. First, the sample of 58 respondents, while purposively selected to represent diverse stakeholder groups, may not fully capture perspectives from more remote and fire-affected communities. Future research should incorporate larger, more geographically distributed samples. Second, the SWOT analysis, while systematic, is inherently subjective in its factor weighting; future studies could employ more rigorous methods such as Analytical Hierarchy Process (AHP) or System Dynamics modeling to strengthen strategic prioritization. Third, this study does not include longitudinal data on fire incidence following WBK implementation, as the model is proposed rather than evaluated empirically. Longitudinal evaluation studies following any real-world WBK implementation would be highly valuable.

6. CONCLUSIONS

This study investigated the ecological, economic, and social impacts of forest and land fires in Riau Province and examined the structural, substantive, and cultural barriers to establishing Fire-Free Zones. Applying Lawrence M. Friedman's Legal System Theory and SWOT analysis, the research developed a comprehensive Fire-Free Zone (WBK) formation model positioned in SWOT Quadrant I, indicating strong strategic potential.

The central finding is that sustainable Karhutla prevention requires simultaneous and integrated intervention across all three dimensions of the legal system. Legal substance must provide a clear, WBK-specific regulatory framework. Legal structure must establish a unified, hierarchical enforcement and coordination architecture from the provincial to village level. Legal culture must be transformed through sustained education, economic incentives, and community participation programs that reduce reliance on fire-based land clearing and increase social accountability for fire prevention.

The study makes a dual contribution: theoretically, it advances the application of Friedman's Legal System Theory to environmental governance and fire management scholarship; practically, it provides an operationalizable model that policymakers, law enforcement agencies, and community organizations in Riau Province and comparable peatland regions can

adapt and implement to achieve fire-free zone designation and sustainable forest governance.

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