

# Innovations

## FOREST FIRE SUPPRESSION IN BENGUET: A SYSTEMATIC REVIEW

**Beberly T. Calugan**

Department of Environment and Natural Resources

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**Abstract:** *Forest fires being one of the major threats to the environment, property, and human life in Benguet, Philippines. This systematic review is aimed at identifying various challenges and proposes evidence-based strategies for effective forest fire management. The study recommends a multifaceted approach to address these challenges. Implementing incentive programs like the No Fire Bonus Plan and establishing a community fire brigades with regular training on forest fire management can further intensify community involvement in forest protection. Investing in the advanced technologies like satellite imagery and drones to improve early detection and immediate responses to forest fires. Developing a comprehensive fire management plan, including the implementation of an ICS to ensure coordinated and efficient response to forest fire. Conducting research on fire behavior, fuel dynamics, and the impacts of climate change to inform effective fire management strategies. Moreover, ensuring well-trained and well-equipped firefighting teams to effectively respond to fire incidents. Strengthening the existing forest protection laws and regulations with strict penalties, and regular allocation of sufficient resources for the prevention and suppression of forest fire are all strong deterrents against illegal activities for the effectiveness of forest fire management. Benguet can significantly reduce the frequency and intensity of forest fires through the implementation of those measures to safeguard its valuable ecosystems and communities.*

**Keywords:** *Forest fire, Benguet, community engagement, technology, fire management*

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### Introduction

Forest fires are a natural phenomenon that can be destructive if uncontrolled and become wildfire and razes natural and plantation forests, residential areas, etc. The increasing incidences of forest fires are often exacerbated by climate change. While forest fire prevention is crucial, effective and efficient suppression strategies are equally important to mitigate the devastating effects.

Global climate changes intensify forest fires, posing a serious threat to global ecosystems. A recent study by van Wees, van Der Werf, Andela, et.al (2021)

revealed that, on average, 38% of worldwide forest loss is due to fire. It is indeed the case that this proportion is relatively stable; however, there are distinctions at the regional level. For instance, forest loss by fire in regions such as Amazon and Indonesia have declined, while the opposite has occurred in tropical Africa. These insights reflect on the complicated relationship between the loss of forests through fire and the cessation of fire itself while underlining the urgency to develop sound strategies to limit impacts on global forests.

Forest fires are an annual problem in the Philippines, affecting various regions. For instance, the Caraga region (Region 13) lost about 134 hectares of tree cover as a result of forest fires from 2001 to 2023. The highest loss was seen in 2016 at 20 hectares (Global Forest Watch, 2023). This region, along with others such as Region 4-A (Calabarzon), Region 10 (Northern Mindanao), Region 12 (Soccsksargen) and Cordillera Administrative Region (CAR) have been very prone to forest fires due to factors like climate change, human factors or presence of highly combustible vegetation.

In the Philippines, Cordillera Administrative Region (CAR), is a hotspot for biodiversity, but its vulnerability to climate change and human activities makes it susceptible to forest fires. As highlighted by Daipan (2023), 8.5% of the region's forest cover is prone to fire, with an estimated area of around 37,000 hectares at risk. Climate change is projected to intensify the situation, leading to more intense and frequent fires. This aligns with the global challenges highlighted by the United Nations Sustainable Development Goals (SDGs), specifically SDG 15 (Life on Land). This goal focuses on sustainable management of terrestrial ecosystems, including forests, with target 15.1 emphasizing conservation, restoration, and sustainable use of these ecosystems (United Nations, n.d.). Suppressing forest fires directly contributes to SDG 15.1 by the preservation of these valuable forests.

The province of Benguet remains one of the most vulnerable provinces to these forest fires. According to Poclis et al. (2024), fire incidents in Benguet significantly increased between 2019 and 2021. In order to lessen the impact of these catastrophic fires, incorporating fire risk indicators into local planning is crucial. This would enable local communities to put into practice efficient preventative strategies like controlled burns, land use planning, and community awareness campaigns by using these indices to pinpoint high-risk areas. Additionally, adequate funding for fire suppression efforts and investments in infrastructure, like watchtowers, are essential for effective forest fire management in Benguet.

Forest fires pose a significant threat to Benguet, causing environmental degradation (including soil erosion, air pollution, and biodiversity loss), property damage, and endangering human lives. The Department of Environment and Natural Resources (DENR, 2024) signifies that the increasing occurrences and intensity of

forest fires in Benguet, attributed to climate change, human activities, and the challenging terrain. Suppression of these forest fires is crucial to mitigate these adverse effects and preserve the natural resources of the province.

The DENR (2024) reported significant incidents of forest fire in Benguet in recent years. These fires reached PhP43.7 million in damages resulted by the burning of 12,180.91 hectares of forestland in just the first four months of the year 2024.

Like other places, forest fires in Benguet have plenty of negative effects. They cause a major loss of biodiversity, which includes the extinction of rare plant and animal species. As highlighted by Attri, Dhiman, and Sarvade (2020), these fires, often worsened by high temperatures and abundant fuel. In addition to cause immediate damage, it can change the characteristics of soil, altering the equilibrium of the ecosystem. Globally, millions of hectares are impacted worldwide, and a significant contributing component is human activity. Furthermore, by releasing greenhouse gasses into the atmosphere, these fires worsen climate change. Economically speaking, forest fires can cause agricultural and tourism-related disruptions, which can result in employment losses and lower local community income. They also endanger human health by creating respiratory disorders and other ailments.

The natural environment and human communities are at risk by forest fires in the province of Benguet. The fires have the potential to spread rapidly, damaging property and destroying large tracts of forestland. Residents' health may be affected by respiratory issues and air pollution brought on by the smoke the fires produce. Moreover, landslides, water shortages, and soil erosion can all be exacerbated by the loss of forest cover.

This systematic review focuses on the challenges faced in suppressing forest fires in Benguet. It aims to identify the primary causes of forest fires, evaluate the effectiveness of existing forest fire suppression strategies, and explore the innovative approaches. The goal is to provide evidence-based recommendations to reduce fire frequency and severity for improved forest fire suppression. Ultimately, this study seeks to safeguard Benguet's ecosystem and communities.

## **Review of Related Literature**

Globally, forest fires have long posed a serious threat to ecosystems, biodiversity, and human life. An effective forest fire suppression strategy that includes prevention, early detection, prompt response, and post-fire recovery is necessary. This review explores the best practices used by different nations to fight forest fires.

*Fire Ecology and Climate Change*

Understanding fire ecology is essential for effective fire management. Fire plays a natural role in many ecosystems, but human activities and climate change have altered fire regimes, leading to more frequent and intense wildfires. Knowledge of fire behavior, fuel loads, and the effects of fire on forest health is important for effective suppression and prevention of fires. Climate change is increasing the frequency and severity of fire weather worldwide. Enhanced fire models are a better comprehension of the relationship between fire and climate change, and proactive steps to lower fire risks are all necessary to reduce this (Jones, et. al., 2022). This therefore calls for an all-around approach to fire management as it takes into consideration long-term climate change effects.

### *Prevention and Mitigation*

#### **Public Education and Awareness**

Effective public education campaigns can reduce human-caused fires. Countries like the US and Canada have invested heavily in public education and awareness campaigns to promote fire safety and responsible outdoor behavior (National Fire Protection Association, 2023; Natural Resources Canada, 2023). The National Fire Protection Association (NFPA) in the US and Natural Resources Canada plays a crucial role in developing and implementing these campaigns. They create materials and resources on safe practices in the outdoors, including campfire safety, responsible burning, and getting permits for an open fire. They also collaborate with provincial and territorial governments to deliver targeted education directly to communities at high risk of wildfires.

Public education may have minimal impact on large-scale wildfires brought on by lightning or other natural causes, but it could reduce fires started from human activity (National Fire Protection Association, 2023). It can be difficult to reach specific groups of people, like landowners and outdoor enthusiasts, so this requires tailored message and distribution tactics (Natural Resources Canada, 2023).

#### **Fuel Reduction**

Fuel reduction techniques include firebreaks, greenbelts and prescribed burning can be adopted to protect the forest. As countries like Australia, Canada, and the United States (US) implemented rigorously including prescribed burning, mechanical thinning, and chemical treatment to reduce fuel loads and create firebreaks (Australia Government, 2021; Natural Resources Canada, 2023; USDA Forest Service, n.d.).

Prescribed burning, however, might harm valuable ecosystems including riparian zones and wetlands and have a detrimental effect on air quality (Australian Government, 2021). Additionally, prescribed burning and mechanical thinning can

be expensive and time-consuming, requiring a large investment of both money and manpower (Natural Resources Canada, 2023).

### ***Climate Change Adaptation***

Countries are changing their approaches to lessen the effects of climate change as it increases the risk of fire. This entails investing in early warning systems and creating forest management strategies that are climate resilient (Intergovernmental Panel on Climate Change, 2021).

Research, technology, and infrastructure must be heavily invested in in order to implement climate-resilient forest management methods (Intergovernmental Panel on Climate Change, 2021). Developing long-term adaptation measures might be tough due to the difficulty of predicting future climate conditions (Intergovernmental Panel on Climate Change, 2021). *Early Detection and Rapid Response*

### ***Advanced Technology***

Remote sensing technologies, including satellite imagery and aerial surveillance, revolutionized the early detection aspect. In this regard, fire activity in many countries, such as the United States and Australia, takes advantage of technologies to monitor fire activity and determine potential fire threats (National Interagency Fire Center, 2023; Australian Government, 2021).

To some extent, remote sensing might be hampered by adverse weather conditions, such as fog or heavy cloud cover. Remote sensing might provide early detection of fires, but eventually it may take some time for ground crews to confirm the fire and then start response efforts.

### ***Incident Command System (ICS)***

Forest fire management is a global challenge. Countries like Australia, and the United States have developed sophisticated fire management strategies, including the implementation of ICS. For instance, Australia's Country Fire Authority (CFA) and the United States' National Interagency Fire Center (NIFC) have successfully implemented effective ICS systems to coordinate large-scale fire suppression efforts.

The ICS is a standardized approach, on-scene management system designed to improve the efficiency, effectiveness, and safety of emergency response operations, including forest fire suppression. By establishing a clear organizational structure, defined roles and responsibilities, and effective communication protocols, ICS enables coordinated responses from various agencies to work together seamlessly (Hanlin & Schulz, 2021). The Southern California wildfires of the 1970s

underscored the importance of ICS in addressing large-scale incidents, as the lack of coordination hindered effective response efforts (Newbury & Obernier, 2024).

Effective ICS implementation calls for skilled staff and regular training to keep skills up to date. The hierarchical ICS structure may cause bureaucratic delays in decision-making in complex occurrences.

#### *Suppression and Control*

#### ***Firefighting Tactics and Techniques***

Suppressing fires requires the use of efficient firefighting methods like controlled burning, indirect attack, and direct attack. The employment of specialist equipment and aircraft is one of the advanced firefighting strategies and techniques established by nations such as the United States and Australia (National Interagency Fire Center, 2023; Australian Government, 2021).

Direct attack, however, can put firefighters in danger, particularly when fire behavior is intense. Traditional firefighting methods might not work as well in severe fire conditions.

#### ***International Cooperation***

Countries frequently work together to collaborate on resources and knowledge in the fight against massive wildfires. Knowledge sharing and coordination are made easier by international agreements and collaborative initiatives like the World Fire Protection Association (World Fire Protection Association, 2023).

Another benefit of international collaboration is that it fosters the sharing of knowledge and best practices for managing wildfires. Experts from many countries can share their experiences and lessons learned through conferences, workshops, and other forums. This sharing of ideas could lead to developing innovative strategies and technologies on fire prevention, detection, and suppression (National Interagency Fire Center, 2023).

International cooperation is certainly offering numerous benefits, but it also has its challenges. Logistical complexities, language barriers, and cultural differences all tend to hinder effective collaboration. Moreover, the pressure put on resources and differing priorities sometimes cause conflicts.

#### *Post-Fire Recovery and Rehabilitation*

#### ***Reforestation and Rehabilitation***

Restoring damaged ecosystems requires post-fire restoration activities, such as stabilizing soil and growing new trees. Successful replanting initiatives have been put in place by nations like Canada and Australia to restore burned areas (Australian Government, 2021; Natural Resources Canada, 2023).

In order to completely restore a forest ecosystem, reforestation is a lengthy process that could take decades. In arid or degraded locations, where soil conditions and water supply may be limited, reforestation can be challenging.

### ***Community Resilience***

A community-based approach in social and political ecology means that forest management involves the local community in decision-making and the practice of managing the forests. Involving the communities in efforts to prevent and suppress fire can boost local capacity while reducing human-caused fire risk (Agrawal & Gibson, 1999). Often, recognizes the importance of indigenous peoples as fire-dependent cultures and advocates for the integration of their traditional knowledge into contemporary fire management strategies (Lake, 2021). The incorporation of such knowledge into fire management practice will enhance better results. A argued by Vázquez-Varela et al. (2022), incorporating traditional fire knowledge (TFK) from indigenous and rural communities is crucial for building fire-resilient landscapes and fire-adapted communities.

Long-term rehabilitation requires enhancing community resilience. This includes creating evacuation plans, teaching communities about fire prevention, and offering assistance to impacted citizens (Federal Emergency Management Agency, 2023).

Continued outreach and education are necessary to create and preserve community resilience. Even communities that are well-prepared may encounter major difficulties during intense wildfire outbreaks.

### **Discussion**

This systematic review aims to comprehensively understand the challenges and root causes of forest fires and evaluate the effectiveness of current practices in suppressing forest fires in Benguet, Philippines. This discussion explores these critical gaps and propose innovative approaches to reduce fire frequency and severity. This research can be valuable for policymakers, fire management agencies, and local communities in Benguet, empowering them to develop evidence-based strategies for sustainable forest management.

#### *Prevention and Mitigation*

Generally, forest fire prevention is achieved when nobody starts one. Nevertheless, preparatory activities are to be undertaken such as public education and awareness, fuel reduction, and climate change adaptation initiatives.

#### ***Public Education and Awareness***

To effectively prevent forest fires, prioritizing community engagement, institutional collaboration, and educational initiatives is crucial. This includes forming

and training community fire brigades, and strengthening partnerships with the Bureau of Fire Protection (BFP), Philippine Information Agency (PIA), Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAG-ASA), and other relevant government agencies for concerted fire prevention and response efforts. Including indigenous peoples and highlanders in fire safety efforts fosters a sense of shared responsibility over the protection of the forest.

Implementing successful public education campaigns can considerably decrease human-caused fires. Programs may educate participants about fire safety, responsible outdoor behavior, and proper fire permit procedures. In the Philippines, the Department of Education (DepEd) has made great efforts to incorporate disaster risk reduction and management (DRRM) into the curriculum. Among these is fire safety education, which attempts to improve student understanding and skill in preventing and responding to fire situations. A study by Delaliarte, Linaugo, and Madrigal (2024) examined the fire safety awareness and practices of Science, Technology, Engineering, and Mathematics (STEM) students in a Philippine public secondary school. Their findings revealed a significant positive relationship between fire safety awareness and practices among students. This emphasizes how crucial it is to continuously improve teachers' instructions to strengthen students' readiness and resilience in disasters like fire.

While these studies provide valuable insights into the effectiveness of fire safety education in the Philippines, it is crucial to acknowledge the challenges in reaching specific particular target audiences and tailoring messages. Creating culturally relevant instructional resources and making use of a variety of communication platforms, including social media, radio, and community forums, are essential to overcoming these obstacles. We can improve engagement as well as understanding of fire prevention practices by utilizing culturally appropriate methods and customizing messages for particular audiences.

Engaging local communities in fire management is important to reduce the frequency and intensity of forest fires, protecting valuable ecosystems, and safeguarding life and property. Understanding the communities needs and priorities, we can tailor fire prevention and suppression strategies to their specific context. As highlighted by Ansari et al. (2024), local community participation in fire management is essential like in fire prevention education, early warning systems, and active fire suppression, we can enhance their capacity to respond to fire threats and reduce the overall impact of forest fires. The Integrated Forest Management project has shown how successful community-based strategies are in addressing issues with fire suppression and prevention. We can increase resilience and save our forests by encouraging local communities to work together (FAO, n.d.).

### ***Fuel Reduction***

Fuel reduction techniques shall be adopted to assure protection of young plantations and allow natural regenerations. Techniques like prescribed burning, greenbelts, and firebreaks can significantly reduce fuel loads, thereby reducing fire damage while enhancing regeneration. Adopting efficient fuel reduction strategies is crucial to preventing forest fires to protect young plantations and natural regenerations.

Although prescribed burning has been shown to be an effective method of reducing fuel loads, its use in Benguet needs to be carefully evaluated. In order to guarantee the efficacy and safety of prescribed burning, Clarke et al. (2023) emphasize that there is no one-size-fits-all solution in fire management; trade-offs are inevitable. In the face of climate change, the effectiveness of prescribed burning may become diminished, and the costs would increase. This requires a flexible and adaptive approach to managing fires.

Firebreaks and fuel loads can be reduced through mechanical thinning techniques like selective logging or thinning from below. It may, however, be expensive and have negative effects on forest ecosystems, including biodiversity loss and soil erosion. As highlighted in the study by Johnston et al. (2021), while mechanical thinning can be effective in reducing immediate fire risks, it may not be sufficient in the long term. The researchers also pointed out that prescribed fire could be employed to maintain low fuel loads and prevent fuels from re-accumulating. Therefore, a well-balanced approach combining mechanical thinning with prescribed fire and close monitoring will ensure sustainable fire management and negative impacts on forest ecosystems.

Establishment of greenbelts and firebreaks with priority on identified fire prone areas can help to contain wildfires and protect communities. However, their effectiveness depends on factors such as width, vegetation type, and maintenance. A study by Marshall, et al. (2024) highlights the effectiveness of green firebreaks to reduce the risk of wildfire while promoting biodiversity and carbon storage, however, simulation showed that green firebreaks had minimal effect on fire behavior in most situations and is needed to assess its effectiveness on a larger scale.

### ***Climate Change Adaptation***

Increased risk of fire can be mitigated through investing in early warning systems and strategies on climate-resilient forest management. However, significant financial and technological resources are needed. Climate changes are difficult to predict in the long term for developing adaptation strategies. As highlighted by Hudson (2023), although long-term climate change is unpredictable, it's really hard to come up with proper adaptation strategies. The study underlines the

reduction of risk due to fire, planting of species that are climate resilient, increasing government investment, and the policy and implementation challenges to enhance forest resilience.

Integrating traditional ecological knowledge with modern technology as an early warning system into management practices can be beneficial. Early warnings drastically reduce wildfire impacts, especially in communities that receive timely alerts for fires. As highlighted by Haokip (2022), this integrative approach enhances disaster preparedness and response efforts, thereby enabling communities to anticipate and mitigate better the risks associated with wildfires.

#### *Early Detection and Rapid Response*

Early detection and rapid response, aided by advanced technologies and a well-structured Incident Command System are crucial for effective fire suppression.

#### ***Advanced Technology***

Advanced technologies like satellite imagery and aerial monitoring play a crucial role in early fire detection. These technologies enable quick response and resource deployment by providing real-time information on the location, size, and intensity, these methods enable quicker response and resource deployment. Integration of solar power into fire-detection systems allows for sustainable operations (Daganato, Dellosa, Center, et al., n.d.). However, unfavorable weather circumstances like cloud cover, fog, or heavy rain can reduce its efficiency.

The significance of advanced fire detection and monitoring systems has been acknowledged by the Philippines. A Forest Fire Danger Rating System (FDRS) is a method created by the Department of Environment and Natural Resources (DENR) to forecast the possibility of forest fires based on weather, fuel moisture, and other variables. This helps authorities to take preventive action and react promptly to fire outbreaks, but its efficacy relies on accurate data and local response capabilities (Carta, et al., 2023). Challenges including a lack of awareness, inadequate facilities and limited funds can prevent such systems from reaching their full potential.

Early detection therefore will remain in the hands of technology; however, its effectiveness must be grounded with a more robust ground-based monitoring system like setting up a network of fire towers, deploying forest rangers, and involving local communities through fire reporting and prevention. Additionally, drones offer a flexible and cost-effective solution for inaccessible areas. High-resolution cameras and thermal sensors could be easily mounted on drones to spot and monitor fires in real-time (Bushnaq, et al., 2022) With this strategy, the province Benguet can work its way better towards effective detection and response for wildfires. Fire detection and monitoring would easily be achievable through drones as they are, especially in inaccessible and remote areas.

In this regard, investment in the training and capacity building of personnel in charge of forest fire management, enhancement of communication networks, and popularizing public awareness about fire prevention and early detection are also important. Combined with the concept of integrating advanced technology with effective ground-based monitoring and response, the province of Benguet can improve its capacity in detecting and suppressing forest fires in order to protect these ecosystems.

### ***Incident Command System (ICS)***

ICS helps to enforce a standardized structure in managing emergencies, thus enabling clear communication, organization, and coordinated response from different agencies in the suppression of any fire. Its effective implementation depends on properly trained personnel and frequent exercise. During more complex incidents, bureaucratic delays might be experienced in decision-making due to the hierarchical nature of ICS.

Assessing the capacity of local agencies and personnel must be made prior to introducing ICS in Benguet. This shall be judiciously assessed including their preparedness with trained personnel, communication structures, and equipment. Training courses must be established or replicated to ensure provision of the knowledge and equipping skills required in applying ICS principles effectively.

Assess the capacity for ICS implementation in Benguet and provide training programs for relevant personnel. Explore adapting the system to the local context to enhance efficiency while considering cultural practices. While ICS provides a standardized framework, it is important to adapt it to the specific needs and cultural context of Benguet. This may involve incorporating traditional knowledge and practices into the ICS structure, ensuring that communication channels are culturally appropriate, and considering the unique challenges faced by local communities.

Despite the worldwide scope of ICS, its applicability within the Cordillera Administrative Region (CAR), like in the province of Benguet has not been given significant study. Hence, a comprehensive assessment of ICS implementation in CAR must be done to identify the existing strengths, weaknesses, and areas for development of this system. Pilot-testing of ICS in small-scale fire events will better provide practical experience and potential challenges. With these pilot projects insights, Benguet can modify the application to actual large-scale fire emergencies in the province.

Although the Philippines has been implementing various kinds of fire management strategies, the application of ICS principles to enhance coordination, resource allocation and decision-making processes in fire emergencies remains an imperative. There is no direct research on the effectiveness of ICS in the context of the Philippine firefighting operations and its utility.

### *Fire Suppression and Control*

A site-based mechanisms shall be developed and institutionalized by the stakeholders to provide quick or immediate response during occurrence of forest fire.

### ***Firefighting Tactics and Techniques***

Effective forest fire response requires a robust site-based mechanism that enables quick and immediate action including efficient communication networks and a fully prepared and trained firefighting teams. A comprehensive analysis of fire behavior and the implementation of appropriate fire suppression strategies, such as constructing firelines, conducting backfires, or direct attacks while prioritizing fire safety is paramount. Further, it is crucial to ensure complete extinguishment and monitoring of the hotspots area to prevent rekindling.

However, direct attack is useful for minor fires, but it poses many risks to firefighters in extreme conditions of fire. The intensity and behavior of the fire should be evaluated before deploying firefighting team. Indirect attack, which involves creating firebreaks and using prescribed burning to reduce the intensity and spread of the fire, is a safer approach but requires careful planning and execution. Prescribed burning is an indirect attack that reduces fuel loads and creating firebreaks but has to be conducted under controlled conditions in the operation to prevent unintended consequences. A study by Hislop et al. (2020) found that fuel reduction burns could help ease fire severity greatly especially in specific locations, and types of forest. However, the study further admitted that extreme conditions can outwit the effects of fuel reduction, which implies that these situations require an overall approach to the management of fires.

In firefighting, adequate training of firefighters on various techniques and tactics of firefighting will ensure their safety and enhance decision-making processes during the operation. Contingency planning for extreme fire conditions and regular fire behavior training will contribute a lot in the effectiveness of suppressing the fire. The ability to combat fires is essential for maintaining safety in various kinds of situations. Proper training in firefighting would be vital for both professional firefighters as well as individuals who might face fire emergencies. Such training educates people with basic skills, generating the knowledge to react correspondingly, which could save lives and minimize property damage (The Safety Master, 2022).

### ***International Cooperation***

International cooperation in the management of forest fires is an avenue through which knowledge and best practices may be advanced. Learning from the past experiences of other countries, Benguet can adopt an effective fire management

practice in combating wildfire. It may seek technical assistance from experts from other countries through participation in training or capacity building, and technology transfer programs. As highlighted by Turaray (2024), international organizations like the United States Forest Service have contributed to strengthening Benguet's firefighting capabilities through training and capacity-building initiatives. By equipping forest rangers with enhanced skills and training, local responders are now better prepared to combat fires.

Lobby international collaboration and government to fund research and development of climate-resilient forest management techniques in Benguet. International cooperation sharing knowledge, technology, and resources would help address climate change and wildfire management. The United Nations Framework Convention on Climate Change (UNFCCC) provides a platform for countries to collaborate on climate mitigation and adaptation strategies. The involvement of international initiatives and support from international organizations will open avenues for Benguet expertise to implement effective forest fire management strategies.

Collaboration on various research with international partners may help in developing innovative fire prevention, detection, and suppression methods that would be specifically suited to Benguet's local ecosystem and climate.

#### *Post-Fire Recovery and Rehabilitation*

Restoring damaged ecosystems and minimizing future fire risks are paramount to ensure the long-term health and resilience of forests. Post-fire recovery and rehabilitation efforts play a critical role in achieving these goals.

#### **Reforestation and Rehabilitation**

Reforestation and rehabilitation are practiced to recover damaged ecosystems and prevent soil erosion. These practices aid in reducing climate change and increasing biodiversity through tree planting, stabilization of the soil, and water quality protection. Reforestation has great potential to restore the degraded forest ecosystems of Benguet.

Post-fire, reforestation is very important for regeneration; the downside is that it is a very lengthy process in which much investment is required. Climate change, the spread of invasive species, and soil degradation can be challenges to reforestation. Adaptive management strategies and monitoring progress in the implementation of reforestation projects are crucial. As highlighted by the National Forest Foundation (2023), tree planting helps landscapes recover from wildfire by restoring forest cover. Prompt reforestation is important to prevent soil erosion and protect water quality in downstream rivers and lakes.

Involvement of local communities in the process of reforestation can be effective to the action. In this, the process helps establish a feeling of ownership and

stewardship in empowered people when they engage at all stages, from decision-making up to implementation. So, many studies have indicated that community-based reforestation programs work wonderfully towards the restoration of degraded forests and improvement in livelihoods.

### ***Community Resilience***

Community resilience is the ability of a community to face various shocks and stresses with the possibility of adapting and recovering—a multifaceted concept that certainly incorporates natural disasters. A strong community resilience is the Community-based disaster risk reduction (CBDRR). CBDRR involves communities in reducing disaster risk, enhancing their capacity and vulnerability (Jagirdhar & Satry, n.d.) especially in highly vulnerable places like Benguet. And supported by the Prepare Center (n.d.), community engagement is very important in disaster preparedness and response. By integrating local knowledge, practice, and context into the reduction of disaster risks, communities can significantly decrease disaster risks and enhance their resilience.

Since Benguet is significantly risky, community participation is crucial for safety and security of residents. Community involvement into disaster risk reduction actions can be helpful in skill and knowledge that may protect the individual and the loved ones such as training the communities on various drills, and pre-disaster preparedness planning. Additionally, community-based early warning systems (CBEWS) empower communities to better prepare and respond to disasters by offering them tools to prepare and respond effectively to disasters (Pham, et al., 2024).

Building resilience is one of the main provisions of fire safety education and training for communities. The capacity build among people in fire prevention and response reduces them from vulnerabilities. In the Philippines, mainstreaming disaster risk reduction and management (DRRM) by the Department of Education into curriculum and fire safety education.

Economic development is an important building block for community resilience. While diversification of livelihoods as well as reducing dependency on natural resources might better prepare a community against all kinds of economic shocks and disasters, investment in infrastructure—captained by roads, bridges, and communication systems—might enhance availability and access to many services as well as facilitate swifter response and recovery. Promotion of local enterprises—from small-scale ventures to inputs in agriculture—upgrades the economic viability of both communities as well as a community's ability to deal with more shocks (World Bank, 2021).

Social cohesion and strong community networks are paramount for resilience building. Building belongingness and trust among members of the community

strengthen social capital and collective action. Community organizations such as faith-based groupings, youth clubs, and women's associations can play a pivotal role in mobilizing resources, providing support, and promoting resilience (Adger, 2000).

Community resilience is complex, and what it requires is a holistic approach. Community resilience building enhances the resilience ability to tolerate disasters and recover from catastrophes by integrating CBDRR with community participation, economic development, and social cohesion. If we invest in these areas, we could create more resilient communities ready to face the challenges of the future.

#### *Zero Forest Fire Incident*

Prevention is the best solution for every disaster to reduce potential damages and sufferings. The No Fire Bonus Plan, a pioneering strategy for forest protection in Mountain Province was proposed by Manual L. Pogeyed way back 1998, has the potential to encourage sustainable forest management and significantly reduce the incidence of forest fires. This incentive-based approach has now been adopted by the municipality of Bontoc, Mountain Province. Those barangays that can maintain a zero-forest fire record from September 2024 to September 2025 will receive additional funding from the local government. This is an initiative that engages barangays to actively participate in the protection of forests and fire prevention efforts (Killa-Malwagay, 2024).

The province of Benguet could consider adopting this as a forest protection strategy to prevent forest fires and involve communities in the protection for its resources. For this is for everyone's own good and for the future generations.

The systematic review points out the critical needs in controlling forest fires in Benguet, Philippines. Critical issues were fuel reduction techniques, education and awareness among the public, adaptation to climate change, early detection and rapid response, incident command systems, tactics of firefighting, international cooperation, post-fire recovery, and community resilience. Even prescribed burning and mechanical thinning and greenbelts in reducing fuel loads, its effectiveness was influenced by careful planning and implementation. Public education and community engagement should also be part of prevention against human-caused fire. Climate change exacerbates the risks, hence climate-resilient forest management and early warning systems. Advanced technologies, such as satellite imagery and drones can upgrade the system of early detection; the ground-level monitoring remains paramount. The Incident Command System can enhance coordination and response but only after proper training and adaptation to context. Effective tactics include direct and indirect attacks, coupled with training and measures of personal safety for the firefighters. International cooperation can be helpful with knowledge and technology transfer. After the fire recovery activities such as reforestation and rehabilitation by community-based inputs are critical for rebuilding community resilience and ecological restoration. In summary,

addressing this big issue of Benguet forest fires requires an integrated approach in its entirety-first, prevention; second, early detection; third, rapid response; and lastly, effective suppression.

### **Conclusions and Recommendations**

This systematic review has highlights critical challenges faced in controlling forest fires in Benguet, Philippines. These include fuel reduction strategies, public education, climate change adaptation, early detection and rapid response, firefighting tactics, and community resilience. To address this, there is a need for a multi-faceted approach toward mitigating the risks of forest fires in Benguet. A community-based fire brigades with regular training in prevention, detection, and suppression of fires of necessary. The No Fire Bonus Plan incentive programs can enhance community involvement on forest protection. Advanced systems for fire detection and monitoring using satellite imagery and drones can ensure quick detection and response. Proper communication among stakeholders, which facilitates timely information sharing, is important.

It shall engage in further studies on fuel dynamics, fire behavior, and climate change impacts in order to have effective fire management measures in place. Collaboration with local and international experts shall facilitate knowledge sharing and innovative solutions. It is indispensable to equip firefighting teams with adequate resources and train them regularly. The developing of comprehensive fire management plans with clear procedures for response, evacuation, and postfire recovery is essential. The strengthening of forest protection laws and regulations, applying stiff penalties, and proper provision for prevention and suppression capabilities are done to prevent illegal activities and guarantee an effective fire management system.

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