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Forest fire disasters and ecological crisis: Impacts on women

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ABSTRACT

Background: Forest and land fires in Riau Province are a recurring issue with significant consequences for the economy, society, and environment. This research examines the impacts of these fires and explores the role of women in disaster mitigation efforts. **Method**: The research used a Desk Study method, collecting secondary data from government reports, scientific journals, and previous studies to conduct a descriptive analysis. **Findings**: The fires result in substantial material losses, including damage to natural habitats, loss of commercial timber, extinction of local wildlife, and health issues for local communities, with women experiencing disproportionate impacts. However, women also have considerable potential as agents of change in disaster mitigation. Their involvement in sustainable natural resource management and policy-making processes can enhance community resilience to forest and land fires. **Conclusion**: Involving women in disaster mitigation efforts, particularly in sustainable resource management and policy-making, can lead to more effective and holistic strategies for managing forest and land fires. **Novelty/Originality of this article**: This study provides new insights into the importance of gender inclusion in disaster risk reduction, emphasizing the potential for women's active participation in mitigating the impacts of forest and land fires in Riau Province.

KEYWORDS: forest and land fires; socio-economic impacts; women; Riau Province; disaster risk reduction.

1. Introduction

Forest fires are one of the serious problems that have not yet been properly addressed to this day. Forest fires are events that almost occur every year during the dry season. This situation results in damage and economic, social, and environmental losses that will hinder the development progress and regional expansion of Riau Province, necessitating efforts to control forest and land fires (Marlina, 2022). Forest fires, occur every year and are predicted to increase in several regions of Indonesia during the dry season. This follows the La Nina weather phenomenon which is expected to weaken and become neutral from March to April 2023. Moreover, hotspots have already appeared in some areas such as Riau, West Kalimantan, and Central Kalimantan, resulting in forest fires. According to the Ministry of Environment and Forestry (KLHK), the forest fires incidents at the beginning of 2023 have increased compared to the same period last year. KLHK records show that after a major fire incident in 2019 which burned an area reaching 1.6 million hectares, there has been a decreasing trend in burnt forested area size. In 2020 it dropped down to 296,000 hectares

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then rose again to 358,000 hectares in 2021 before falling once more to 204,000 hectares in 2022.

Forest is also an ecosystem that holds an important role in maintaining the climate's stability while serving as a habitat for a majority of the world's biodiversity. Indonesia has one of the world's largest tropical peatlands with a total area of approximately 21-22 million hectares (1.6 times larger than Java Island). Tropical peatlands capable of saving carbon 20 times more compared to normal tropical forests. This is why Indonesian forests greatly influence the world's climate.2 Due tots forests' abundant natural resources, Indonesia has a tremendous carbon reserve saved in forest biomes, amounting to 12.477 million metrics of approximately 21-22 million hectares (1.6 times larger than Java Island). Tropical peatlands capable of saving carbon 20 times more compared to normal tropical forests. This is why Indonesian forests greatly influence the world's climate.2 Due to its forests' abundant natural resources, Indonesia has a tremendous carbon reserve saved in forest biomes, amounting to 12.477 million metrics of carbon.

The Riau Province has become one of the areas prone to forest and peatland fires, as it contains approximately 50 percent of peatland area out of the total area of Riau Province, or about 4 million hectares of peatland out of approximately 9 million hectares that make up the territory of Riau Province. These peatlands are highly susceptible to fires due to their unique composition and the widespread practice of draining them for agriculture, which makes them drier and more flammable (Okamoto et al., 2023). Riau province is situated in a strategic position within Sumatra's central eastern coast and has been subjected to recurrent episodes of hazardous forest fires over recent years. The ecology of Riau is key for its rich peatland forests which serve as carbon sinks crucial for global climate regulation. However, this vital ecosystem is increasingly threatened by both man-made and natural forest fires that cause extensive damage, with shrubland resulting from deforestation identified as the most fire-prone land cover type, while conserved peat swamp forests show greater resistance to fires (Ishihara et al., 2017). The conversion of peat swamp forests to other land uses further increases their vulnerability to fires, creating a precarious situation that escalates into a crisis with far-reaching consequences for ecology as well as human health, livelihoods, and social structures—with women bearing a disproportionate brunt of these adversities.

The forest fires in Riau, Indonesia, have significant environmental, social, and economic impacts. These fires are often linked to human activities, particularly land clearing for agriculture and plantations, which is a common practice due to its cost-effectiveness and speed (Chazdon & Guariguata, 2016). Despite efforts by the Riau Provincial Government to mitigate these fires through policies and funding, technical and regulatory challenges persist, leading to recurring fire incidents.

The situation became particularly notable since the late 1990s when massive burning caused regional environmental disasters affecting several Southeast Asian countries with haze pollution. One significant event occurred in 1997-98 due to an El Niño-induced drought, which led to devastating fires across Southeast Asia. These fires resulted in severe air quality issues known as the "haze crisis," significantly impacting human health and causing widespread regional disruptions.

The pattern of fire events continued throughout the 2000s (2005, 2006), repeating almost yearly with varying intensity. Serious episodes occurred again during 2013 and 2015 when another major haze event impacted Singapore, Malaysia, southern Thailand and even reached parts as far south as Australia. In 2015, the area of land burnt in Riau Province reached 183,000 hectares, which was the most extensive fire in Riau Province. In 2019, forest and peatland fires in Riau Province affected 90,000 hectares of land. In the year 2020, forest and peatland fires occurred over an area of 21 hectares (Anhar et al., 2022).

Riau is the second province after Papua to have the largest peatland area in Indonesia. In line with the vast expanse of peatlands it possesses, Riau also contributes the most fire hotspots during several forest and land fire events in Indonesia. Most of these hotspots are found on peatlands. In 2013, there were 624 (73% of all hotspots in Riau) fire hotspots

discovered on peatlands. And in 2014, the number of hotspots on peatlands increased to 5,461 (92% of all fire hotspots in Riau).

Forest and land fires in Riau Province have caused damage and various other negative consequences felt by the community. The damage that occurs, for example, includes the loss of various types of wood, extinction of animals, birds, destruction of rattan and resin, and the occurrence of global warming experienced by the people of Riau every year (Pasai, 2020). For nearly two decades, residents have been forced to live surrounded by smoke due to forest and land fires that hit Riau Province. It is suspected that smoke attacks have worsened in the last five years. The smoke attack from August 2015 until the end of 2015 coinciding with El Nino paralyzed Pekanbaru City. Dangerous smoke consisting of a mixture between gases, particles and other toxic chemicals has decreased the air quality in the city to very dangerous levels threatening the health of about 1 million residents of Pekanbaru City. According to data released by Pekanbaru City Health Office, from July to August in 2019 there were 7,745 people suffering from acute respiratory infections (ISPA). The increase in ISPA patients was caused by haze due to the forest and land fires while there was not as significant an increase compared to previous years with only an additional 900 people per month. In August 2018 alone there were more than 3,000 cases reported. This shows that from aforementioned data there is a fairly high number resulting from forest and land fires.

The impact of the forest and land fire has caused a thick haze, disrupting social and economic activities as well as public health. One of the groups affected by this disaster is women. The physical impacts of the forest fires include loss of life, eye diseases, respiratory tract diseases, and cardiovascular diseases. Smoke and dust from forest fires produce toxic gases such as CO¬2 and O3. When inhaled, these substances can cause respiratory problems and irritate the eyes. Post-disaster impacts felt by women tend to have potential continued risks such as increased loss of livelihoods, gender-based violence, and even loss of life after natural disasters occur. It is recorded that sixty to seventy percent of disaster victims in Indonesia are women and children. However, it is women who experience deeper disconnection from their environment. With nature being damaged, it becomes increasingly difficult for women to cooperate with nature.

"Nature and women both produce and reproduce life. Women are connected to nature in their roles as providers of food/basic necessities and as caretakers of survival. Nature and women are life-givers, not only because women biologically produce and reproduce, but also through their social roles in providing for living needs. With the degradation of nature, it becomes increasingly difficult for women to work together with the environment. There are now few women who plant rice. Another example of the suffering experienced by women occurs on palm oil plantations. On palm oil plantations run by small investors, typically one or two families are placed to guard and maintain the plantation. Almost all tasks in these palm oil gardens are performed by men. From land clearing, seeding, planting, weeding, fertilizing, harvesting to transporting palm fruit to the factories is almost entirely done by men. Women's labor in this production process—and even this is generally done by men—occurs during seedling stages, weeding, and fertilizing phases. Therefore, wages given to these families are based on the male (husband's) capacity within that family. Women become increasingly pushed into domestic roles; they become less involved in economic life; they become more dependent on men—this causes male superiority over women to be further perpetuated (Warah & Hamid, 2023).

The consequences of forest and land fires reveal that women's circumstances are often overlooked, with the prevailing belief that both genders encounter identical challenges. However, this is not the case in reality; there are notable variances in what men and women endure. These disparities extend beyond mere biological factors to encompass unique requirements and responsibilities. Such distinctions have significant implications on women's rights, duties, experiences, and access—particularly in relation to recovery initiatives post-disaster.

The primary aim of this research is to investigate more deeply into how women are affected by these incidents. It goes further than examining biological differences; it seeks an elaborate exploration of women's specific needs and their roles during such calamities. The

goal is to enhance understanding of gender-based disparities amid natural disasters and underscore the pivotal role women play in overcoming obstacles in the aftermath. By adopting this comprehensive approach, the study hopes to contribute significantly towards crafting policies that are inclusive and effective—laying a solid groundwork for gender-responsive rehabilitation and reconstruction strategies after forest and land fires occur.

2. Methods

2.1 Data collection method

This research employed the Desk Study approach for data collection. This method involves procuring data and information by reviewing and evaluating secondary sources. These sources include relevant reports, scholarly journals, previous research outcomes, and academic articles. Within the scope of the research, secondary data will be relied upon, focusing on forest and land fires and their impacts, with an emphasis on how women are affected. Such secondary data consists of disclosures found in literature reviews, official documentation, and prior research findings.

2.2 Data gathering process

The research employs a comprehensive approach to compiling necessary data through an extensive review of multiple literary works. The primary focus of this data collection process is to examine incidents related to forest and land fires and their profound impacts on women's experiences and vulnerabilities. Particular attention is directed towards understanding the multifaceted consequences of environmental disasters on female populations, with a specific emphasis on the critical year of 2015. During this year, Riau province experienced its most catastrophic forest and land fires, which served as a pivotal case study for analyzing the gendered dimensions of environmental challenges and their social implications.

2.3 Data analysis method

Our analysis includes both qualitative descriptive analysis as well as quantitative descriptive analysis techniques. Qualitative description helps delineate features specific to forest and land fires by comparing different literary sources; it also aids in comprehending the ecological disaster's effects—especially those that affect women—from such events. On the quantitative side, this research aim to ascertain loss magnitude by seeking figures that represent how much women have suffered due to these calamities within Riau province.

2.4 Location of study

Our study takes place in Riau Province located in Sumatra between latitudes 01° 05'00" S - 02° 25'00" N and longitudes 100° 00'00" E - 105° 05'00" E. Spanning roughly 9.4 million hectares where nearly half is composed of lowland peatlands influenced by tidal changes making them among Sumatra's most expansive peatland regions. Over recent decades there has been an extensive exploitation of Riau's forests which has included opening lands for plantations often through cost-effective but environmentally damaging practices like burning leading to a heightened risk of forest fire occurrences; a notable outbreak occurred in 2015 causing significant materialistic and non-materialistic damages

The selection of Sumatra, and specifically Riau Province, as the research focal point is deliberate and multifaceted. Sumatra represents a critical case study for understanding forest fire dynamics due to several key factors: First, the island contains the largest concentration of tropical peatlands in Indonesia, which are particularly susceptible to fires and carbon emissions. These peatlands, representing approximately 36% of Indonesia's total peatland area, are characterized by their high carbon density and extreme

vulnerability to environmental disruptions. Second, Sumatra has experienced the most intensive land-use transformations, with extensive forest conversions for palm oil plantations, pulp and paper industries, and agricultural expansions. This anthropogenic pressure creates a unique environmental context that amplifies forest fire risks. Moreover, Riau Province specifically emerges as an exemplary research site due to its historical significance in forest fire occurrences. Between 2010 and 2020, the province consistently ranked among the top regions in Indonesia for forest fire incidents, making it an ideal location for examining the intricate relationships between environmental changes, economic activities, and gender-specific vulnerabilities. The province's complex ecological landscape, characterized by extensive peatlands and diverse forest ecosystems, provides a comprehensive lens through which to analyze the multidimensional impacts of forest fires.

3. Results and Discussions

Forest ecosystems are essential for maintaining global biodiversity, regulating climate patterns, and supporting human economies. However, in recent decades these ecological havens have come under threat from an increase in both natural and anthropogenic activities leading to devastating wildfires. These events can lead to a widespread ecological crisis with long-term repercussions that extend beyond immediate environmental damage. The sustainability of Indonesia's forest ecosystems is increasingly threatened, with significant impacts on natural resources including valuable timber loss, degradation of forest plantations, and extensive deforestation. These changes have resulted in diminished forest protective functions, increased soil erosion, and degraded water resources across affected regions (Yulianti et al., 2024).

Forest fire incidents have become an annual climate disaster that the government has come to accept. The environmental characteristics that influence forest and land fires are land cover, rainfall, elevation, land slope, river networks, and road accessibility (Geist & Lambin, 2002). For nearly two decades, communities especially in Sumatra, Kalimantan, and Papua have felt the impact of haze resulting from burning forests and land. In Riau Province alone, 49,266 hectares were burned with 90 hotspots detected as of August 2019, creating a significant ecological crisis affecting both the environment and local communities (Nailufar & Rahmawati, 2022).

According to data released by the Central Statistics Agency (2025), the extent of forests in Indonesia reached 101.22 million hectares in 2021. This figure is equivalent to 52.80% of the total land area of Indonesia which amounts to 191.69 million hectares. Compared to the year 2000 when the tree cover area in Indonesia was 161 million hectares, this means there has been a reduction of more than 50 million hectares of forest cover in Indonesia over a span of 20 years. These changes have led to significant biodiversity loss, altering biogeochemical cycles and fundamentally changing ecosystem structures and functions (Weeks et al., 2023). The fires have caused extensive habitat destruction for native species, disrupting local food chains and ecosystem balance (Yulianti et al., 2024).

Forest and land burning events are often carried out with the aim of changing land allocation. The Food and Agriculture Organization of the United Nations (FAO UN) recorded that in 2011, Indonesia released 61.6% of its Greenhouse Gas (GHG) emissions caused by changes in land allocation and forestry activities. The fires release dangerous pollutants including particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), and toxic compounds like dioxins and polyaromatic hydrocarbons, severely degrading air and water quality (Hajek et al., 2021). In 2015, Global Forest Watch Fires revealed that more than half of the fires occurred on peatlands. Peatland fires have an extremely significant impact on increasing greenhouse gas emissions due to the characteristics of peatlands formed from organic material as an accumulation of decomposed organic matter that has piled up over thousands of years; when dry, organic material tends to burn more easily and is difficult to extinguish.

Peatland fires are a source of 90% of the resulting smoke, contributing significantly to increased carbon emissions. The smoke contains harmful substances like carbon monoxide

and other toxic chemicals, leading to respiratory problems and potentially interfering with fetal development, particularly affecting women and pregnant mothers (Nailufar & Rahmawati, 2022). In October 2015, daily emissions from forest fires in Indonesia exceeded those from the entire economy of the United States, or more than 15.95 million tons of CO2 per day. This places Indonesia in the position as one of four countries with the largest gas emissions in the world. This is a sad fact for a country with the largest tropical peat forest area in the world.

The conversion of peatland through burning leads to the drying out of the peat and the release of a massive amount of carbon into the atmosphere. This accelerates the depletion of the ozone layer, causing an increase in Earth's temperature due to direct solar radiation received without any dampening effect from the ozone layer. The sun's rays that reach Earth are then reflected and bounce back towards it, leading to a rise in temperature on our planet. This condition is known as the greenhouse effect. The occurrence of the greenhouse effect results in unstable climate conditions, with extreme weather changes occurring rapidly across various areas, subsequently contributing to crop failures in various cultivated plants and eventually leading to food scarcity. Additionally, rising temperatures on Earth cause polar ice caps to melt, which leads to rising sea levels. The increasing sea levels can submerge islands and cause flood disasters due to high tides. This illustrates how significant forest fires and burning peatlands in Indonesia are for global climate change. Damage caused by forest fires greatly affects everything that resides within them as well as humans who rely on forests for their livelihoods, particularly women communities because of their close relationship with nature.

Wildfires in tropical forests cause significant devastation, impacting the environment, economy, and communities across various regions. Although the reasons behind these tropical fires are extensively recorded in literature, they are examined through the lenses of numerous disciplines. Each of these studies often concentrates on particular aspects of a broader issue, potentially restricting a holistic comprehension of wildfires as intricate systems interwoven with both ecological and societal dimensions. This ecological crisis demonstrates the need for integrated management approaches that consider both environmental and social impacts, particularly focusing on vulnerable populations most affected by these environmental changes (Yulianti et al., 2024).

3.1 Women as victims

Forest fires in Riau Province have created a significant ecological crisis, with profound impacts on the environment and local communities, particularly women. The fires have led to severe air pollution, health issues, and economic challenges, disproportionately affecting women due to their roles in society.

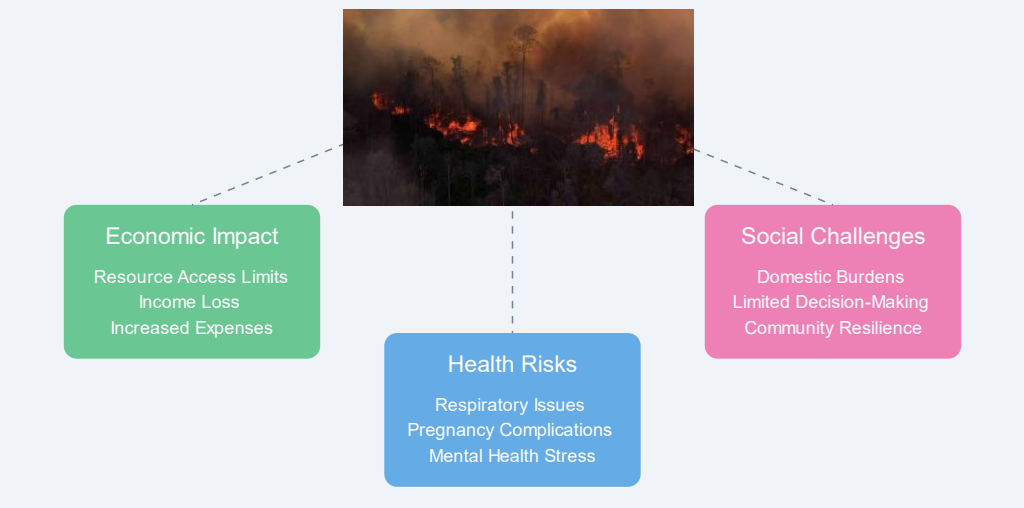

Fig. 1 Impact of forest fires on women in Riau Province

Women in Riau are often the primary caregivers and are directly involved in domestic and community responsibilities, making them more vulnerable to the adverse effects of forest fires. This situation necessitates a comprehensive understanding of the ecological crisis and its gendered impacts, as well as the strategies employed to mitigate these effects. The infographic in Figure 1 illustrates the multifaceted impacts of forest fires on women in Riau Province, revealing a complex web of challenges across three critical domains: economic, health, and social dimensions.

3.1.1 Gendered economic vulnerabilities and resource access barriers

Forest fires and corporate activities in Riau have created severe economic hardships and resource access challenges for women. As companies begin operations, locals face restricted access to forests, with security guards and dogs preventing entry to areas traditionally used for gathering resources. This particularly impacts women who, due to their domestic roles, are responsible for fulfilling family needs for food and medicine. When companies restrict forest access, "women are considered responsible to fulfil the family's food and medicine needs, and now their access to the forests—as a source of food and herbal medicines—becomes more dangerous and limited."

The economic burden intensifies through increased household expenses, particularly related to water access. When water sources become polluted from plantation activities, women must find alternatives, often requiring the purchase of clean water, leading to increased household expenses. This financial pressure is particularly acute since women typically manage household finances as part of their domestic responsibilities. The situation becomes more challenging when the primary breadwinner falls ill due to fire-related health issues, forcing women to assume additional economic responsibilities while maintaining their caregiving duties (Marlina, 2022).

Women engaged in forest-based livelihoods face particular economic hardships due to resource destruction. Those involved in traditional crafting with forest materials experience direct income losses when fires destroy their raw materials (López-Serrano et al., 2018). Their vulnerability is further heightened by socio-economic factors and pre-existing health conditions, making them more susceptible to fire impacts (Kumar et al., 2021).

Infrastructure limitations compound these challenges. In Pelalawan District, the lack of electricity forces women to rely on diesel generators for domestic work, extending their working hours significantly. Despite their active involvement in firefighting efforts and advocacy against companies responsible for forest fires, women are often excluded from decision-making processes related to forest management (Nailufar & Rahmawati, 2022). This exclusion perpetuates a cycle of economic marginalization, as women's perspectives on sustainable resource management and alternative economic opportunities remain unheard.

The economic disparity between company staff and local residents remains stark, despite years of plantation operations in these areas. This situation particularly affects women who must balance increased economic pressures with heightened domestic responsibilities, especially when family members fall ill due to fire-related health issues (Nailufar & Rahmawati, 2022). This multifaceted economic impact demonstrates how forest fires disproportionately affect women's economic security and access to essential resources.

3.1.2 Health and environmental vulnerabilities: Gendered impacts of forest fires in Riau

Forest fires in Riau Province create disproportionate health and environmental hazards for women. By August 2019, with 49,266 hectares burned and 90 hotspots detected, air pollution particularly affected women and other vulnerable groups (Nailufar & Rahmawati, 2022). The smoke, containing over 40 pollutants like carbon monoxide, poses heightened risks for pregnant women, potentially causing respiratory complications, preterm birth, low birth weight, and developmental anomalies (Nailufar & Rahmawati, 2022; Yulianti et al., 2024; Basilio et al., 2022; Zheng, 2023). Women, especially those with conditions like asthma and COPD, face increased risk of exacerbation and cardiovascular diseases (Revich,

2024; Sandoval et al., 2019). Women experience multiple exposure pathways. Pesticide contamination of water affects women more severely due to domestic roles in water usage. During evacuations, women's reproductive health needs create unique challenges regarding clean water and sanitation access.

Figure 2 provides a critical visual representation of the escalating forest fire crisis in Riau Province, illustrating the changing patterns of hotspots and burned areas over several key years. The graph clearly demonstrates the significant environmental challenges faced by the region, with dramatic variations in hectares burned between 2015 and 2021. These fluctuations not only highlight the intensity of forest fires but also underscore the disproportionate impact on local communities, particularly women who bear the brunt of these ecological disruptions. The visual data corroborates the research findings that forest fires in Riau Province have created a persistent and evolving environmental crisis, with substantial implications for health, economic stability, and social resilience.

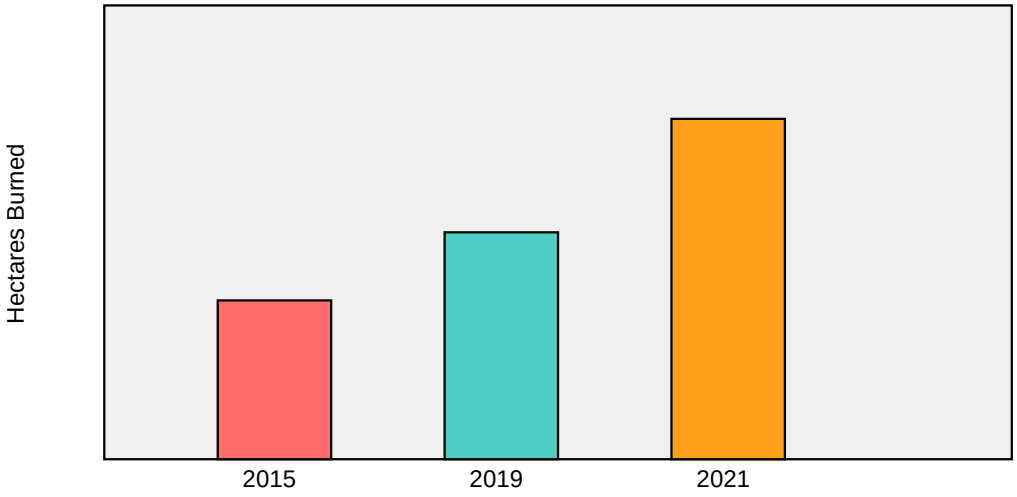

Fig. 2. Hotspots and burned areas in Riau Province

The impact extends to mental health, with women experiencing increased PTSD, anxiety and depression due to fire-related stressors and reduced resilience (Silveira et al., 2021). These compound with caregiving responsibilities women manage alongside their own health challenges (Carmenta et al., 2011; Alston, 2021).

Environmental degradation from fires creates long-term risks through habitat and biodiversity loss (Yulianti et al., 2024). This disruption affects women reliant on natural resources for traditional medicines and household needs. Poor infrastructure exacerbates chronic exposure, impacting women disproportionately. These multifaceted impacts demonstrate how forest fires create gender-specific vulnerabilities intersecting with women's social roles, biological needs, and environmental dependencies. The implications extend to long-term physical and mental health challenges affecting women's wellbeing and community resilience.

3.1.3 Sociocultural and domestic burdens: The compounding effects of forest fires on women's daily lives

Forest fires in Riau create a complex web of domestic and sociocultural challenges that disproportionately burden women, particularly in rural and forest-dependent communities. Women are often the primary caregivers responsible for their families' health and well-being. During fires, they may have to care for sick family members while managing their own health issues, leading to increased physical and emotional strain (Nailufar & Rahmawati, 2022; Alston, 2021).

Infrastructure limitations significantly increase women's workload. In Siak, poor infrastructure causes persistent air pollution, leading to respiratory infections, cooking

difficulties, and increased cleaning demands primarily managed by women. This extends to firewood collection, which becomes more arduous after fires destroy accessible wood (Njenga et al., 2021).

The burden intensifies through resource scarcity management. Women invest extra time securing clean water and food when traditional sources become contaminated. In Pelalawan, lack of electricity forces women to concentrate work during limited generator access hours, impacting income-generating potential when fires destroy agricultural lands (Velichkova et al., 2024).

Women bear primary responsibility for household stability, managing food security, health, and family wellbeing (Wan et al., 2011; Marlina et al., 2020). Domestic violence tends to increase post-disaster, as increased indoor time and stress escalate tensions while reducing escape opportunities (Rees & Wells, 2020). These circumstances disrupt traditional forest-based activities central to women's cultural practices and knowledge transmission. Environmental degradation exacerbates gender inequalities, with women having less access to resources and decision-making related to disaster management (Giudice et al., 2021), as they are frequently excluded from these processes (Nailufar & Rahmawati, 2022). The compounding effect creates a cyclical pattern of increasing inequality. As women spend more time managing crises, opportunities for education and advancement diminish. Environmental crises reinforce inequalities through increased responsibilities and diminished opportunities, impacting gender roles and community resilience long-term.

3.2 Evolving response mechanisms: Adaptation and mitigation strategies in Riau's forest fire crisis

Recent developments in Riau's forest fire management demonstrate a shift toward integrated approaches combining technological innovation with community engagement. The Masyarakat Peduli Api (MPA) program exemplifies successful community-based initiatives, incorporating both fire prevention and sustainable livelihood development through activities like pineapple farming. Government efforts have yielded significant results, achieving a 90% reduction in burned areas from 2016 to 2021 through coordinated interventions (Reyhan et al., 2021).

Technological advancements have strengthened monitoring capabilities, with tools like the Lancang Kuning dashboard application enhancing early detection systems. However, resource limitations and varying levels of community participation continue to challenge implementation effectiveness. These initiatives operate within a complex social framework where gender disparities in decision-making persist, despite women's extensive knowledge of forest ecosystems and heightened vulnerability to fire impacts.

The intersection of environmental management and social equity remains critical, particularly regarding women's participation in governance structures. Successful mitigation strategies must balance ecological preservation with social justice, addressing both environmental sustainability and gender-specific vulnerabilities in affected communities (Qaisrani & Samavia, 2017). This evolving landscape of response mechanisms provides context for examining women's emerging leadership roles in forest fire management and conservation efforts.

3.3 Reimagining forest protection: Gender-inclusive environmental leadership

As human activities intensify ecological pressures, women's leadership emerges as crucial for forest conservation, particularly in regions like Riau facing recurring forest fires (Steffen et al., 2011). Forest fires, often exacerbated by slash-and-burn land clearing techniques, require innovative approaches that integrate gender perspectives for effective environmental protection. The intersection of ethical environmental practices and women's leadership presents opportunities for sustainable solutions, especially in addressing the complex challenges of forest fire management.

In Riau, women lead concrete initiatives in environmental recovery and disaster mitigation. They participate in creating firebreaks, coordinating evacuation plans, and establishing volunteer groups for fire management. Their involvement in reforestation and land restoration draws on deep connections with forests as gatherers and knowledge custodians. This relationship encompasses multiple facets: they serve as custodians of ancestral wisdom, vital contributors to family economies, and experts in sustainable resource management. When women actively participate in prevention efforts, they become visible leaders whose expertise gains recognition, breaking gender stereotypes while inspiring younger generations toward environmental stewardship (Marlina, 2022).

Women's leadership in education and advocacy demonstrates their capacity for driving transformative change. They conduct training sessions on fire hazards and environmental protection, utilizing their intimate knowledge of indigenous plants and animals. Research shows their participation significantly improves decision-making processes and conservation outcomes through more equitable program benefits (Sidiq & Prawira, 2019). In forest user groups, women's involvement strengthens conflict resolution capabilities and rule compliance (Swigonski & Raheim, 2011), while gender-responsive actions, particularly in land and tree tenure rights, improve forest landscape program performance (Weiss & Moskop, 2020).

Their effectiveness extends across multiple domains, particularly in communities neighboring forests. In Kereng Bangkirai Urban village, women actively participate in fire prevention and risk communication demonstrating how their involvement enhances community preparedness. Their adaptation to changing environmental conditions, shown through post-fire farmer groups and traditional land management systems in Central Kalimantan, illustrates their crucial role in building community resilience (Marlina et al., 2020).

At the community level, women's strong social networks facilitate collective action for sustainable land management. Their leadership extends to emergency response planning and volunteer group formation for fire management. When facing threats like forest fires, they guide community groups toward adopting sustainable practices, such as judicious use of fire and vigilant monitoring. Economic initiatives, such as eco-friendly product development and sustainable agriculture, demonstrate how environmental protection can align with community development. Successful examples like Nepal's Women's Forest Sanctuary, where women safeguard wooded areas, and India's Chipko movement, where rural women protected trees from illegal felling, illustrate the potential of gender-inclusive environmental leadership.

However, traditional decision-making structures and gendered workplace cultures present ongoing barriers (Giudice et al., 2021). Addressing these challenges requires systematic efforts to promote gender diversity and challenge existing norms in fire management organizations. The integration of women's perspectives enhances both conservation outcomes and community resilience, providing valuable lessons for regions like Riau in developing more effective and equitable forest management approaches (Sidiq & Prawira, 2019).

Through gender-inclusive environmental leadership, communities better address complex forest protection challenges while promoting social equity and ecological sustainability. These initiatives demonstrate how women's involvement strengthens environmental conservation while fostering community development and resilience against forest fires. The goal remains to empower communities through extensive education about forest fire repercussions while highlighting the importance of preserving healthy environments through inclusive, sustainable practices. There are multiple initiatives aimed at promoting women's leadership in addressing forest fires, particularly in Riau.

3.3.1 Leadership in environmental recovery

Women can play a crucial role in the efforts to rehabilitate and restore ecosystems affected by forest fires. They can take the lead in initiatives related to reforestation, land

restoration, and sustainable natural resource management. Women have a deep connection with forests that encompasses multiple facets: they serve as gatherers, custodians of ancestral wisdom, and vital contributors to family economies. Moreover, involving women not only empowers them economically and socially within their communities but also enhances the overall impact of these initiatives.

When women actively participate in prevention efforts such as creating firebreaks or promoting practices that reduce fire risks, they become visible leaders whose expertise is recognized and valued. This active involvement breaks down stereotypes about gender roles while simultaneously inspiring other young girls to consider careers related to environmental stewardship.

3.3.2 Women's leadership in education and environmental advocacy

Women possess the capacity to drive transformative change by educating others and elevating community consciousness about forest fire hazards and the necessity of protecting our natural environment. They are well-equipped to spearhead outreach initiatives, deliver training sessions, or orchestrate educational endeavors that enhance communal comprehension of responsible and enduring environmental practices. Inhabiting areas neighbouring forests, women amass a wealth of knowledge concerning indigenous plant and animal species, showcasing their proficiency in stewarding natural resources sustainably. Their role transcends mere identification of therapeutic vegetation, foraging opportunities for wild edibles, and other vital resources; they are pivotal in maintaining the longevity of their communities through sustainable means.

Historically marginalized from formal positions of influence, women nonetheless make substantial contributions to forest stewardship. When included in forestry-related policymaking processes, they often advocate for holistic approaches that integrate ecological conservation with human welfare. With their profound insights and active participation in eco-friendly practices, women within forested locales emerge as foundational figures in striking a balance between exploiting natural resources judiciously and preserving ecosystem vitality. Their inclusion within policymaking spheres fortifies efforts aimed at harmonizing human necessities with the imperatives of environmental stewardship. Leadership in disaster risk mitigation: Women can also become leaders in disaster risk mitigation efforts related to forest fires. They can be actively involved in designing emergency response plans, coordinating evacuations, or forming volunteer groups to assist in fire management.

3.3.3 Women's leadership in local communities

Women at the local community level often possess strong social connections and an innate capacity for mobilizing collective action. When facing threats like forest fires, they can guide community groups toward adopting sustainable land management practices, such as judicious use of fire or vigilant fire monitoring. In their communities, women regularly rise as informal yet potent leaders, championing initiatives such as tree planting or fighting against illegal logging. Within their families and broader community circles, women serve as primary educators and are uniquely positioned to foster environmental responsibility among upcoming generations. Furthermore, economic projects that promote female empowerment—such as the creation of goods from eco-friendly materials or participation in sustainable agriculture—can simultaneously bolster healthy forest ecosystems and improve these women's quality of life.

Illustrative examples of women leading the charge in forest conservation include the "Women's Forest Sanctuary" in Nepal, where local females play a central role in safeguarding wooded areas; or India's "Chipko" movement, where rural women famously encircled trees to shield them from illicit felling. These examples show how women's leadership can provide a significant contribution in addressing forest fires and promoting environmental conservation in Riau.

4. Conclusions

In conclusion, this study sheds light on the extensive damage inflicted by forest fires on ecosystems and underscores the intricate connection between environmental crises and societal structures, notably in relation to gender inequality. It highlights the critical need for intersectional approaches in disaster management to develop informed and responsive strategies that address the needs of the most vulnerable populations, such as women. Therefore, it is imperative to incorporate gender perspectives throughout the policy-making process—from planning to implementation—to guarantee equitable and sustainable recovery efforts that alleviate detrimental effects on both nature and society.

The field of sustainable natural resource management, particularly in forestry, is essential for our planet's health. Forests serve as a linchpin for ecological equilibrium, providing benefits that range from carbon storage to serving as habitats for a myriad of species. Yet these vital ecosystems face threats due to human-induced pressures. To tackle these challenges head-on, there is an increasing acknowledgment of empowering women leadership within this sector. Women's participation introduces invaluable insights and approaches crucial for achieving sustainability.

To bolster women leadership in forest conservation and wider environmental guardianship successfully requires several strategic measures. First off is granting access to education and training focused on sustainable natural resource management practices. Such education arms women with ecological knowledge and conservation tactics while equipping them with leadership capabilities necessary for spearheading initiatives aimed at safeguarding our forests. Ensuring women's active involvement in public discussion is another key step toward having their voices heard where pivotal decisions about land use and environmental policies are made. When women engage actively within political arenas, they champion policies that emphasize preservation efforts while considering community necessities alongside gender-specific issues. Furthermore, cultivating microcredit schemes and financial support systems designed for eco-friendly businesses led by women can encourage green entrepreneurship—enhancing their economic standing not only boosts individual well-being but also bolsters community resilience against environmental degradation.

Incorporating these measures into a cohesive strategy will yield significant benefits beyond forest conservation alone; it will contribute towards achieving gender equality as envisaged under United Nations Sustainable Development Goal 5 (Gender Equality). Moreover, it aligns with other SDGs such as SDG 13 (Climate Action), SDG 15 (Life on Land), among others. To conclude, embracing an inclusive approach by enhancing women leadership through education, political participation and financial empowerment forms a multi-faceted solution capable of safeguarding our forests while simultaneously advancing global development goals centred on sustainability and equality. The time has come to harness the potential of women leaders who stand ready not just as guardians of our forests but also as architects of a sustainable future for all.

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Author Contribution

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