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Harnessing Fire with AI and Drones: A Holistic Approach to Wildfire Damage in South Korea

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Abstract. The beginning of spring 2025 brought South Korea its worst wildfires which caused extensive environmental damage and fatal human losses and permanent destruction of cultural heritage. The wildfires demonstrated South Korea's rising exposure to climate change-driven disasters in an unprecedented way. South Korea needs to develop urgent wildfire prevention and detection and management strategies because climate change continues to accelerate at a dangerous rate. The research examines the factors that increase wildfire occurrence and intensity through rising temperatures and extended droughts and poor land management practices. The paper assesses innovative technological solutions which show promising outcomes for wildfire management. The research explores experimental drone technology and artificial intelligence systems which improve wildfire detection speed and precision while enhancing suppression effectiveness. The analysis examines recent studies and real-world implementation cases to demonstrate both the advantages and constraints of these innovative solutions. The research shows that technological progress by itself does not solve wildfire risks effectively. Innovation needs to form part of an integrated system which combines climate-smart forestry with ecological restoration and sustainable land-use planning. The study determines which strategies work best for South Korea while stressing the requirement for an urgent coordinated framework that unites advanced technologies with climate-responsive forestry practices. An integrated system enhances disaster readiness and response capabilities and builds long-term resistance against increasing wildfire threats.

Keywords. South Korea, Wildfires, Climate Change, Drones, Artificial Intelligence, Climate-smart Forestry

1. Introduction

The wildfires that destroyed large areas of remote South Korea in the spring of 2025 were "made twice as likely as a result of climate change"[1]. The first fires of 2025 destroyed four times more land than the worst fires in recorded history, with the total area destroyed estimated at 104,000 hectares, which is just over 1% of the total land area of the country[1]. South Korea's experience is part of a larger trend, with experts finding that compared to twenty years ago, wildfires in 2024 burned double the total amount of tree cover worldwide[2].

The causes of increased wildfire risk are widely recognized. Wildfires are recognized as playing an important role in various ecosystems' long-term health, and the patterns of wildfire season length, frequency, and burned area are changing, which "threaten to upend the status quo"[3]. The factors causing these changing patterns are "warmer springs, longer summer dry seasons, and drier soils and vegetation"[3]. NASA has stated that internationally, the main cause of increased wildfire activity is "human caused climate change"[4]. The wildfires in South Korea have been linked to "exceptionally low rainfall in the months preceding the fires and very high temperatures, more than 10c above average, on the days of outbreak"[5].

Internationally, one factor strongly associated with the increased intensity and spread of wildfires is the Fohn Effect. Fohn in German means "hairdryer" and describes a particular meteorological event that is difficult to predict and control. The Fohn Effect occurs when a moist wind rises over a mountain and mixes with cooler air, which condenses the moisture, releasing energy. On the other side of the mountain, the dry air is exposed to the sun because of a lack of cloud cover. As the dry air falls down the leeward side of the mountain, it can cause temperatures to rise extremely rapidly[6]. In 1972, the Fohn Effect caused temperatures in one area of Montana to rise from -48c to 9c in 24 hours[6]. The Fohn Effect is experienced all over the world, including in South Korea. However, its most destructive form was seen in Hawaii in 2023 when "warm temperatures, low humidity, dry grasses in the area and strong winds" in combination with the Fohn Effect created what was described as a "fire hurricane"[6].

Although wildfires cause widespread damage, their presence in some ecosystems has been part of a natural cycle of destruction and renewal. Wildfires often have a variety of benefits in specific conditions. The main benefit is the clearing of dead organic material, which can "prevent organisms within the soil from accessing nutrients" and "choke out growth of newer and smaller plants. Once a wildfire starts in a healthy, well-balanced ecosystem, high moisture levels in the soil will prevent the fires from spreading to the extent that they become catastrophic for populations of fauna and flora. Regular fires also prevent excessive build-up of organic material that can burn over extended periods of time and space and overwhelm the ecosystem. For this reason, experts often recommend allowing wildfires to burn naturally before attempting to extinguish them. The United Nations Office for Disaster Risk Reduction describes how "when forests aren't allowed to burn, they become more dense, and dead branches, leaves and other biomass accumulate, leaving more fuel for the next fire". The UN states that "the yearly burned area increased more than three times faster under conventional suppression than under less aggressive suppression. The current recommendation is for developing cultures of coexistence with wildfires, with a focus on "safe management of wildfires under moderate burning conditions"[7].

One of the variables driving the over-suppression of wildfires is an increase in the "wildland-urban interface"[8]. The proximity of urban areas and infrastructure to wildfires often determines whether conditions are safe enough to allow moderate burns. Even when moderate burns can be controlled, pressure from local populations and governments to suppress wildfires intensifies rapidly due to smoke exposure. Health risks of exposure to wildfire smoke include but are not limited to "exacerbation of existing respiratory diseases such as asthma and chronic obstructive pulmonary disease, worse birth outcomes, and cardiovascular events"[9].

With the pressure to prevent wildfires from spreading or having any effect on nearby human settlements or infrastructure, various technological advances have been used to identify places and conditions at high risk for wildfires and the monitoring and control of wildfires after they begin. Infrared cameras can be positioned in high-risk areas to detect increases in temperature in organic matter. A newer form of wildfire identification, infrared cameras have ranges of between 30-40 miles and have been proven effective at identifying new ignitions, informing the effective allocation of resources[10]. Temperature and humidity sensors can be linked to systems that monitor conditions, which can then be analyzed for the threat of ignition.

NASA uses space observation systems to create "near-real time monitoring" of wildfire outbreaks; however, the use of space observation is more useful after fires have reached a certain scale, which is often much later in the development of wildfires than the point at which infrared and humidity and temperature monitors become useful. Once a wildfire has broken out, aircraft and drones can provide an overview of its development, but smoke often disrupts this type of monitoring[11]. Direct intervention to prevent the spread of fires has reportedly had some success with stationary prevention platforms and flame-retardant products. Stationary prevention strategies include firebreaks and trenches and are often developed with the use of flame-retardant products such as "sprays, foams, or gels" that can be applied before or during wildfires.

With the increasing risk of wildfires, some experts are calling for a radical change in wildfire prevention strategies. In contrast to reactive monitoring and intervention, a new approach called Climate-Smart Forestry is being developed and is described as "an emerging science-based approach which optimizes forest adaptation and mitigation goals in a holistic manner". Supporters of this approach argue that the increasing scale of wildfires means that the public subsidies required for effective monitoring and intervention are "clearly not enough to deal with the scale of the problem we are facing". They also argue that a holistic approach would take into account carbon emissions from fires, which are currently not reported despite constituting "a large source of global land-carbon emissions". This approach would quantify emissions reductions connected to "management measures for landscape resilience – such as fire management, fuel treatment and biodiversity enhancement"[12].

2. Methods

A review of the literature will be used to identify the specific characteristics of the South Korean wildlife threat. This will include the causes and the factors that exacerbate the fires once they have started. A review of recent technological developments in other parts of the world will be conducted for their compatibility and usefulness in the South Korean context. Although South Korea has experienced wildfires as a natural part of the temperate forest ecosystem within the country, other regions of the world have faced a greater threat from wildfires and developed effective responses to them over an extended period of time. This research aims to identify gaps in South Korea's knowledge and approach and find solutions based on the experiences of other countries. There will be a specific focus on the use of artificial intelligence, drones, and remote sensing technology and how it can be integrated into broader wildfire prevention and limitation strategies.

Finally, potential future developments will be explored with the aim of informing projects and directions for research funding and efforts.

3. Literature Review: South Korea Wildfire Threat

A possibly surprising finding from recent research on South Korean wildfires is that the South Korean government's efforts to reforest the country since the 1970s may have contributed to the scale and intensity of the 2025 fires. Specifically, there are concerns "about the effect of tree-planting on wildfire risk, with continuous forest cover resulting in high fuel loads and increased fire risk". Experts have recommended that there should be a focus on reducing and managing "fuel loads near human settlements" to mitigate against the increased risk of wildfires. Across large areas of the regions affected by the wildfires, the tree cover is mainly pine trees. Experts from the South Korean National Institute of Forest Science have

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described how "pine trees contain resin, which acts like oil, intensifying fires when ignited. The resin causes wildfires to burn faster, stronger, and longer"[13].

The initial causes of the wildfires in spring 2025 have mainly been identified as forms of human activity, such as the lighting of small candles and fires near gravesides on mountains which are at high risk from wildfires[14]. Before the major fires which led to widespread devastation, two hundred and fifty-five separate wildfires had already been reported since the beginning of the year, which experts have described as "2.4 times higher than the same period" in 2023[15]. Although there is extensive evidence supporting the theory that human-induced climate change is creating conditions more likely to create and sustain massive and catastrophic wildfire events, the management of natural wildfires is also causing an increased risk of these events. In various regions internationally, the development of urban areas has increased what has been described as the wildland-urban interface. However, in the South Korean context, government-led large-scale reforestation projects over the past seventy years since the Korean War have successfully introduced billions of trees and rapidly increased forest cover. The spread of forested areas has increased the wildland-urban interface, specifically where forest meets inhabited areas. The meeting of urban areas with new forest developments has affected wildfire suppression strategies, with local governments and fire services unable to allow moderate burning under controlled conditions in many areas because of their proximity to human settlements and critical infrastructure[16].

The Fohn Effect on the southern half of the Korean Peninsula is caused by the presence of mountain ranges in the east. Moist air from the ocean rises over the eastward side of the mountain range, cools and condenses, and then descends to the westward side, with large increases in temperature and dryness. The Fohn Effect in South Korea has been connected to record high temperatures in recent years, with a temperature of 41c recorded at Hongcheon, on the western leeward side of the Taebaeksan Mountain Range[17]. Research shows a persistent Fohn Effect caused by this mountain range on South Korea's east coast, with temperatures averaging 1.75c higher on the western leeward side when easterly winds are blowing. Research suggests that current climate change trends on the Korean Peninsula will lead to a stronger Fohn Effect, which will increase the number and intensity of wildfires in the leeward region of the Taebaek Mountain Range on days with easterly winds[18].

Two effects of climate change on South Korea will be changing wind and precipitation patterns. These changes have already become evident in recent years. Climate change is causing an increased risk of drought, which dries soils and plants, making them vulnerable to wildfire ignition and spread. In Spring 2025, the Korean Meteorological Association released alerts indicating the dryness of vegetation, and the alerts indicated persistent drought conditions[27]. The drought conditions combined with near "typhoon force gusts" to create conditions which led to some of the worst wildfires in South Korean history[19]. The conditions that lead to the fires can be predicted by extended winter droughts, which are predicted to become more frequent as climate change accelerates.

Research on soil moisture levels, before wildfires ignite, reveals a complex interaction between water content and vegetation growth or drying. A large-scale study of 9,840 wildfires revealed that wetter-than-average soil conditions in arid regions promoted vegetation growth five to six months before wildfires. This vegetation subsequently dried and became fuel for the fire[29]. On the other hand, drier than normal conditions in humid regions were found in the months before wildfires ignited[20]. In recent years, monitoring of soil moisture levels has been identified as an effective way of predicting wildfire risk. Across large regions, the use of satellite capabilities such as the European Space Agency's Soil Moisture and Ocean Salinity and NASA's Soul Moisture Active Passive projects have proved to be useful in detecting localized drought and wildfire risk. The United States Forest Service has established a soil moisture monitoring network as part of a strategy to improve the capacity of government agencies to use rapidly updated information to make decisions and allocate limited resources.

4. Discussion

4.1. Recent Developments in Technology and Methods

Although experts are calling for a better understanding of how allowing moderate burning of wildland can reduce the risk of catastrophic level wildfires, a holistic model requires the ability to choose when to intervene to prevent a wildfire from spreading or when to allow burning to continue. For effective decision-making, wildfires need to be detected in their earliest stages. The current understanding of wildfires is that they progress through four stages: the incipient stage, the growth stage, the fully developed stage, and the decay stage[21]. Across these four stages, a visual method of ranking is also used to assess the strength of the wildfire, and whether the various forms of prevention and intervention are more effective or less effective with each rank. The rank descriptors are: "Rank 1 Smoldering Ground Fire; Rank 2 Low Vigor Surface Fire; Rank 3 Moderate Vigor Surface Fire; Rank 4 High Vigor Surface and Passive Crown; Rank 5 Extreme Vigor Surface and Active Crown; Rank 6 Extreme and Aggressive Fire Behavior"[32]. For the highest level of control of a wildfire, "the most cost-effective and least risky suppression method is to contain the fire during the incipient stage, either rank 1 or rank 2"[32]. A study based on California wildfires found that "an investment that helps California fire officials achieve a 15-minute reduction in response time could be expected to generate £3.5-8.2 billion in economic benefits and $150-350 million in fiscal benefits annually for California"[33]. Even with the introduction of a holistic approach that incorporates controlled and monitored moderate burns, it is vital for cost and damage prevention that wildfires are detected at the incipient stage to allow a rapid response. Awareness of a wildfire at an incipient stage would allow decision-makers a full range of options, from immediately ending the fire to allowing a controlled moderate burn.

4.1.1. Gas Sensors for Ultra-Early Wildfire Detection

Solar-powered gas sensors that can detect small increases in hydrogen, carbon monoxide, volatile organic compounds, and other gases related to wildfire smoldering, or rank 1 fires, have been used in a variety of contexts to detect wildfire ignition and spread[34]. Each sensor can monitor a 1-2km radius, and they are all connected through artificial intelligence communication networks for rapid data comparison[34]. Researchers in Italy recently tested a "smart CO2 sensor network-based early detection system"[35]. Using a network of 44 sensors in high-risk areas for wildfires, they found that integration of AI models with sensors that can measure the concentration of "carbon dioxide, temperature, humidity, and barometric pressure" led to a 56% increase in the number of sensors detecting early stages of wildfires but also contributed to "tracking potential fire front propagation based on wind patterns"[35].

A secondary benefit of gas sensors is that levels of pollutants emitted from a wildfire can be monitored in real time to inform controlled burn strategies, in circumstances where allowing a moderate burn is judged beneficial to the long-term management of flammable organic matter. Sensors for monitoring specific pollutants could be integrated into early detection systems or could be developed as portable systems to inform decision-makers of pollutant levels in specific locations affected by the wildfire, such as residential, medical, and educational locations[36].

4.1.2. Soil Moisture Monitoring, Irrigation and Sprinkler Systems

Although sprinkler systems have been used to protect individual buildings, recent research suggests the installation of irrigation and sprinkler systems in remote regions experiencing drier-than-average conditions can be an effective method of limiting wildfire spread and intensity[37]. This reactive form of water use, after the ignition of a fire, has been recommended as part of an autonomous integrated system of wildfire response, with permanent water turrets integrated with sensors and centralized algorithmic analysis of collected data informing an automated response of directed water[38].

4.1.3. Autonomous Drones

The development of autonomous drones to fight wildfires has the potential to revolutionize the way that wildfires are fought and controlled. Any attempt to interact with wildfires poses a significant risk to human health and is expensive and unpredictable. The use of autonomous drones would remove most of the risk for human firefighters and allow a rapid and cost-effective response to wildfires of any scale. In recent years, research has focused on the development of swarm robotics and drone technology. The first research on proof of concept for autonomous swarms of firefighting drones was published in 2018, so the development of the technology is in its early stages. The proof of concept focused on showing how "the use of fleets of decentralized cooperative and self-organizing robots results in a robust and resilient system with collective decision-making which can cope with uncertainty, errors, and the failure or loss of a few non-essential units without jeopardizing the mission"[39]. The technology has rapidly improved, to the point that in 2023 researchers began developing autonomous biodegradable self-sacrificing drones to be used in wildfire fighting, to prevent negative environmental impacts when the drones are damaged or destroyed while being used to fight fires[40].

The most significant challenge for the application of drones to firefighting is the interaction with an unpredictable environment and coordination in fast-changing conditions. Artificial intelligence and advances in machine learning have created the ability to develop a "decentralized drone swarm system designed for the dynamic search, detection and the monitoring of wildfires"[41]. The self-organization of swarms of drones in response to the dynamic events that characterize wildfires ensures that there is minimal duplication in the use of resources, as swarm intelligence has already developed to the point that swarms have been shown to "position themselves around the fire to observe it from as many angles as possible" which leads to the emergence of "a single continuous ring of evenly spaced drones"[41].

To maximize the effectiveness and efficiency of autonomous drones, whether as individual units or in swarms, researchers are developing systems of integration with data from sensors and satellites such as those already described. By creating feedback loops between drones that can detect and monitor, and static sensors that can provide early warning or more in-depth data, decision-makers can quickly establish a clear understanding of wildfire ignition locations and wildfire spread and intensity[42]. However, technology for directly combating wildfires with drones is also developing quickly. In the simplest form, large drones connected to sources of water through piping to the ground have been used on a small scale to target fires. These drones are not yet autonomous and are limited in range due to the necessity for a connection to a continuous supply of water[43]. Larger drones that can carry up to 100kg of fire-retardant chemicals have also been developed, to some extent overcoming the limitations of the ground-to-air pipe system[44]. These drones are also equipped with sensing technology, such as infrared cameras, to more effectively and strategically target areas of a wildfire[44].

Rather than relying on water or large amounts of liquid fire suppressants, some researchers are pursuing the development of fire extinguishing balls – "a foam casing encased in PVC and containing a dry chemical fire suppressant. Activated by heat or flames, triggers within the unit prompt an immediate dispersal of the suppressant"[45]. The advantage of fire extinguishing balls is that they can be transported by much smaller drones when compared to drones used for carrying large amounts of liquid fire suppressants or water pipes directly connected to the ground[45].

Currently, the main limitation of drones in wildfires is their resilience to high temperatures, or "thermal shock," in particular with regard to battery design, which is vulnerable to warping and explosion once in close proximity to a fire. However, rapid advances are being made in the design of heat-resistant materials for firefighting drones and heat-resistant lithium-ion batteries[46].

4.1.4. Artificial Intelligence for Wildfire Prediction

Using artificial intelligence to analyze large datasets is effective in various contexts for predicting the possibility of wildfire ignitions[47]. For example, the Fire Aid Program in Turkey has used "400 factors from 14 datasets, enabling the anticipation of wildfires with a precision rate of 80% up to 24 hours in advance[47]. Researchers in Finland have developed neural networks that can use historical data on climate and wildfire occurrences. In testing, the model recommended interventions at specific locations and times that would have "cut the number of fires by 50 to 76 percent"[48]. In South Korea, machine learning has been used to create models that can identify high-risk zones, with a success rate of 76%[49]. Recently South Korean researchers also used modelling to assess the outcomes of three management strategies until 2100. The three strategies modeled were current, ideal, and overprotection. By using the models to assess current datasets, the team developed an "ideal" management strategy that predicted a 60-70% reduction in the frequency of fires and the total area burned[50].

4.1.5. Climate-Smart Forestry

Although specific technologies and methods are often researched and employed, experts argue that there is "currently a lack of comprehensive and cohesive assessment to implement" holistic approaches that have been shown to lower costs and have more impact on reducing the damage of wildfires[51]. The definition of climate-smart forestry is: “Sustainable adaptive forest management and governance to protect and enhance the potential of forests to adapt to and mitigate climate change. The aim is to sustain ecosystem integrity and functions and to ensure the continuous delivery of ecosystem goods and services while minimizing the impact of climate-induced changes”[51].

In the last year, a holistic climate-smart forestry approach to mitigating climate change has begun to emerge in South Korea, but the focus has been on the "climate-resilient development pathways" and South Korean forests for their potential as carbon sinks[52]. Although this approach has not been taken specifically to reduce the damage caused by wildfires, the aims of creating climate resilience through forest management and wildfire damage mitigation strategies overlap. Research shows that South Korea's forests are "over-mature" and thinning of the trees that were planted as part of the reforestation efforts of recent decades would create healthier forests that absorb more carbon[52]. This approach overlaps with the research on wildfires, which shows that large amounts of old and dead wood are accumulating in South Korean forests because of poor management and imbalanced ecosystems.

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4.2. Application to the South Korean Context

As shown by the literature review, various methods and technologies are available for the prediction and management of wildfires. However, despite the wide range of options available, South Korea still suffered the worst wildfire damage in its history in early 2025. The plethora of options available is not translating into effective management, prediction, and combating of wildfires. As an example of the disjointed and unplanned approach to wildfire management, a 73-year-old pilot was killed while firefighting using an s-76 helicopter, which was built in 1995. The South Korean Forest Service had tried to avoid using the older helicopters but eventually asked any pilots who consented to fly them to fight the wildfires in March[53]. With the wide range of drone options currently being developed, the last-resort use of older technology with increased risk to life reveals the absence of a well-prepared and comprehensive approach to wildfire prediction and management in South Korea.

To improve the response to wildfires, South Korea should move toward holistic preventative strategies and the integration of rapidly improving sensing technologies with artificial intelligence to inform decision-making related to wildfire suppression, containment of moderate burns, and recording of pollution levels. To better react to and manage wildfires, the development of an integrated network of autonomous drones, including those with swarm capabilities, and varying sizes and capabilities, should be a priority. The integration of drone technology with large datasets from comprehensive systems of monitoring, including underutilized data such as soil moisture, should be a focus of investment. The integration of these systems with artificial intelligence and machine learning that has been calibrated to the South Korean context is necessary and urgent to prevent catastrophic damage such as that seen in Spring 2025.

However, a comprehensive approach to reducing the damage of wildfires requires a balance between prevention and reaction. Effective prevention will facilitate better management of both the risks and potential to harness wildfires as a tool for reducing old and dead organic material. In many cases, the technology used in prevention will become part of the reaction once a wildfire ignites. The literature review shows that preventive and reactive approaches will be most effective when considered as part of a system of feedback loops in an integrated network that contributes to effective and safe management of the environment.

Regarding preparation and prevention, a significant challenge will be addressing the unintended consequences of reforestation that have emerged in recent decades. Reforestation became an entrenched policy regardless of changes in political power, but balanced ecosystems in which flora and fauna break down old and dead wood require more than only planting trees. As soil moisture levels are highly correlated with the spread and intensity of wildfires, forestry planning that includes monitoring of soil moisture levels and interventions to create ecosystems that maintain adequate soil moisture is required. The research shows that both preventative and reactive strategies are required to reduce the increasing damage caused by wildfires. However, if stable ecosystems that have been cultivated to develop characteristics that limit wildfire risk are created, the long-term cost of reactive policies will be significantly reduced. The need for better management of South Korea's forests has been identified in research directly on the causes of wildfires and the potential for forests to be more efficient carbon sinks. Both areas of research have found that thinning the forests and reducing the age of the wood would be beneficial for preventing wildfires and improving the efficiency of South Korean forests as carbon sinks. The literature review shows that controlled burns or management of identifying wildfires, which can be monitored and contained as moderate burns, would be one way to achieve this goal. As part of a holistic approach to wildfires and South Korean forests, it would

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therefore be productive to create policies and capabilities to integrate moderate burn wildfires into South Korean forestry management.

Another significant part of the preventative strategy will be increasing responsibility and awareness among communities that are facing increased risks from wildfires. The literature review shows that most wildfires are caused by human activity, such as the lighting of candles at the ceremony on the mountainside, which led to the ignition of one of the wildfires in South Korea in Spring 2025. However, only educating citizens about the wildfire risk associated with their behavior is not enough. Citizens need to be given more responsibility for maintaining healthy ecosystems in the forests and wildlands that surround them. The wildlands should be understood as a resource, not a threat, and climate-smart forestry can become the norm for citizens' interactions with wild environments such as the forest.

From a broader perspective, the most effective way to reduce the damage caused by wildfires is to limit or reverse the climate change that is causing the wildfires' frequency and intensity to increase. South Korea is currently committed to producing 20% of its energy through renewable sources by 2030. This is much lower than the 60% global target set by the International Energy Agency[54]. South Korea also only uses low-carbon sources for 40% of its energy, and 60% is still reliant on fossil fuels[54]. Although South Korea alone cannot stop or reverse global climate change, politicians and citizens need to become more aware of the fact that the cost of transitioning to renewable and low-carbon sources of energy quickly is offset by the unpredictable costs associated with rapid man-made climate change, such as the damage and pollution caused by the wildfires this year.

Finally, a specific localized challenge is the pervasiveness of pine trees and their influence on wildfires. In the Mediterranean context, it has been found that volatile organic compounds in some plants may "rapidly burst into flames" and act as catalysts and intensifiers of wildfires[55]. The Mediterranean plants that cause this spread play a role analogous to the pine trees of South Korea, with the pine sap acting as an accelerant. Rapid detection of wildfires in the incipient stage in both the Mediterranean and South Korean contexts becomes futile unless the efforts are focused on monitoring the behavior of volatile organic compounds before they ignite. Researchers in Portugal have found that monitoring systems using impedance spectroscopy can accurately detect changes in volatile organic compounds as they begin to increase in temperature but before they ignite explosively[55]. As part of a comprehensive approach to reducing the damage caused by wildfires, this type of local characteristic should be researched, and solutions specific to the context need to be developed. The example of the pine trees shows that South Korea will need to develop a wildfire response system that is designed specifically for the South Korean context.

5. Future Research

Further research needs to be conducted on the most efficient allocation of resources across systems of sensors, autonomous drone development, and preventative climate-smart forestry. Different locations will require a flexible approach that is sensitive to the challenges of specific sites and the allocation of resource plans unique to the characteristics of the site. For example, sensors on the leeward mountainsides on the East Coast should focus on monitoring the Fohn Effect, whereas networks of sprinkler systems or irrigation connected to lakes and rivers should be developed around human settlements. Within human settlements, pollution and smoke monitoring would require resources to allow informed decision-making for when controlled moderate burns are allowed to continue to prevent the buildup of dry organic material that characterizes the most catastrophic wildfires. Locations where this strategy should be used need to be identified.

A long-term goal should be the development of a comprehensive, integrated, and automated network of sensors, drones, and other technologies, such as sprinklers, to increase the speed of response time when wildfires ignite and to collect data that can inform decision-making. This development should happen alongside a climate-smart forestry plan that develops healthy ecosystems more resilient to wildfire and fulfills their potential as a productive resource for citizens. Research on climate-smart forestry plans and how to integrate an automated network of technology is necessary, including how artificial intelligence and machine learning can be leveraged to inform the development and maintenance of both.

Research on the most effective way to educate and include citizens in these plans is required. Local people need to become the custodians of their forests by being aware of how their behavior contributes to wildfires and how citizens' habits can be shaped to contribute to climate-smart forestry and overall environmental resilience.

Finally, research on the feedback loop between rapid climate change and the increasing frequency and intensity of wildfires is needed. Each wildfire creates the gases associated with climate change, and climate change makes wildfires more likely. Once the cost of this feedback loop is understood, it can be used to inform policy development on climate change and the environment, including the costs of wildfires when considering investment in renewable and low-carbon sources of energy.

6. Limitations and Weaknesses

This paper aims to highlight the need for a holistic and preventative approach to the management of the increased wildfire risk in South Korea. However, as a general overview, a few specific suggestions for specific sites could be made. Analysis of data related to specific sites and the development of a holistic model for a specific site would strengthen the argument that this approach would be effective. Although this paper argues that a more holistic approach was needed, an effective critique of the wildfire response in Spring 2025 by the South Korean authorities would have required access to the local government strategies and data on the responses.

7. Conclusion

Like many regions around the world, South Korea faces an increasing risk of significant damage from more frequent and intense wildfires. The damage caused by the wildfires in Spring 2025 shows that a different approach is needed to manage the risk. The development of new technologies such as autonomous drone swarms and sophisticated remote gas sensors provides an opportunity to limit the risk to human life and the environment by responding to wildfire ignition at the earliest possible opportunity and with a strategy that is customized to the site of the fire. However, the adoption of these technologies should be simultaneous with the adoption of holistic long-term planning through climate-smart forestry. In this way, the environment can be managed to its full potential, minimizing risk, enriching biodiversity, and increasing awareness of how citizens interact with their environment. Although this approach will require a combination of centralized planning, efficient allocation of resources, site-specific knowledge development, and the customization of new technologies to the South Korean context, the cost and effort will be insignificant compared to the cost associated with catastrophic human, environmental, economic, and cultural damage caused by extensive wildfires such as those that spread rapidly through South Korea in spring 2025.

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