Figure 1: An example of a firefighting drone (Press 2017)

FOREST FIRE RISK REDUCTION IN ALBANIA:

Using Drone Systems to Improve Current Methods of Fire Prevention, Monitoring, and Extinguishing

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Using Drone Systems to Improve Current Methods of Fire Prevention, Monitoring, and Extinguishing

An Interactive Qualifying Project submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the degree Bachelor of Science

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Report Submitted to:

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ABSTRACT

This project investigated the feasibility of integrating EXINN Technology Center's innovative fire protection drone system into Albania's current firefighting strategies. We interviewed seven forestry management and fire protection experts in Tirana as well as four employees at the Dajti Mountain National Park to determine gaps in current fire protection methods. Our Dajti case study indicated that EXINN's system has the potential to augment early detection and risk reduction in mountainous Wildland-Urban Interfaces. The majority of interviewees considered monitoring the most realistic drone function, while prevention and extinguishing have the most promise. We recommend that EXINN considers implementing their system incrementally, beginning with utilizing drones for monitoring forests.

ACKNOWLEDGEMENTS

Our team would like to offer a special thanks to the following individuals for their assistance, hospitality, and time in helping us gain the information necessary to complete our project:

- Our advisers, Professor Robert Hersh and Professor Robert Kinicki, for their extensive guidance and feedback from the very start of the project all the way to its completion within 14 weeks.

- Our sponsor at EXINN, Endri Bahja, for connecting us with key stakeholders and providing us with the opportunity to contribute research towards the implementation of cutting-edge technology.

- Our co-sponsor at the Agricultural University of Tirana, Dr. Marsela Luarasi, for facilitating our interviews at the university and providing transportation. Also for translating during some of our interviews.

- Andrea Papa and Niki Xara, for helping us understand the intricate details of EXINN's system.

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- Professor Metaliaj and Dr. Pasho for providing their expertise and research regarding forest fire trends

- All individuals that we interviewed for taking the time to assist our project

EXECUTIVE SUMMARY

Forest fires in Albania

For the past few decades, forest fires in Albania have increased in both number and intensity (Nikolav & Nemeth, 2015). Recent fire seasons, such as during 2007, 2011, 2012, and 2017, were some of the most destructive fire seasons Albania has faced in terms of number of fires and total amount of burnt area (GWIS, n.d.). Climate change is a leading contributor to this, due to rising temperatures and decreasing precipitation, which can lead to heat waves and droughts that dry out vegetation. Researchers predict that these factors will continue to increase the risk and frequency of large forest fires in the future (Worldbank, 2011). Forest fires pose significant property and health risks, especially in Wildland-Urban Interfaces (WUIs), where developed land borders closely with wild forest or grassland areas. Due to increased human activity and proximity to the forests, these areas experience an increased likelihood of forest fire occurrences (Modugno, Balzter, Cole, & Borrelli, 2016). These forest fires have negative environmental, economic and health effects that experts believe will worsen unless civil protection agencies take proactive measures to combat them.

Multiple UN reports have concluded that Albania's current civil protection system is inadequate at reducing the risks and impacts of all-natural disasters, including forest fires. Despite efforts such as the National Civil Emergency Plan (NCEP) in 2004 to improve the division of responsibilities and resource allocation in respect to civil emergencies, reports have highlighted a disconnect between many government ministries and disaster risk reduction. Firefighters and rangers are not able to carry out many of the proactive measures that the NCEP outlines to prevent fires such as controlled burning displayed in Figure E1 (Lawson, 2018).

EXINN's Fire Protection System

Our sponsor, EXINN technology center, is a technology and innovation development company. They are currently developing a fire prevention system that utilizes swarms of drones and thermal camera stations to detect and extinguish

Figure E.1: An example of controlled burning (Oregon Department of Forestry, n.d.)

small forest fires before they become a significant threat. As part of this system, EXINN is creating an algorithm that will allow the thermal camera stations to communicate the location and size of fires to drones and direct the drones to fly to the fires and drop fire extinguishing balls to put them out. Figure E2 shows a model of a single drone in the system carrying a fire-extinguishing ball. EXINN intends this system to work in tandem with current prevention and monitoring strategies that firefighters and rangers employ.

Goal and Objectives

The goal of this project was to identify current fire monitoring, prevention, and extinguishing practices throughout rural areas, national parks, and Wildland Urban Interfaces in Albania, with a case study focus on Dajti Mountain National Park, and to understand how key stakeholders assess the feasibility of EXINN's drone system as a tool to improve these practices. We chose Dajti as area for a case study because it is a WUI, an area where wilderness abruptly meets with an urban area. The intention of EXINN's system is to prevent forest fires in areas that may be inaccessible to firefighters. Thus we selected this national park as an area that may benefit from EXINN's system.

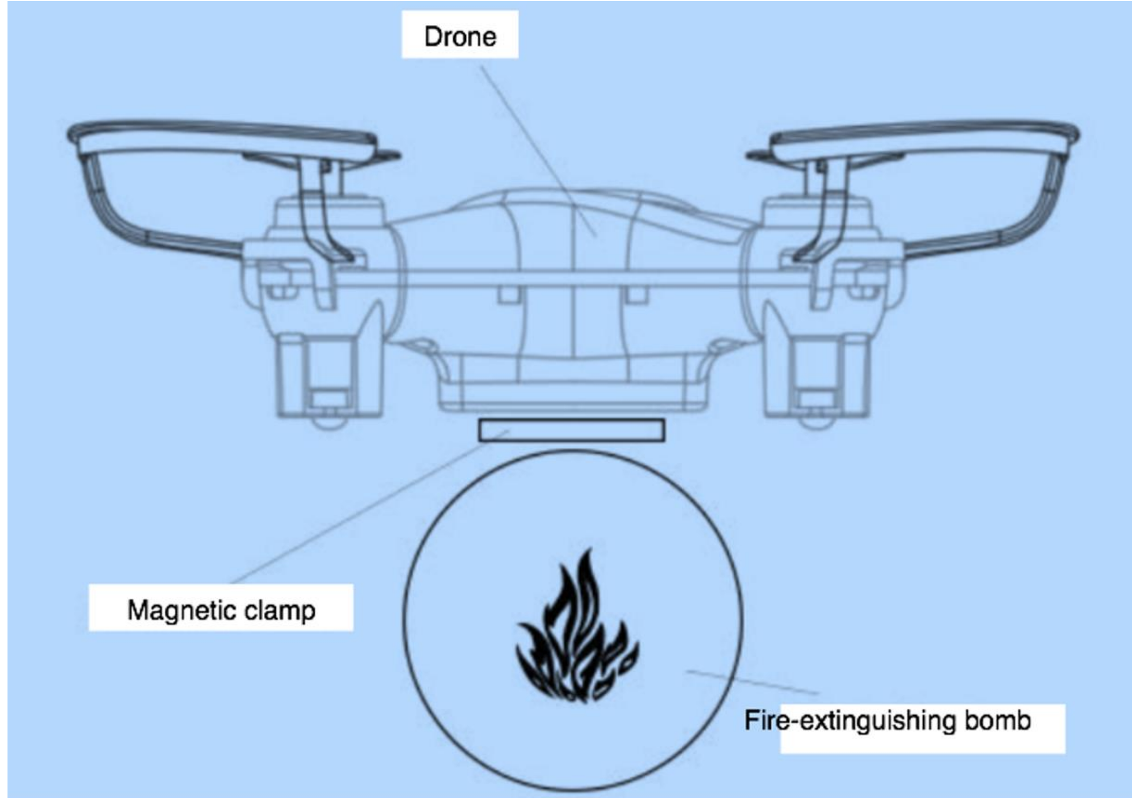

Figure E.2: Diagram of a drone from EXINN's system with its magnetic clamp and fire-extinguishing ball

Our objectives for our project were:

1. Identify current and predicted trends related to Albanian forest fires
2. Determine the legal framework for fire management
3. Examine fire prevention, monitoring, and extinguishing practices
4. Analyze how EXINN's system fits into current fire protection practices
5. Investigate the potential for the implementation of EXINN's system in Dajti Mountain National Park

Methods

We interviewed 11 individuals, 7 of which were experts related to forest issues or fire management. The remaining four individuals were employees at the Dajti Mountain National Park, who we interviewed as part of a case study of the

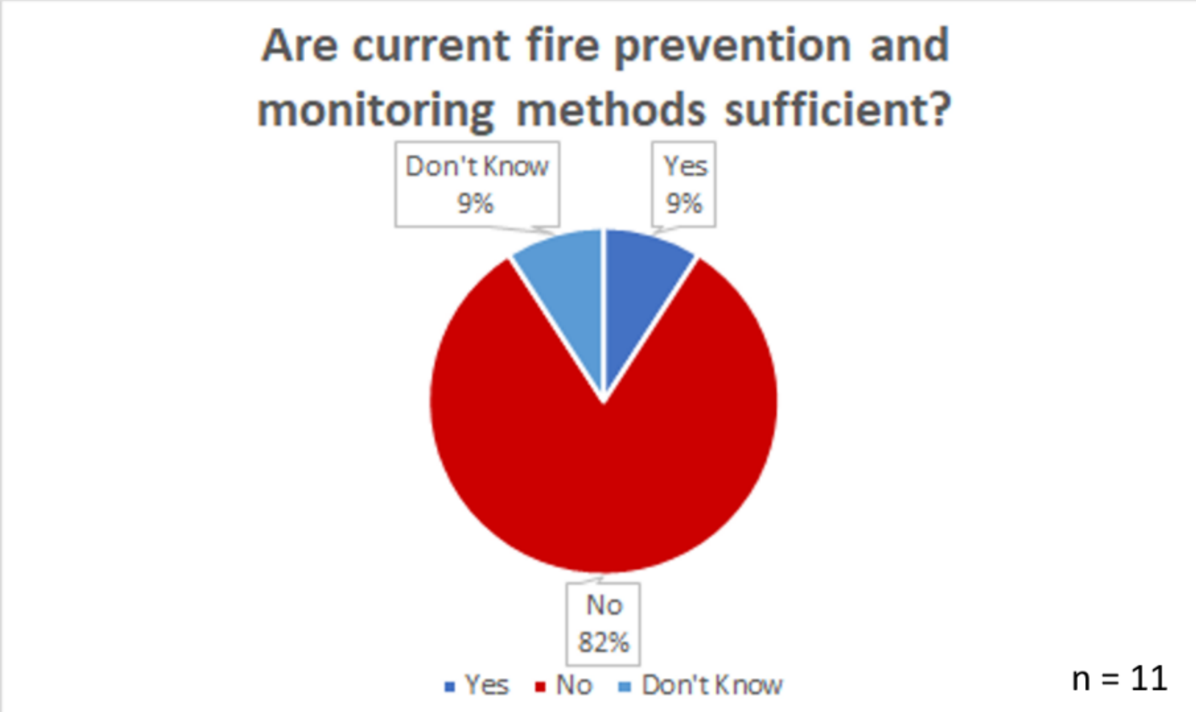

Figure E.3: Interviewees' perceptions on the sufficiency of fire prevention and monitoring

park. The experts came from various backgrounds, including a former Director of Planning and Coordination for Civil Emergencies, two forestry professors from the Agricultural University of Tirana, a project manager from the BRIGAID, the current director of the Tirana fire department, and two climate scientists from the Institute of GeoSciences, Energy, Water and Environment (IGSEWE). From the Dajti Mountain National Park, we interviewed a park ranger, a business manager, a resort employee and a restaurant employee, all with experience extinguishing fires during a major forest fire event at Dajti in 2012.

Findings & Analysis

From our interviews, we learned about areas in Albania that are most vulnerable to forest fires and gaps in fire protection practices. Interviewees believe that forest fires have a higher frequency in southern Albania. Centralized records on forest fire frequencies and damages, however, are not consistently available to government ministries. Municipalities collect a limited amount of statistics regarding fire damage, but their records are often incomplete due to lack of surveying equipment and access to rural areas. In regard to the frequency of fires, experts believed that forest fires were occurring more often because the effects of climate change have been increasing fire risk.

Figure E3 shows that the majority of the experts and stakeholders we interviewed expressed that current fire prevention and monitoring strategies were not sufficient to manage the growing risk of forest fires in Albania. Rural volunteer firefighters and rangers rarely implement the fire prevention and risk reduction strategies designed in the National Civil Emergency Plan. There is an insufficient number of rangers to effectively monitor forest fires, and they are not adequately equipped to early warnings. The Institute of GeoSciences, Energy, Water, and Environment creates daily and monthly risk bulletins as a form of fire monitoring, but the reports have limited accuracy and scope. Additionally, municipality employees and firefighters do not utilize bulletins to inform forest monitoring strategies. In regard to extinguishing fires, mountainous areas prove difficult for firefighters due to a lack of equipment and infrastructure.

From the case study at Dajti Mountain National Park, the team learned that the park has a history of forest fire occurrences and there are perceived gaps in the park's fire protection practices. Rangers practice limited fire prevention but do not prioritize fire detection when patrolling the park. Employees at Dajti did not perceive issues relating to fire extinguishing because fire responses in the past have been quick and effective. Many of the employees volunteer to extinguish flames nearby when they occur.

All interviewees were optimistic about the use of EXINN's system for filling the gaps in current fire protection practices. They were confident that the system would be able to successfully detect and put out small fires. The employees at the Institute of GeoSciences, Energy, Water and Environment were interested in the possibility of forest data collection, including temperature, humidity, wind speed, vegetation structure. Interviewees believed that system could work in tandem with traditional fire response practices to help monitor and put out fires.

Despite the positive reception to EXINN's system, eight out of ten interviewees expressed concerns about its implementation. Figure E4 shows that four out of ten interviewees believed that bureaucratic issues were the largest obstacles. Some of them believed that the government does not prioritize proactive fire prevention and monitoring methods. Two of these four had difficulties when collaborating with the government with the innovative projects they were involved in.

For a system of this scale, it is important to assess the most appropriate financial implementation strategy. Figure E5 displays that three of seven interviewees believed that a public private partnership would be the most successful path to implementing EXINN's system. In this type of partnership, a private entity purchases the system and then through a contract, the government pays a fee for service to use the system as a public service. This can allow the private entity to assume most of the risk by making the initial investment and managing the system, while the government provides financial incentives to the private entity.

EXINN's system aims to address all aspects of fire protection through the combination of thermal cameras and drones, but the high initial cost may be limiting. To provide insight on drone use, our team explored perceptions of using drones for each individual function: prevention, monitoring, and extinguishing. Figure E6 shows that most interviewees viewed monitoring as the most realistic function for drones by a significant margin, while extinguishing was the least realistic.

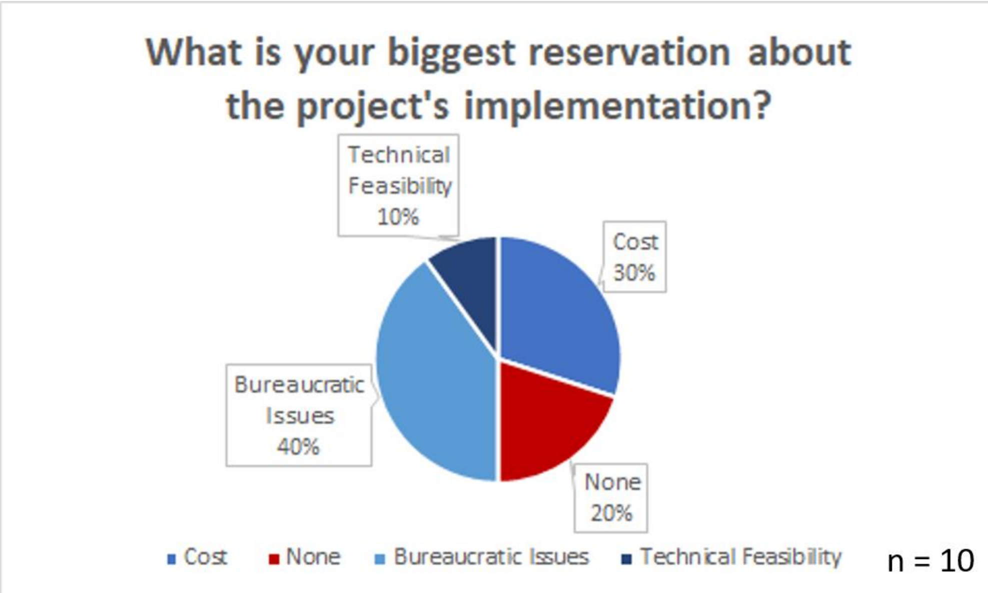

Figure E 4: Interviewees' biggest reservations about EXINN's system's implementation

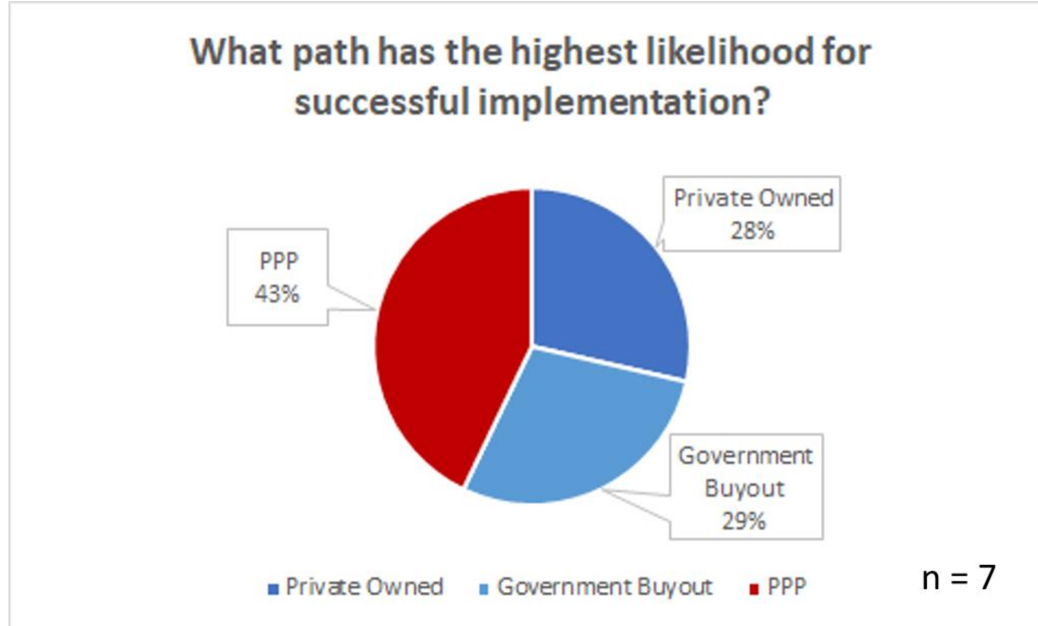

Figure E 6: Interviewees' opinions on which path has the highest likelihood for successful implementation of EXINN's system

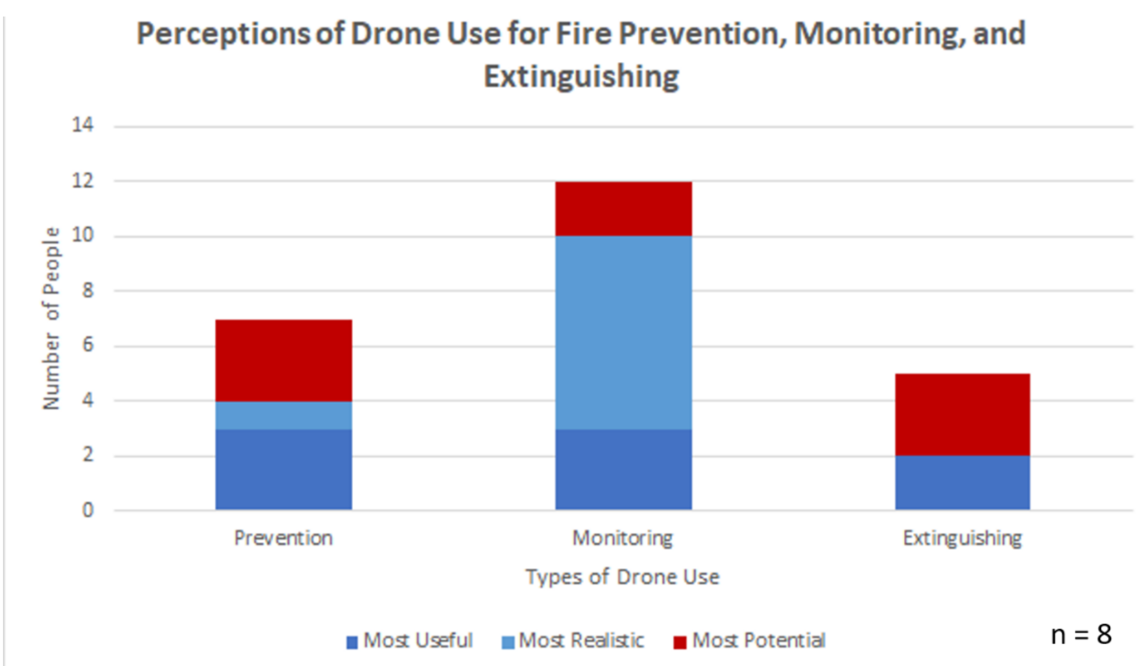

Figure E 5: Interviewees' responses to most useful, realistic, and potential applications for drones

Conclusions

All of our interviewees believe there are gaps in current Albanian fire preventing and monitoring practices. At the local level, rangers lack access to watchtowers, patrolling vehicles, and monitoring technology to better detect fires and provide early warning. Additionally, rangers rarely carry out fire prevention strategies such as prescribed burning and fire breaks. Municipalities often submit incomplete and incorrect fire statistics to the Disaster Loss Database, and the IGEWE has not been able to create precise risk maps to guide resource allocation and inform prevention strategies. Through the Dajti Mountain National Park WUI case study, our interviews concluded that the area has a history of forest fires, and the inadequate fire prevention and monitoring procedures puts valuable real estate investments at risk.

Our research has shown that EXINN's system can improve fire prevention practices by extinguishing small fires before they become a threat and performing fuel reduction during its idle time. The drone system can enhance monitoring practices by collecting valuable forest data and improving early fire detection. Finally, the drone system can potentially work alongside traditional fire response strategies to aid the extinguishing of larger fires. When looking at separate drone functions, interviewees considered fire monitoring to be the most realistic use, though extinguishing and prevention have the greatest potential for the future because technology is progressing rapidly towards automating jobs that put lives at risk. Despite all interviewees being optimistic about EXINN's system there were concerns about technical feasibility, the high initial cost, and the government's role in overseeing its implementation. Due to the concerns about bureaucratic issues, the majority of interviewees believed a Public Private Partnership would be the most successful method of implementing the system.

Recommendations

- EXINN should perform extensive testing to prove the system's full capabilities to potential investors.
- EXINN should consider implementing their system incrementally, beginning with utilizing drones for fire monitoring purposes.
- EXINN should consider a collaboration with the Institute of GeoSciences, Energy, Water, environment and the National Environmental Agency to analyze current statistics and trends to determine an appropriate pilot testing site.
- Our limited research indicates that Dajti Mountain National Park has the potential to be an appropriate pilot site.
- EXINN should explore the benefits and drawbacks of using multiple smaller sensors instead of one large thermal camera, to eliminate a single point of failure.

AUTHORSHIP

Andrew Markoski: Andrew is from Massachusetts in the United States. At WPI, he majors in Computer Science.

Olivia Caton: Olivia is from Massachusetts in the United States. At WPI, she majors in Environmental Engineering, with a minor in Interactive Media and Game Design.

Jeffrey Tallan: Jeffrey is from New York in the United States. At WPI, he majors in Civil Engineering.

Emily Osterloh: Emily is from New York in the United States. At WPI, she majors in Chemical Engineering and is pursuing a master's degree in Fire Protection Engineering.

Figure 2: Our team from Left: Andrew Markoski, Olivia Caton, Jeffrey Tallan, Emily Osterloh

Our team chose to collaboratively write each chapter, with individuals taking the lead on writing certain sections or editing based on understanding of the information and personal skills. The details are shown in the table below.

Chapter	Author	Editor	Chapter	Author	Editor
Abstract	Jeffrey	Andrew	Methods	Introduction – Andrew 3.1, 3.6 – Jeffrey 3.2, 3.3 – Emily 3.4 – Andrew 3.5 – Olivia	Andrew, Olivia
Executive Summary	Jeffrey	Olivia	Findings	Introduction, 4.4 – Olivia 4.1 – Andrew 4.2 – Jeffrey 4.3 – Jeffrey	Olivia
Introduction	Emily	Jeffrey	Conclusions	Jeffrey	Olivia
Context	2.1, 2.1 – Andrew 2.4, 2.5, 2.6 – Jeffrey 2.7, 2.8 – Olivia 2.3, 2.9 - Emily	Andrew	Appendices	A, B – Andrew C, D – Jeffrey E, F – Olivia G, H, I – Emily	Emily

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CHAPTER 1: INTRODUCTION

Figure 3: A model of EXINN's drone monitoring a forest (Climate Innovation Window, 2017)

Forest fires pose a serious and growing threat to communities and ecosystems around the world. Each year, forest fires burn around 3.4 million km^2 of vegetated land globally (Royal Botanic Gardens, 2017). The Balkan region alone loses over 2,200 km^2 of forest - an area slightly smaller than the country of Luxembourg - to fires each year (Nikolav & Nemeth, 2015). The length of global fire seasons, as well as the frequency, size, and intensity of forest fires has been increasing over the past few decades due to climate change (North et al, 2015). Experts predict zthat more frequent droughts, higher temperatures, and less precipitation will likely increase the severity of Balkan forest fires in the future (Pausas & Ribeiro, 2013; World Bank, 2011; Raftoyannis et al, 2014).

For the past few decades, forest fires in Albania have increased in number and intensity (Nikolav & Nemeth, 2015). Uncontrolled forest fires can cause soil erosion, release greenhouse gasses into the atmosphere, destroy forest habitats, and reduce biodiversity (Palliser, 2012). Wildfires can spread past forests and reach arable land that agriculture relies on. Particulates in smoke can contaminate water and crops, lowering the market value of the next harvest (Barth, 2018). Developed areas adjacent to forests, also known as Wildland Urban Interfaces (WUIs), are at risk of significant financial losses. The wildfires also pose risks to human health, both in the short term and long term. Short term risks include burns and injuries from debris. Long term respiratory issues arise in urban and rural communities in close proximity to areas with exposure to smoke from wildfire (Reisen et al, 2011).

Albanian emergency planners and firefighters do not sufficiently utilize mitigation techniques to reduce the impact of the harmful effects of forest fires (Lawson, 2018). Firefighters have different methods of fighting forest fires depending on the fire's location and intensity.

Figure 4: Example of a fire in Dajti Mountain National Park (Ministry of Defence, 2012)

However, these efforts only concentrate on eliminating a single fire at a time, rather than how to collaboratively prevent forest fires altogether (Andone, 2017). This lack of preemptive planning encourages firefighters to use monitoring practices only after a fire has started, in order to determine the most efficient method to fight the individual fire (Andone, 2017). Fuel reduction and fire suppression are common forest firefighting methods, but the former performs on a long-term scale while the latter is potentially dangerous to execute in Albania (Molina-Terrén, Cardil, & Kobziar, 2016; North et al, 2015; Raftoyannis et al, 2014). These problematic areas have left emergency responders struggling to prevent and manage forest fires.

Our group's sponsor, EXINN Technology Center proposes using drones to improve forest fire prevention and detection. Studies have revealed that drones can play an instrumental role in preventing these fires, specifically by monitoring forests with high risk of fires (Boucher, 2015; Laksham, 2019; Rao, Gopi, & Maione, 2016). Emergency responders use drones for fire detection and monitoring in many countries, but efforts to develop drones to extinguish forest fires are currently preliminary (Brocious, 2016; Restas, 2015). There are also drawbacks to using drones - they possess limited flying ranges, and hour-long battery lives.

EXINN is creating an algorithm that will allow a thermal camera station to detect small fires and communicate with a swarm of drones to locate and extinguish the fire before it becomes a significant threat. It intends to market this product to government agencies in the Mediterranean region and private landowners in Albania. The company is currently developing a prototype of the algorithm, but there are large gaps in research about current forest firefighting and forest fires that make it difficult to ascertain the system's role. Thus, EXINN has enlisted our team to find the answers to these questions and provide recommendations.

This project had five main objectives: identify current and predicted trends related to Albanian forest fires; determine the Albanian legal framework fire management; examine fire prevention, monitoring, and extinguishing practices Albania; analyze how EXINN's system fits into current fire protection practices; and investigate the potential for implementation of this system in Dajti Mountain National Park. The team conducted interviews with key experts and stakeholders to inform EXINN about the functionalities of fire protection systems that these individuals value.

Nine of our eleven interviewees believed current proactive fire protection methods to be insufficient. Rangers rarely implement fire prevention practices such as prescribed burning and fire breaks. They also lack access to effective early detection tools and technology. All interviewees were optimistic about the ability of EXINN's system to fill these gaps, but seven had concerns regarding bureaucratic issues, high initial investment cost, or the system's ability to perform its intended tasks successfully. Through these findings, our project provides EXINN with a promising pilot testing site in the form of Dajti Mountain National Park, as well as several recommendations intended to move the future development of the EXINN system forward.

CHAPTER 2: BACKGROUND

Figure 5: A forest fire in Albania (Albanian Daily News, 2019)

In this chapter, we first discuss forest fire trends and their impacts on the areas they burn. Section 2.2 identifies the factors that cause forest fires in Albania. Section 2.3 discusses current Albania policies relating to fire prevention and monitoring as outlined in Albania's legal framework. We then explain sources of information that government agencies use to predict fires. Section 2.5 introduces drones as a technology to monitor, prevent, and fight fires and considers their strengths and weaknesses. Section 2.6 provides background information about Dajti Mountain National Park, an area which serves as a case study for this investigation. The chapter ends with an overview of our sponsors, a description of EXINN's system, and a listing of the key stakeholders affected by this project.

2.1 Forest Fires Trends in Albanian

Figure 6 demonstrates that forest fires in Albania steadily increased for over 20 years, amounting to 7,333 forest fires during that time period, with losses of 20,891 hectares of land and with a cost of US $5.9 million. (Nikolov, 2006). Damages include soil erosion, emission of greenhouse gases, and significant forest degradation (Nikolov, 2006). In 2012, 440 cases of forest fires destroyed 1,161.30 x 10^3 tonnes of biomass and caused 2,052.60 x 10^3 tonnes of CO_2 emissions (Mesquita, Monnier, Aleksic, & Nikolov, 2015; Nikolov & Nemeth, 2015).

The Tirana Times newspaper reported that the 2017 wildfire season was the worst on record. Authorities discovered up to 20 hotspots in a week near Tirana, Elbasan, Fier, Gjirokastra, Berat, Durrës, and Korça out of 280 hotspots where firefighters needed to intervene (Tirana Times, 2017).

In the past decade, the intensity of fire seasons in Albania has

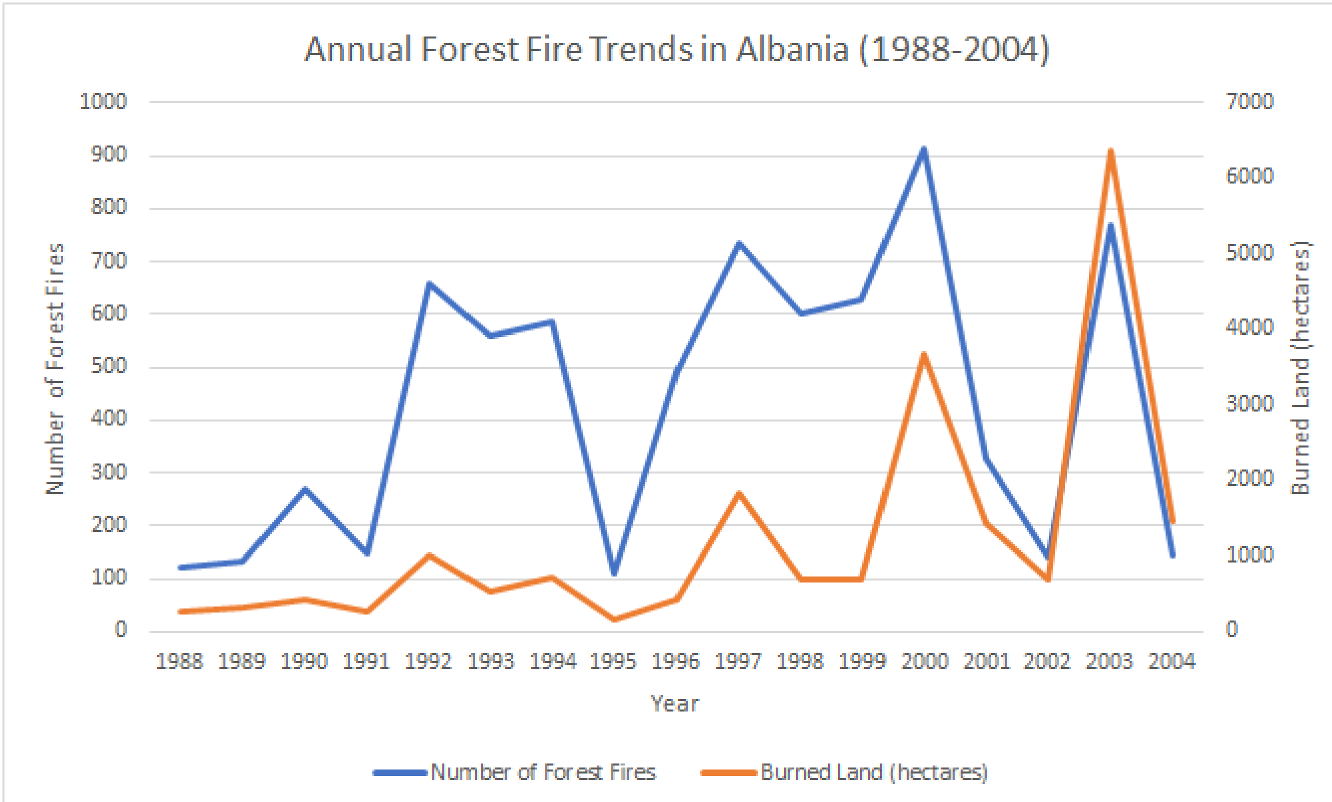

Figure 6: Number of forest fires and total burned land in Albania from 1988-2004 (Nikolov, 2006)

fluctuated, with some years having significantly more harmful fire seasons than others. As shown in figure 7, recent fire seasons with a large amount of burnt area and forest fires include 2007, 2011, 2012, and 2017. The largest annual amount of burnt area was 54,778 hectares in 2007. The most fires that occurred within a year were 268 fires during 2007. Figure 8 shows the concentration of burned areas in the northern and southern regions of

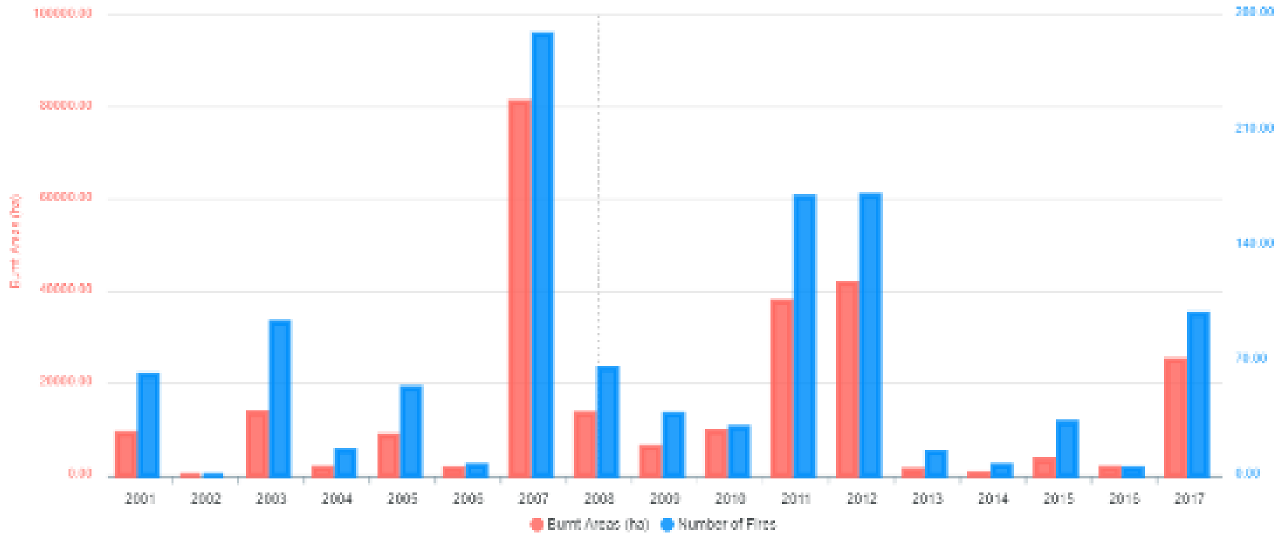

Figure 7: Annual burnt areas (ha) and total number of fires in Albania from 2008-2018 (GWIS, n.d.)

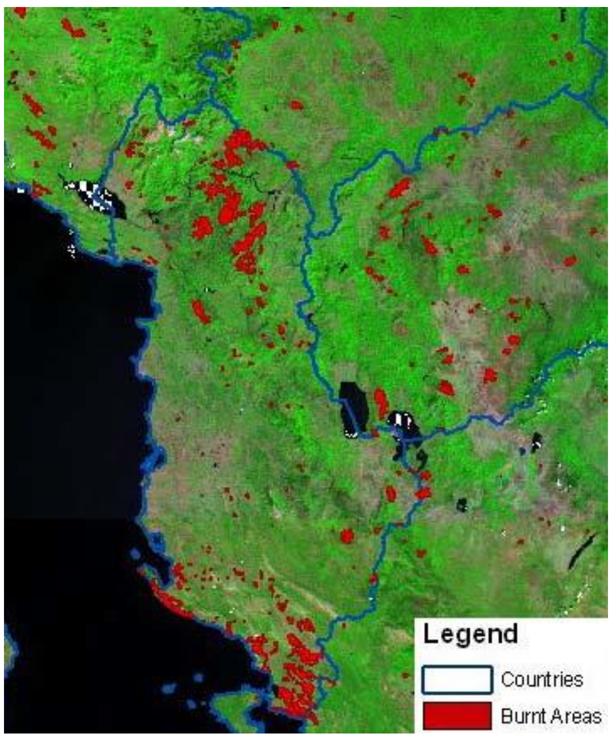

Figure 8: Satellite imagery of burnt areas in Albania due to forest fires in 2007 (Maat, 2010)

Albania during this fire season. Within the scope of the past decade, there is not a significant trend of increasing or decreasing fires due to the uneven mix of mild and severe fire seasons (GWIS, n.d.).

Forest fires tend to consume the wooded land they burn, releasing large amounts of carbon monoxide and fine particulates into the air (Reisen et al, 2011). Long term human exposure can lead to asthma, lung damage, and respiratory diseases. When forest fires reach communities, they burn homes, livelihoods such as crops, and can even take lives, all of which harm the future of neighboring communities. Additionally, areas susceptible to forest fires experience drastic reductions in biodiversity. The blaze can destroy many types of flora and fauna, giving invasive species time to grow before the forest's biome can recover (Palliser, 2012). This upsets the delicate balance of the ecosystem, having potentially permanent effects on the fate of different species and landscapes.

2.2 Causes of Forest Fires in Albania

Human activity is the major cause of forest fires in the

Mediterranean region, through both negligent and intentional fire setting. Some examples include improper crop clearing after harvest, deliberate forest burning for pastures and poor fire safety practices. Indirect human factors like rural land abandonment contribute to forest fires as well (Raftoyannis et al, 2014). Figure 9 shows that 29% of forest fires in Albania in 2015 are due to negligence, 1% are due to unusual and natural events, 9% are due to arson, and 61% are due to unknown factors, which Albanian forest fire statistics note as largely being human activity (refer to Figure 5) (Mesquita et al, 2015). Media coverage can misrepresent these unknown factors since it tends to center on more dramatic or illegal causes of forest fires, such as land development and arson, while providing little information on other causes. This implies that arson and land development are the leading causes of forest fires, when, in actuality, that is not the case (Varela, Jacobsen, & Soliño, 2014).

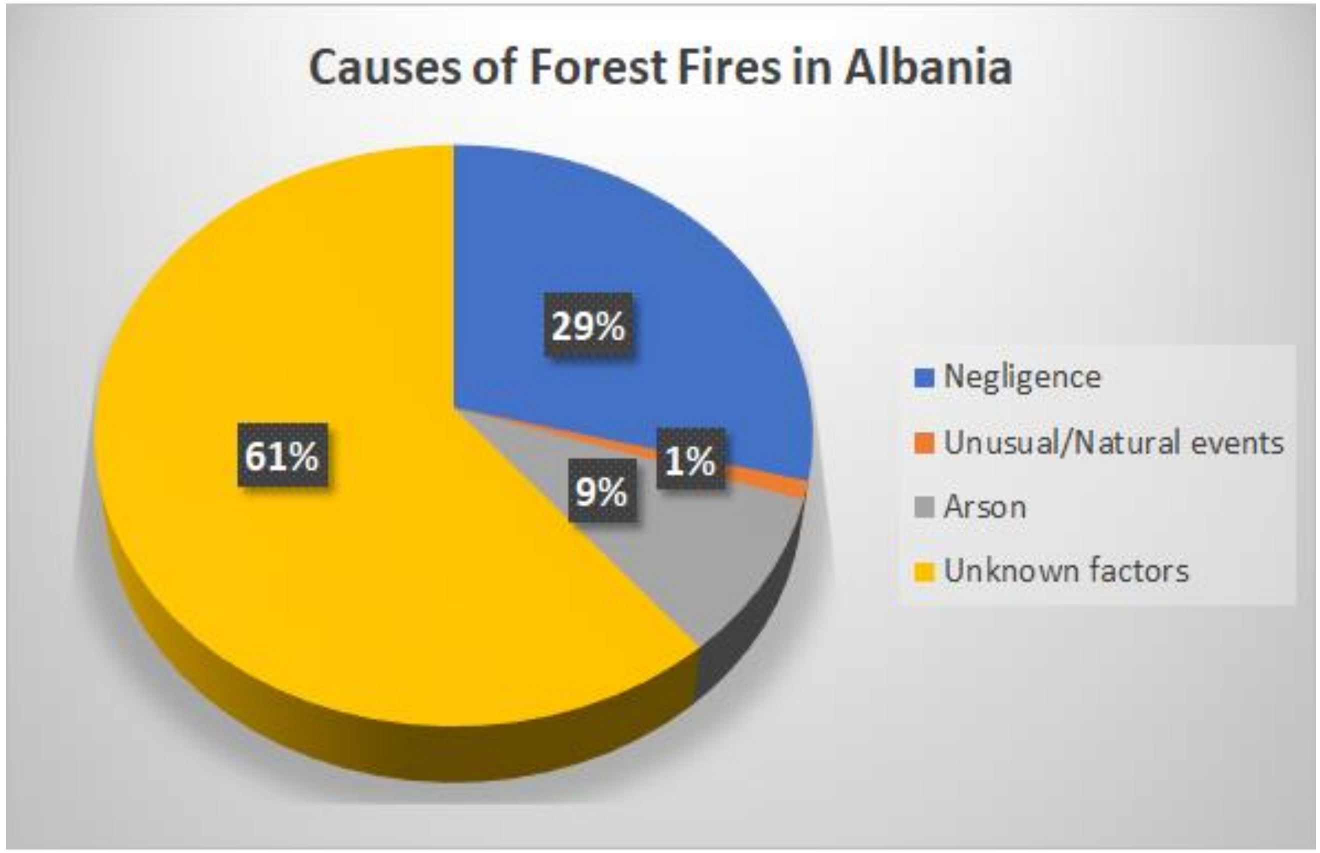

Figure 9: Causes of Forest Fires in Albania in 2015 (Mesquita et al, 2015)

Rural abandonment is one of the main human-related causes of forest fires in Albania. In Albania, 40% of individuals work in agriculture, but this percentage is mostly comprised of older individuals as younger generations migrate to cities in search of employment (Xanthopoulos & Nikolov, 2019). This has led to an increase in wild vegetation transforming previously cultivated lands into shrubland and more fuel for forest fires (Hernandez-Escobedo, Manzano-Agugliaro, & Perea-Moreno, 2017). In many Mediterranean countries, particularly Greece, the rural population dropped 22% in 56 years while experiencing an increase in burned area despite increased investments in fire suppression (Xanthopoulos & Nikolov, 2019). This highlights the sheer volume of combustible biomass created by rural abandonment, and how it affects forest fires.

The climate in Albania varies by region, but generally consists of mild, rainy winters and hot, dry summers. The landscape of Albania consists of three zones: lowlands, hills, and mountains (see Figure 10).

The warm lowlands border the Adriatic Sea, averaging 12-18°C with an annual rainfall of 600-1000mm mostly outside of summer. Moving inland, elevations rise to hills, and eventually to the mountains in the north and east. Colder winters and rainier summer characterize these regions. The mountains average 4-12°C and about 3000mm of rain throughout the year (World Bank, 2011).

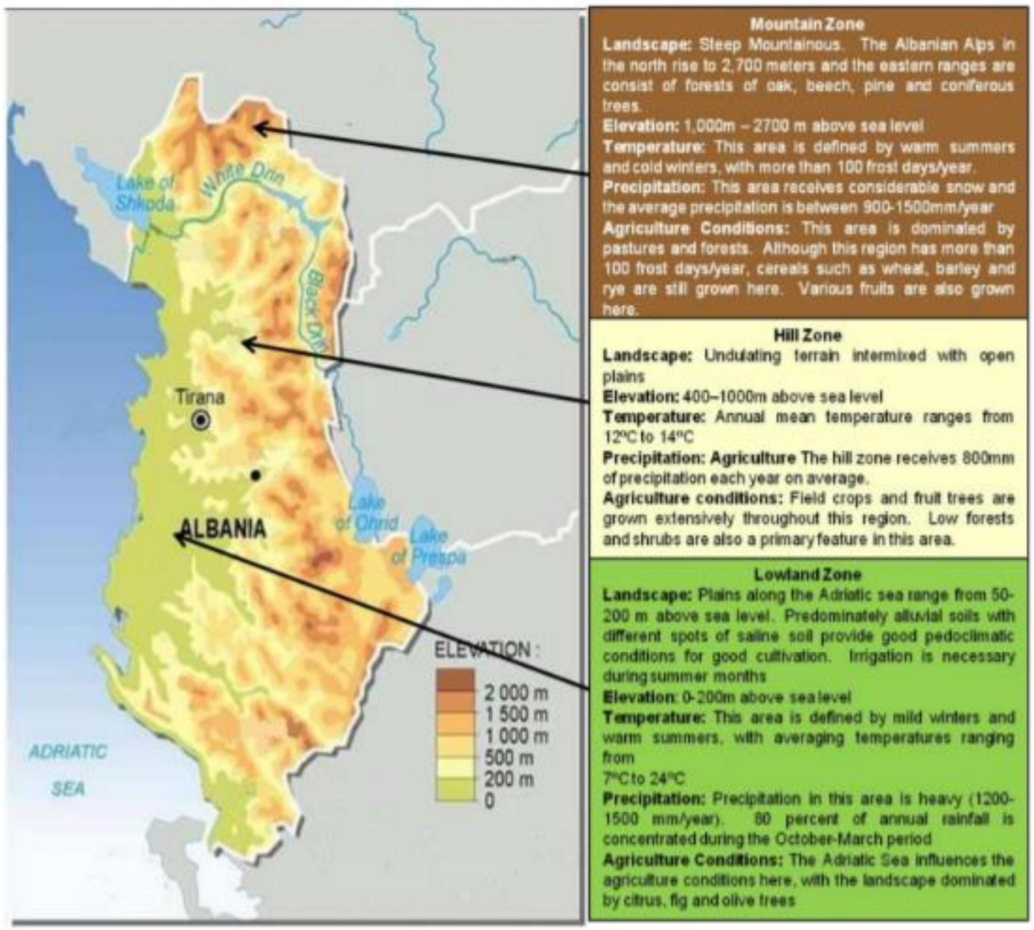

Figure 10: Geographic regions of Albania (World Bank, 2011)

Due to climate change, climate researchers expect Albania and other Mediterranean countries to experience an increase in average temperature and a decrease in precipitation. Higher temperatures push flammable substances to their burning points more easily than lower temperatures, as they are closer to the burning point. Decreased rainfall creates a lack of moisture in the environment, drying up vegetation, and subsequently rendering it more flammable. Furthermore, less rainfall removes a natural method of extinguishing fires. Climate researchers predict that summers will produce more heat waves and drought, with an increase in varied seasonal precipitation (World Bank, 2011).

This has the potential to drastically change the growing seasons in Albania, contributing to tree mortality and subsequently providing more fuel for forest fires. In addition, hotter, drier seasons combined with unpredictable rainfall contribute to longer fire seasons by directly affecting the diversity of an area's vegetation and its flammability (Raftoyannis et al, 2014). Climate change alters weather patterns, and it makes modeling burnt areas for future forest fire preparation more difficult (Pereira, Hayes, Miller, & Orenstein, 2017). The climate of Albania plays a considerable role in the risk of forest fires in addition to the country's geographical and regional differences.

Albania is part of the Balkan Peninsula with a landmass of 28,748 km^2, with nearly 40% being arable land and 36% forests (Albanian National Tourist Agency, 2019; World Bank, 2011; Naka, Hammett, & Stuart, 2000). Oak trees and maquis trees comprise the coast, and areas further inland boasts beech trees and pine trees, but hills and steep mountains cover the rest of the country. Many different lakes cover the terrain, while rivers flow from the mountains to the sea. These locations are important for biodiversity, tourism, and hydroelectricity (Albanian National Tourist Agency, 2019).

Elevation, vegetation, and land abandonment significantly influence the probability of forest fires. Areas with sudden changes in elevation, such as mountainous regions, consist of different shrubs and trees stacked over one another, placing them more closely together than they would be on a flat surface. This allows fires to spread more rapidly, especially with bountiful vegetation. Without vegetation, fires lack the fuel needed to travel effectively in forests. If the vegetation consists of only a few species, there is little variation in the plant's ability to resist catching fire. As a result, there are no natural breaks that could slow the flames. This affects shrub and grasslands the most, as their high regeneration rate allows fuel to accumulate quickly (Oliviera, Moreira, Boca, San-Miguel-Ayanz, & Pereira, 2014).

<u>Wildland-Urban Interfaces</u>

Another vegetation related problem applies to Wildland-Urban Interfaces (WUIs). WUIs are urban areas that border closely to wild forest or grassland areas. One example is Dajti Mountain National Park, which is a large forested mountain on the outskirts of Tirana with a significant commercial area accessible by cable car on the top of a subpeak (Google Maps satellite view, 2019). The close proximity of human activity in and near this park raises the probability of a forest fire having a human-related origin. WUIs near areas experiencing rural abandonment have left a wide range of dry fuel for forest fires to use, increasing their intensity and burn time. Albania has the highest correlation between WUI proximity and forest fires in the Mediterranean region, especially near Berat, Gjirokastër and Korçë. Researchers believe that this is related to the relatively high growth of urban development and rapid social economic changes (Modugno, Balzter, Cole, & Borrelli, 2016).

Areas with little to no vegetation, less sunlight, and certain types of slopes inhibit the spread of forest fires. A lack of vegetation leaves forest fires with no fuel to burn, while less sunlight allows what vegetation has grown to capture more moisture. This makes the plants less likely to burn, even acting as a sort of natural barrier if they are sufficiently wet. Slopes facing northward at high elevations are less prone to fire, mainly due to moist vegetation and a lack of direct sunlight (Oliviera et al, 2014).

2.3 Albanian Fire Prevention and Monitoring Policies

The Albanian Council of Ministers passed the National Civil Emergency Plan (NCEP) in 2004, to clarify the division of responsibilities and planning resource allocation with respect to civil emergencies. This document provides the framework for government and non-government structures to abide by legal responsibilities relating civil emergencies (Lawson, 2018). Similar to the Federal Emergency Management Agency in the U.S., the NCEP outlines the four phases of emergency management as shown in Figure 11.

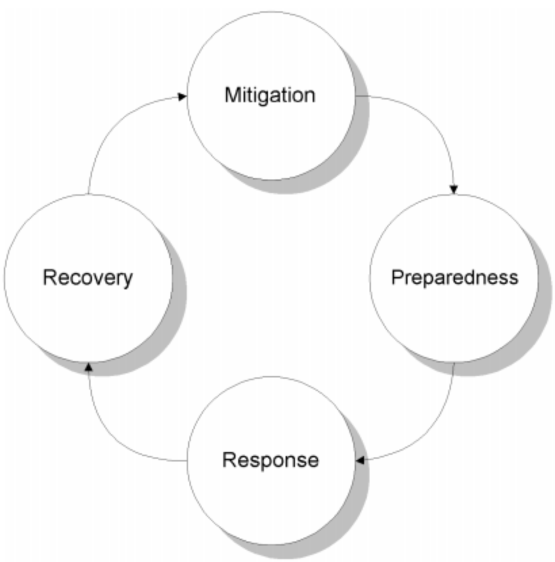

Figure 11: The four phases of emergency management (FEMA, n.d.)

In terms of fire prevention and mitigation, the NCEP lists a few action items to reduce forest fire impacts. The first is to strengthen the forest patrol system to build awareness and enforce legislation. Secondly, the NCEP states that farmers must avoid agricultural practices such as crop burning and pasture burning at times of high fire risk. The NCEP also recommends rangers implement fire safety awareness campaigns at both the local and national level. To improve fire preparedness, the NCEP aims to encourage current prevention methods such as the construction of fire barriers as well as investment in fire suppression equipment to prevent the fire from reaching intensities beyond human control. In addition, the document suggests that rangers staff observational towers and create observation-signalization networks. With regards to response, the NECP prioritizes quickness of action, proper evacuation procedures and international collaboration.

To improve recovery practices, the NCEP recommends that a full review of the situation can highlight potential improvements that the National Civil Protection Agency can make to not only future response, but also in prevention and mitigation. Furthermore, the NCPA should measure and compare the economic loss to prevention costs to solicit investment in improved prevention strategies (NCEP, 2004).

Despite this legal framework, many reports on Albania’s current state of emergency preparedness since the adoption of the NCEP have reported mixed results. One such report, written by the Center for European and Security Affairs, specifically highlights that Council of Ministers wrote and adopted the NCEP before the Hyogo Framework for Action (HFA) of 2005, which outlines the practical means to achieve a multi-stakeholder led disaster risk reduction forum. In their report, the Center for European and Security Affairs highlight a disconnect between many ministries and disaster risk reduction, and the central government did not give civil protection structures at the municipality level any decision making power to carry out their own disaster risk reduction strategies (Duro, n.d.).

The Food and Agricultural Organization of the United Nations came to a similar consensus when analyzing the legal framework for disaster risk reduction, stating that a priority action item "is the need to engage line ministries at a higher level around Disaster Risk Reduction, including the formalisation of a multi-stakeholder National Platform for DRR" (Lawson, 2018).

The Council of Ministers approved Law 45 on Civil Protection on August 16th, 2019, to address this need for a multi-stakeholder National Platform for DRR. The mission of Law 45 is to "aim at creating conditions enabling the society to reduce disaster risks, to prevent, prepare, cope with, and recover employing an integrated and efficient civil protection system in the Republic of Albania." Law 45 created the National Civil Protection Agency (NPCA) to improve communication and collaboration between the local level and the central level of government for disaster risk reduction planning. This includes the creation of a Disaster Loss Database, that the NCPA compiles using fire damage data collected at every level of the government. In addition, Law 45 mandates the cooperation of ministries responsible for civil protection, defense, internal affairs, transport, infrastructure, agriculture, health, energy, education, environment and culture to allocate between 2% and 4% of the total annual budget to disaster risk reduction and civil protection according to the scope of their responsibility.

For example, the Ministry of Transport may use the 2%-4% to improve road access to remote rural areas to lower fire response times. The Ministry of Agriculture may use the 2%-4% to discourage farmers from burning leftover crop debris to make room for the next planting season during high risk fire seasons. However, due to the recent approval of this law, predictions on its effectiveness to create a multi-stakeholder national platform for disaster risk reduction are speculative.

2.4 Creation of Risk Maps

To maximize the effectiveness of fire prevention and monitoring strategies, and resource allocation, many countries around the world have created risk maps (see Figure 12) to identify areas requiring additional attention (Keane, 2008).

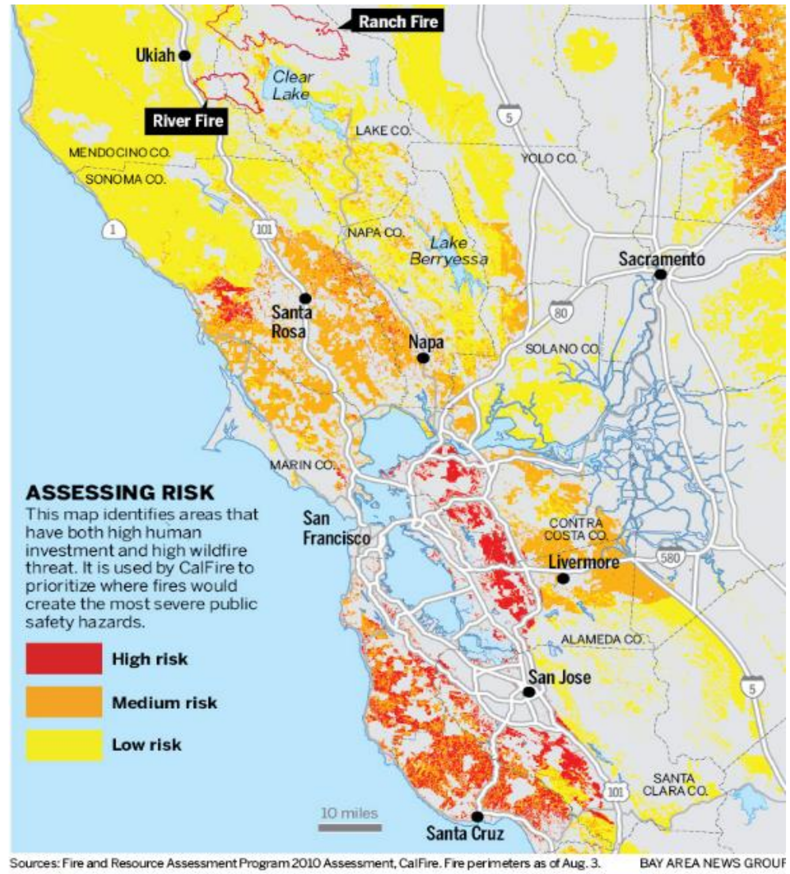

Figure 12: An example of a California risk map (Fire and Resource Assessment Program, 2010)

The calculation of risk assessment depends on two different types of risk. This first type uses the fact that the probability that a forest fire will ignite and burn at an uncontrollable rate. The second risk focuses on the total amount of damage caused by the fires, encompassing ecological losses, health impacts and property damage.

Most risk maps created around the world use data collected by Geographic Information System, or GIS, and remote sensing (Ahbineet, 1996). This data includes: topographic factors such as slope, altitude, plan curvature, landform, and the topographic wetness; meteorological factors such as temperature, potential solar radiation, and wind effect; vegetation factors such as vegetation type, vegetation connectedness, burned area and vegetation regrowth; and human factors such as proximity to roads, villages and human activity (Ghorbanzadeh, 2019). Researchers often check the accuracy of risk maps through site visits and update them annually (Ghorbanzadeh, 2019).

Risk Mapping in Albania

In Albania, the Institute of GeoSciences, Energy, Water and Environment (IGEWE) collects and publishes information related to forest fire risk. The institute has operative centers in each prefect of Albania to monitor meteorological conditions and provide early warnings for weather conditions and natural disasters such as forest fires. They maintain a real-time web-based GIS tool known as Dewetra to predict and map vegetation dryness, fire behavior, spread rate, and intensity (IGEWE, n.d.).

The Institute publishes daily risk bulletins and monthly climate bulletins on their website. The daily risk bulletins provide data such as precipitation and temperatures, and an evaluation of flood risk during wet seasons and fire risk during dry seasons. Figure 13 displays an example of the first page of a daily risk bulletin, which contains a brief summary of expected precipitation, temperature, and fire risk for the day. The bulletins contain tables (see Table 1) and risk maps (see Figure 14) to rate the risk of these events but only on the prefect (regional) level, not the municipality level (IGEWE, n.d.).

The monthly climate bulletin extensively analyzes how trends in data such as temperature, rainfall, and thunderstorms have changed or stayed the same since the previous months. It identifies specific days with notably unusual weather, and compares current trends to those of previous years and other countries to help predict future risks. The Institute also provides training on early warning systems and risk assessment to the General Directorate of Civil Emergencies and municipalities (IGEWE, n.d.).

BULETINI MBI RREZIQET NATYRORE *(Bulletin on Natural Hazards)*
Qendra Kombëtare për Parashikimin dhe Monitorimin e Rreziqeve Natyrore
Facebook page : Instituti i Gjeoshkencave, Energjisë, Ujit dhe Mjedisit, Web-Page: www.geo.edu.al

Buletini Nr. 192 / 2017, 10-10-2017	**Parashikimi** nga: 10-10-2017, ora 12:00 deri më 11-10-2017, ora 23:59.

PARASHIKIMI METEO :

RESHJET
Gjatë pjesës së dytë të ditës së sotme (dt.10) dhe nesër (dt.11), në përgjithësi, nuk priten reshje, përveç ndonjë reshjeje të izoluar dhe të dobët, më e mundshme në terrenet e larta malore në Jug (siç tregohet në tabelë respektivisht për secilin qark).

TEMPERATURAT ekstreme të ajrit për nesër pritet të luhaten :
në bregdet :
temp. minimale do të zbresin deri në 10 °C, ndërsa ato maksimale do të ngjiten deri në 24 °C
në vendet e ulta : përkatësisht 7 / 25 °C
në vendet malore : përkatësisht 5 / 20 °C

ERA : sot pasdite (dt.10) dhe nesër (dt.11) do të ketë një rritje të lehtë (në perëndim të territorit për momente deri 25 km/orë).

RREZIKU NGA ZJARRET

Gjatë pasdites së sotme (dt.10) dhe nesër (dt.11) pritet një tjetër rritje e lehtë e rrezikut. Për pasojë, shumica e qarqeve do të ngjiten në nivelin "I ULËT" të rrezikut dhe Fieri në nivelin "I MODERUAR" (siç tregohet në tabelë respektivisht për secilin qark).

NIVELET E RREZIKUT	**S'KA RREZIK**	**I ULËT**	**I MODERUAR**	**I LARTË**

Figure 13: Page 1 of Daily Bulletin on Natural Hazards for 10-10-2017 (IGEWE, n.d.)

PARASHIKIMI I DETAJUAR MBI RREZIQET NATYRORE (SOT DHE NESËR)

RREZIKU MAKSIMAL I QARKUT	Zjarre në Pyje: Zjarret Mesatarja e qarkut	Ngjarje Meteorologjike: Reshje 24-orëshe Mesatarja e qarkut	Ngjarje Meteorologjike: Reshje 24-orëshe Maksimale të lokalizuara	Ngjarje Meteorologjike: Shtrëngata	Ngjarje Hidrologjike: Përmbytje të Shpejta	Ngjarje Hidrologjike: Përmbytje Lumenjsh	Ngjarje Hidrologjike: Rrëshqitje toke
Shkodër	S'KA RREZIK	pa reshje					
Kukës	S'KA RREZIK	pa reshje					
Dibër	S'KA RREZIK	pa reshje					
Lezhë	I ULËT	pa reshje					
Durrës	I ULËT	pa reshje					
Tiranë	I ULËT	pa reshje					
Elbasan	I ULËT	pa reshje					
Fier	I MODERUAR	pa reshje					
Berat	I ULËT	pa reshje					
Korçë	I ULËT	pa reshje					
Vlorë	I ULËT	pa reshje					
Gjirokastër	I ULËT	pa reshje					

Table 1: Table of prefects at risk on page 2 of Daily Bulletin on Natural Hazards for 10-10-2017 (IGEWE, n.d.)

LEGJENDA: ***Reshjet 24-orëshe***

Niveli i Rrezikut	***Reshje shiu*** (mm / 24 orë)
S'KA RREZIK	të dobëta (0 - 15 mm / 24 orë) Nuk priten fenomene hidro-meteorologjike problematike.
I ULËT	mesatare (15 - 45 mm / 24 orë) Mundësi që të shfaqen fenomene hidro-meteorologjike problematike.
I MODERUAR	intensive (45 - 90 mm / 24 orë) Moti parashikohet i rrezikshëm. Parashikohen fenomene të pazakonta hidro-meteorologjike.
I LARTË	shumë intensive (> 90 mm / 24 orë) Moti është shumë i rrezikshëm. Parashikohen fenomene të pazakonshme hidro-meteorologjike mjaft intensive.

LEGJENDA: ***Zjarre në pyje***

S'KA RREZIK	Zjarret e mundshëm janë të kontrollueshëm lehtësisht nga skuadrat e zjarrfikësve.
I ULËT	Barërat e thatë dhe pyjet mund të digjen lehtë. Flakët janë te mesme në pyje dhe të shpejta në zonat e ekspozuara.
I MODERUAR	Ndezja e zjarreve mund të ndodhë lehtë dhe me përhapje të shpejtë. Zjarret mund të jenë shumë të nxehtë, me kurora përhapje të vogla dhe të mesme.
I LARTË	Ndezja mund të shkaktohet edhe nga një shkëndijë. Zjarret janë shumë të nxehtë me përhapje shumë të shpejtë të flakëve si rrjedhim kontrolli i tyre është shumë i vështirë.

SIMBOLE

	Shtrëngata: reshje mbi 20 mm/3orë. Moti mund të krijojë probleme të ndryshme
	Përmbytje urbane ose nga përrenjtë dhe lumenjtë e vegjël
	Përmbytje nga lumenjtë e mesëm dhe të mëdhenj

RREZIKU MAKSIMAL I QARKUT për sot dhe nesër, dt. 10 - 11

Figure 14: Risk map of prefects on page 3 of Daily Bulletin on Natural Hazards for 10-10-2017 (IGEWE, n.d.)

2.5 Common Forest Fire Prevention Techniques

There are two main methods of preventing the spread of forest fires that firefighters use globally: fire suppression and fuel reduction. Fire suppression takes the form of small controlled fires used to burn chosen areas of forest to prevent forest fires from spreading. These prescribed fires create breaks within forest vegetation, such as Figure 11 shown below.

Although generally considered a more efficient economical solution, fire suppression is difficult to implement in Albania. Albanian fire tracking technology and equipment has developed slowly, which, along with difficult terrain such as mountains, makes it too dangerous to attempt fire suppression in many areas (Molina-Terrén et al, 2016).

Fuel reduction is a preemptive method of fighting forest fires, where forestry staff removes dry debris and reduces overly dense sections of forest. The staff closely monitors the situation to only burn smaller trees and shrubs, providing a natural thinning and increasing fire resistance (North et al, 2015). However, many in the Balkan region consider this preemptive type of forest firefighting less effective, leading most governments to direct attention towards solely on immediate methods of forest firefighting (Raftoyannis et al, 2014; North et al, 2015). If performed under turbulent wind conditions or without careful supervision, fuel reduction will negatively affect the overall landscape and contribute to more frequent forest fires. Moreover, fuel reduction varies wildly in terms of economic efficiency, mainly due to wind orientation (Elia, Lovreglio, Ranieri, Sanesi, & Lafortezza, 2016).

Figure 15: An example of controlled burning (Oregon Department of Forestry,

2.6 Drone Usage in Forest Firefighting

Drones, also known as unmanned aerial vehicles (UAVs), are aerial vehicles that operate solely by remote control or autonomous means. Size, altitude limitations, and distance limitations vary greatly based on design and purpose. For example, military drones possess fixed wings to accommodate large payloads, increasing their speed and efficiency, but lack the ability to hover in place (Rao et al, 2016; Lidynia, Philipsen, & Ziefle, 2017; Floreano & Wood, 2015).

A second common type of drone is the quad copter, featuring multi-rotor systems, a lightweight plastic or metal frame, various cameras, sensors, and navigational tools, and are made of common, inexpensive materials. These drones are more popular among the general public because of their wide availability, maneuverability, and less space needed for take-off and landing.

Drones often use gyroscopes to monitor and correct their movement (Rao et al, 2016). Pilots often manually control drones remotely through the use of a controller or special equipment, although engineers have made progress in their research on the feasibility of fully autonomous drones that use algorithms and sensors to make decisions (Floreano & Wood, 2015).

These many capabilities make drones a versatile tool for a variety of areas such as environmental monitoring, military use, delivery systems, film production, emergency responses, recreation, and firefighting (Boucher, 2015). Initially, the military used drones for equipment transportation and bombing, but drone manufacturers have repurposed their product for commercial, civil, and personal uses. They are well-suited for delivery services, as they can quickly traverse difficult terrain and unlike satellites, their navigation systems are not as dependent on weather and cloud conditions (Laksham, 2019). This makes drones particularly popular for disaster relief efforts and photography/filming, where they can search areas too dangerous or time-consuming for humans or record high quality footage at high areas respectively (Laksham, 2019; Rao et al, 2016).

Figure 16: An example of a drone using cameras and sensors for monitoring (AGLON IT & Aero-Data, n.d.)

These capabilities allow drones, such as the one shown in Figure 16, to effectively monitor forest fires from various angles to provide the most coverage. Designed by the technology

Table 3. Extent of fire risk zones

Fire risk zones	Degree of fire risk	Description of fire risk zones	Propn of total area (%)
I	Very high	Areas with bamboo and dry mix type of forest; high and very high ignition value on high and very high slopes	20
II	High	Areas with a forest type dominated by bamboo; high ignition value on high slopes	10
III	Moderate	Areas with mainly sal forest; moderate ignition value on moderate and high slopes	15
IV	Low	Areas with agriculture and less forest; low ignition value and moderate slope	55

Table 2: An example of a fire risk zone map constructed in Madhya Pradesh, India (Jaiswal et al, 2002)

company AGLON IT & Aero-Data, the firefighting drone displayed below is able to monitor fires from distances or angles that may be unsafe or unattainable for firefighters on the ground. The data collected by the drone provides guidance to firefighters on the best strategy to extinguish the fires, thus demonstrating a practical use of drones in firefighting (AGLON IT & Aero-Data, n.d.).

Currently this is the main use of firefighting drones- monitoring before and during a forest fire. By periodically viewing areas in forests that are significantly prone to fire ignitions, drones can detect forest fires more quickly than humans can, allowing more time for firefighters to react. During a forest fire, drones work alongside firefighters to quickly determine information about a fire such as its characteristics, intensity, rate of spread, smoke emissions and wind direction. This helps firefighters gain a more comprehensive view of how the fire is acting and how best to extinguish it (Restas, 2015).

A Geographic Information System, or GIS, captures and stores data by dividing forest structures into four categories based on fire risk. Table 2 displays an example of these categories and calculates the proportion of these zones to the total examined area (Jaiswal, Mukherjee, & Raju, 2002). Many determining factors relate to spatial relationships, such as topography and forest distance to settlements, which can be difficult for humans to determine accurately from the ground, especially in difficult terrain. Consequently, drones are an ideal technology for forest fire risk zone mapping that provides information to predict a fire's place or origin and probably track.

While the functionality of most drones consists of the detection and monitoring of forest fires, there have been efforts to create drones capable of extinguishing forest fires. To aid in fuel reduction efforts, a team from the University of Nebraska is developing a drone that drops flammable ping pong balls to clear excess vegetation (Brocious,2016).

These drones inject glycerin into the powder filled balls moments before dropping them on grasses and shrubs. This ignites a small, controllable fire to contain ongoing wildfires and keep them from increasing in intensity. The drone's ability to fly at lower altitudes compared to helicopters make the drops safer and more accurate, while also reducing the risk that firefighters suffer injury (Brocious, 2016).

Figure 17: AFO and Elide fire extinguishing balls (Aydin et al, 2019)

Drones can suppress fires with water or chemicals, but they cannot carry adequate amounts of water to put out a full forest blaze. IBM engineer Thomas Frey proposed a swarm of drones, using satellite monitoring to roam and detect forest fires in order to extinguish them while they are still small (Frey, 2018). Researchers at Texas A&M University proposed an alternative solution requiring two drones, where the first drone monitors and the second carries fire extinguishing balls, as shown in Figure 17. High temperatures activate these balls, causing them to release environmentally friendly fire suppressing chemical powders. These research trials illuminate the idea that the drones are able to effectively suppress grassland fires, though the researchers must conduct further tests to determine their effectiveness on timber litter, short needle litter, and chaparral vegetation (Aydin, Selvi, Tao, & Starek, 2019).

Figure 18: Frame of drone used by Florida International University for fire prevention (Marchant & Tosunoglu, 2016)

Researchers at various universities have explored the use of artificial intelligence to control drone swarms for the purpose of extinguishing small fires. Engineers at the Florida International University designed a drone prototype to hold a payload of fire extinguishing balls and utilize various cameras and sensors for navigation and fire detection. The customizable frame of the drone without the added tools is shown in Figure 18. To coordinate the swarm of drones, the engineers developed a centralized algorithm where one drone would act as the leader of the swarm, and an operator in the field would manually control this leader drone. The other drones would then follow the leader drone and complete certain actions when the operator sends signals to them. Though this concept is theoretically developed, the researchers have completed almost no tests on this concept to evaluate its practicality (Marchant & Tosunoglu, 2016).

Researchers at Coventry University investigated a more decentralized variant of the previously mentioned project. This project utilized a form of artificial intelligence known as swarm intelligence to direct drones to find and extinguish fires. Swarm intelligence follows the principle where “the whole is more than the sum of its parts.” Rather than following a leader, the drones follow a decentralized algorithm such that each drone is self-organizing and only reacts to other drone feedback and the environment to complete their tasks. The researchers applied this model to a model of how fires spread to theoretically determine how efficiently the drones could find and extinguish fires in a dynamic environment. The results were promising but the researchers need additional theoretical models and testing, as well as more advanced algorithms before practically implementing the models (Innocente & Grasso, 2018).

Despite their many benefits drones have several limitations that may hinder their effectiveness in firefighting. Smaller drones are unable to carry heavy loads or travel long distances, limiting the amount of fire extinguishing material they can bring to remote areas (Laksham, 2019). Continuous monitoring and training is necessary to handle drones properly, and concerns about privacy, regulations, liability, public safety, and airspace interference greatly affect their public perception (Rao et al, 2016).

The perception of drones depends on their use. The media often portrays the military uses for drones such as surveillance and combat. The general public views drones used for environmental and emergency purposes in a significantly more positive manner than drones used for recreation and personal photography (Aydin, 2019; Lidynia et al, 2017). Many surveys have shown that the general populace is concerned about the loss of privacy and safety risks, partially due to a lack of regulation and enforcement related to drones. In regard to firefighting, fire chiefs are confident that drones could make the firefighting process more efficient, but are concerned about expenses, training, and meeting regulations (Russell, 2016).

Figure 19: A thermal camera used for border security (SPi Infrared, n.d.)

2.7 EXINN’s Project

Our sponsor is the technology and innovation development company, EXINN Technology Center. They are a research-driven group dedicated to pushing ideas from prototype into a marketable state. They provide services for training, marketing, designing, manufacturing, and digital work. EXINN originally conceived the idea of a thermal camera (see Figure 20) and drone system after a competition concerning innovative solutions to combating climate change. The thermal camera is mounted on top of a 50-meter-high watchtower to gain a clear view of the

Figure 20: EXINN's drone prototype

surrounding area above elevation changes.

Connected to the watchtower is a drone bay that stores eight drones when not in use. Each drone is capable of traveling up to 6 km, has a battery life up to 1 hour, and recharges via solar energy at the drone bay. The thermal camera scans a 150 km area continuously for fires in their early stages of forming. This makes thermal detection an ideal for detection due to the inversely proportional relationship between fire size and intensity. The camera uses mid-infrared sensing because this technology provides the greatest sensing range (San-Miguel-Ayanz, et al, 2004).

When the camera detects a fire, it evaluates the severity of the fire, and sends the fire's coordinates to an appropriate number of drones via a wireless network. The drones then pick up an extinguishing ball and fly to the location of the fire, where they drop the balls to extinguish the fire. The drones finally return to the drone bay to recharge. EXINN designed the system to stop fires when they had first begun, preventing the outbreak of a large forest fire.

Currently, EXINN is still developing the drone swarm algorithm, particularly the portion that allows drones to drop the extinguishing balls on the fires. Since the company wishes to use the latest, most updated technology available for their fire prevention and extinguishing system, they have not yet chosen any specific thermal camera or drone models. The main limitations to this model are the drones' poor battery life, and the tendency for strong winds to blow them into trees, where they may suffer damage. Figure 17 shows the drone prototype that EXINN uses for testing purposes.

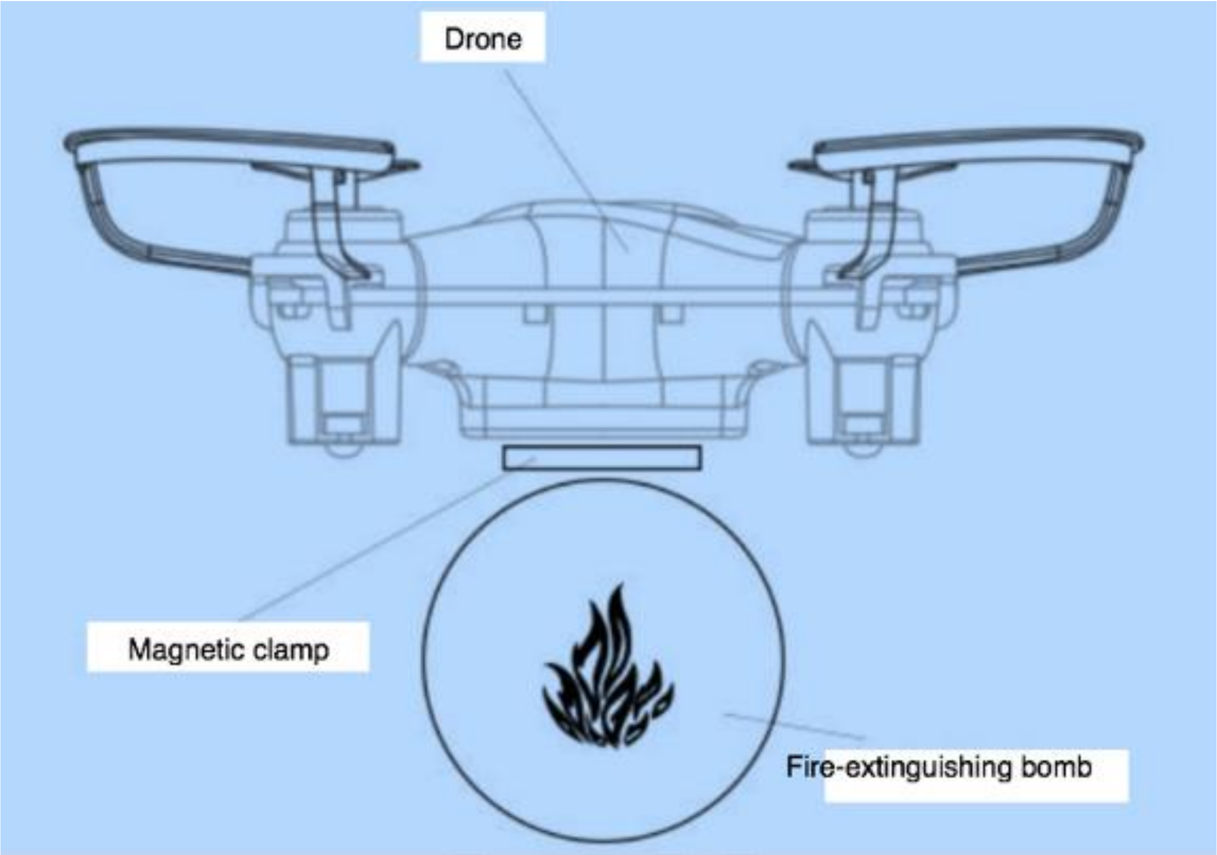

Figure 21: Diagram of a drone from EXINN's system with its magnetic clamp and fire-extinguishing ball

EXINN expects to equip the drones with wireless receivers, GPU rigs, and magnetic clamps for holding the extinguishing balls, as shown in Figure 21. Based on EXINN's current price estimates, the entire system will cost about 200,000 euros, 100,000 euros for the camera alone, and serve as an investment for a ten-year period.

EXINN has planned for the system to serve multiple purposes in the future due to the versatility of drones, including early fire detection, small scale fire extinguishing, and post-fire assessment. When there are no fires present, EXINN anticipates the system will measure forest temperature, plant seeds in post-fire landscapes, and pick up litter. The drones would complete these actions with the aid of various additional sensors, as well as using WiFi to communicate with other systems.

The Canadian Institute of Technology has partnered with EXINN to help conceptualize the system, while BRIGAID, an EU funded organization that supports innovations for climate change adaptation, has partnered with EXINN to assist with funding and networking. They hope to support the concept, testing, and development of the system, but would like to provide it to the Albanian government to continue the project.

EXINN has not finalized the security plans for protecting the drones while in the drone house, though they are currently considering using a camera or having a separate guard drone. This is ultimately outside the scope of our project, and we will not consider this in the report, but should be researched further.

2.8 Dajti Mountain National Park

Dajti Mountain National Park is a popular tourist destination located in the mountainous area of the eastern part of Tirana (see Figure 22). Mount Dajti is in this park, and is one of the three peaks of mountain chains in the area, alongside Priska Mountain and Brari Mountain (Meçaj & Muharremaj, 2002) (Parks Dinarides, n.d.).

The park, known as the "Natural Balcony of Tirana" due to the vast perspective tourists can gain of Tirana and cities beyond it, consists of 3,300 hectares of surface area. Together, the coverage area between all three mountains consists of 29,216.9 hectares. In 2006, the area of 3,300 acres known as a "protection area" expanded to 9,000 acres (Parks Dinarides, n.d.).

The park is a well-known tourist destination in Tirana, especially for its forests and landscapes. These protection areas keep the park's wildflowers and mammals safe. The lower parts of the mountains contain various types of plants, such as fragaria and myrtle. At 1,000 meters, oak trees and beech forests are prominent, though there is not much vegetation at the very top.

Tourists reach the top of the mountain via cable car, shown in Figure 23, where there is also a resort consisting of a hotel, restaurant, adventure park, and mini golf course. There are other restaurants and hotels are present on the mountain as well, and tourists enjoy visiting the area to experience the views of the city, the facilities, and other activities such as mountain climbing, hiking, and paragliding (Dajti Ekspres, 2017).

Dajti Mountain National Park is an example of a WUI around Albania because it contains more developed areas in close proximity to wilderness areas**.** There have been occurrences of fires in this area in the past, one of the biggest being in August 2012. This fire lasted around three days and burned over ten hectares of forest. There was fear among residents, who believed their homes were not sufficiently secure, and many specialists believed that a human purposefully caused the fire, though others argued that the challenging terrain made this idea impossible (Cupaj, 2012). The fire

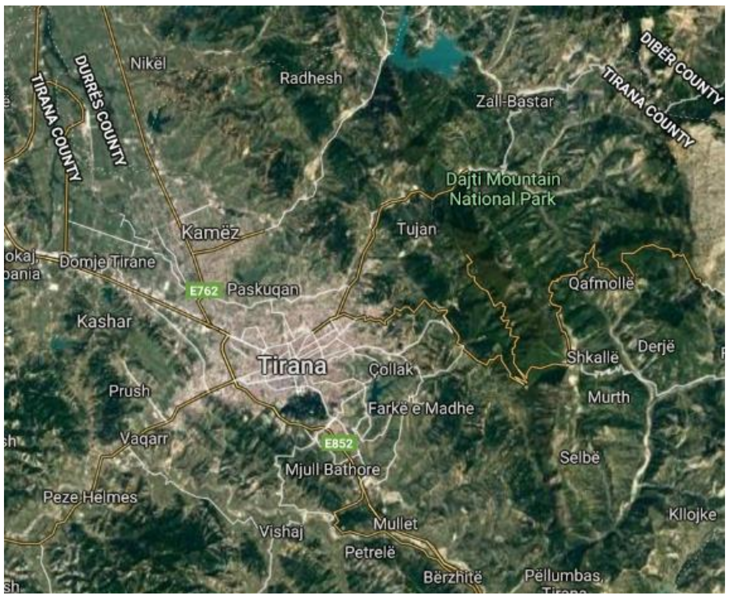

Figure 22: Google Maps satellite image of Dajti Mountain National Park and Tirana (Google Maps, 2019)

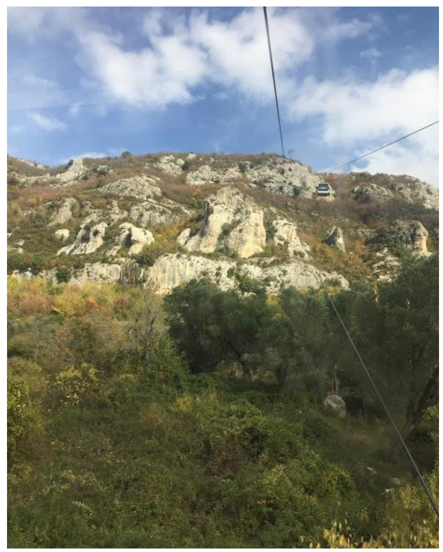

Figure 23: View from cable car heading up Mt. Dajti

grew to a point that the General Directorate of Civil Emergencies had the Ministry of Defense and General Staff of Armed Forces recruit military assistance for purposes of locating and extinguishing the fire; locating the fire was especially difficult because of the rugged terrain. The government called upon 185 military forces and ten different types of vehicles, one of them being helicopters, to the scene, where they extinguished the fire. The State Police, firefighters, military forces, employees of Dajti, and residents in the area had initially located and subdued the fire, but the wind and high temperatures caused the fire to expand uncontrollably, creating the need for more groups to intervene (Ministry of Defense, 2012).

2.9 Stakeholder Questions

There are a number of questions that this technology raises for various stakeholders. Forest rangers will want to understand how drones will change their responsibilities of forest management and monitoring. Firefighters will ask about the effectiveness of drone response to fires that are currently inaccessible, and their ability to work with drones in tandem to tackle large fires. Employees of the Institute of GeoSciences, Energy, Water and Environment will inquire about data collection capacities to improve their risk bulletins. The public and private sector will be concerned with the system's cost, its ability to reduce the risk of damage from forest fires, and its ability to provide valuable services when there are no fires. Residents of WUIs may have concerns about the safety risks, the invasion of privacy, and ruining the aesthetic of forested areas.

Figure 24: A view of the summit of Mount Dajti

The goal of this project was to identify current fire monitoring, prevention, and extinguishing practices throughout rural areas, national parks, and Wildland Urban Interfaces in Albania, with a case study centered around Dajti Mountain National Park, and to understand how key stakeholders assess the feasibility of EXINN's drone system as a tool to improve these practices. Our objectives to accomplish this were:

1. Identify current and predicted trends related to Albanian forest fires
2. Determine the legal framework for fire management
3. Examine fire prevention, monitoring, and extinguishing practices
4. Analyze how EXINN's system fits into current fire protection practices
5. Investigate the potential for the implementation of EXINN's system in Dajti Mountain National Park

Figure 22 represents our approach, including our project goals, objectives, methods and analysis techniques, and end product.

Table 3 lists the names and professional positions of the individuals the team interviewed in the chronological order of the interviews. The final column indicates whether the interviewee provided follow up in terms of either a subsequent interview or sent answers to our additional follow-up questions via email. Our interviews followed the general format detailed in Appendix A. One or two team members led the interviews by asking questions, while the other members took notes on the interviewees' answers, general attitude, and nonverbal cues. We conducted some interviews with all four team members present and others with only two members to address project time constraints. If given permission, one team member recorded the audio of the interviews to refer to later and create paraphrased transcripts based on this and our recorded notes. The team also provided interviewees with the option for their answers to be confidential. If the interviewee did not speak English, we used a translator, such as our sponsor from the Agricultural University of Tirana, Dr. Luarasi.

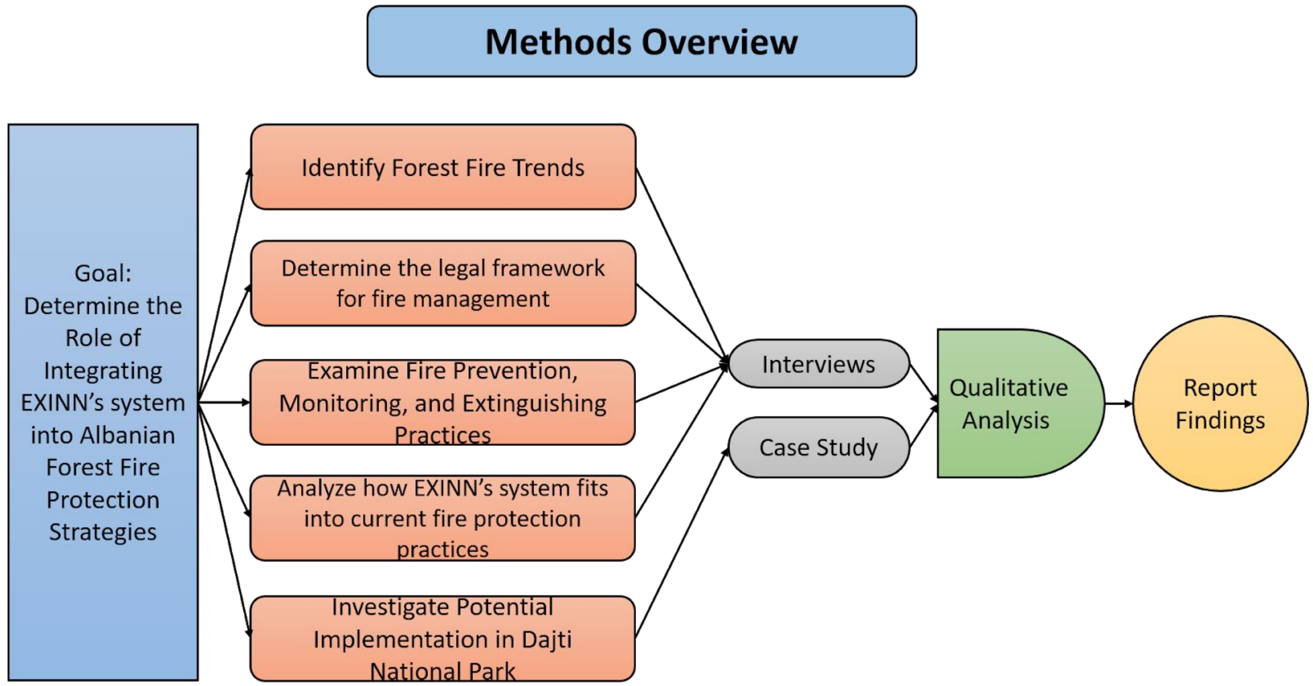

Figure 25: Methods Overview

Interviewee Name	Interviewee Position	Follow-up Correspondence
Maksimiljan Dhima	Former Director of Planning and Coordination for Civil Emergencies - General Directorate of Civil Emergencies	Yes
Ramiz Metaliaj	Forestry Management Faculty from Agricultural University of Tirana	Yes
Shkelqim Goxhaj	Director of Firefighting Department of Tirana	No
Nensi Lalaj	Project Manager of BRIGAID and National Territorial Planning Agency	No
(anonymous)	Business owner from Dajti Mountain National Park	Yes
(anonymous)	Restaurant employee from Ballkoni Dajtit at Dajti Mountain National Park	Yes
(anonymous)	Ranger from Dajti Mountain National Park	No
(anonymous)	Resort employee from Dajti Mountain National Park	No
Amparo Hiraldo	Hydrologist from Institute of GeoSciences, Energy, Water and Environment (IGEWE)	No
Edmond Pasho	Forestry Management Faculty from Agricultural University of Tirana	Yes
Orjeta Jaupay	Biologist from Institute of GeoSciences, Energy, Water and Environment (IGEWE)	No

Table 3: List of interviewees that the team consolidated in this project

Each interview lasted one to two hours at most. Insights from previous interviews helped shape additional questions for subsequent interviews. If needed, our group followed up with previous interviewees to schedule additional interviews or answer questions through email. We are aware that there is a certain amount of bias while interviewing EXINN employees or partners, as they are intimately involved with the project. This may give them a deeper understanding and different perception on EXINN's system than an interviewee who was not aware of EXINN's proposed system before our interview.

3.1 Identify current and predicted trends related to Albanian forest fires

Limited information was available at WPI on current Albanian forest fire trends, leaving many gaps in our understanding of the current situation in Albania. We met with two individuals from the Forestry Management department at the Agricultural University of Tirana: Professor Ramiz Metaliaj, who specializes in fire protection, and Dr. Edmond Pasho, who specializes in forest mapping. Our team also met with Mrs. Nensi Lalaj, the project manager at BRIGAID with the National Territorial Planning Agency, an agency that gathers spatial data to identify areas by the use of the land. Additionally, the team interviewed Mrs. Hiraldo and Mrs. Jaupay, two employees from the IGEWE who contribute to the creation of the daily fire risk bulletins and would have records of forest fires. During these interviews, our investigation centered around the following questions:

- What areas of Albania are most affected by forest fires?
- How are forest fires growing in terms of intensity and damages over the past few decades?
- What are the main causes of forest fires in Albania?
- How are climate change and property development patterns related to future forest fire trends?

Appendices D, E, F, and I contain a full list of interview questions related to this objective. The purpose of these interviews was to determine if there was a need for EXINN's drone technology, and if so, which Albanian regions would benefit most from this technology. Our team hoped to identify where EXINN's system would provide the most benefit and enable people living in fire prone areas a chance to better prepare for the next forest fire, potentially reducing damages.

3.2 Determine the legal framework for fire management

Forest fires are one of the many disaster emergencies that occur in Albania, especially near Wildlife Urban Interfaces. To learn more about fire protection policies and the responsibilities of civil protection organizations, we interviewed members from the National Civil Protection Agency, the Agricultural University of Tirana, BRIGAID, and the Institute of GeoSciences, Energy, Water, and the Environment (IGEWE). Our group focused the interviews around answering the following questions:

- What government agencies are responsible for fire management and civil protection?
- What agencies are responsible for monitoring fire risks, developing forecasts, and compensating for damages?
- How effectively do central agencies communicate and coordinate with each other as well as with local and regional agencies?

Appendices C, D, E, F, and H consist of the interview questions that address this objective. From our interview with Maksimilijan Dhima, former director of General Directorate of Civil Emergencies, our project looked to closely examine how the central, regional, and local governments work together and allocated resources for the purpose of disaster management. Our interviews with Professors Metaliaj and Pasho from the Agricultural University of Tirana would establish which organizations or groups are most responsible for overseeing the health and maintenance of forests. The interview with Nensi Lalaj, a project manager, would reinforce our understanding of the communication and coordination between all agencies responsible for fire protection and risk reduction. By interviewing Mrs. Hiraldo and Mrs. Jaupay, researchers from the IGEWE, we hoped to learn how their risk bulletins play a role in government policies and decisions.

3.3 Examine fire prevention, monitoring, and extinguishing practices

To assess the need for EXINN’s innovative technology and how to integrate it into current practices, the team interviewed a firefighter and a ranger who prevent, monitor, and extinguish fires. This included Shkelqim Goxhaj, director of the Tirana fire department, who would be able to elaborate on how firefighters manage fires in Albania. To gain a broader perspective, we also interviewed Professors Metaliaj and Pasho, and Mrs. Lalaj, all of whom are familiar with how firefighters and rangers mitigate and extinguish forest fires, especially Mr. Goxhaj, who has a thorough understanding of how they manage fires in Albania. The group also met with Mrs. Hiraldo and Mrs. Jaupay, since the IGEWE uses online monitoring tools to develop risk maps. Our interviews addressed the following questions:

- What strategies do firefighters and rangers carry out to prevent and put out forest fires?
- To monitor areas for fires and determine risk of fires and create risk maps, what information do firefighters and rangers need?
- What procedures do residents in rural and forested areas follow when they detect a fire?
- What challenges do firefighters and rangers face in monitoring, preventing, and extinguishing fires?

Appendices D, E, F, G, and H contain a full list of interview questions related to this objective. By learning about currently practiced fire monitoring, prevention, and firefighting activity, our report can determine which areas are sufficient and which areas require improvement. Depending on the gaps in ability to complete these actions, the project examined how EXINN's system can address these needs for improvement.

Additionally, Appendix K contains a list of scenarios that we presented to each of the interviewees. The scenarios intended to capture the steps that inhabitants in WUIs, rural villages, and remote national parks, would take in response to identifying a fire. The intent of the scenarios was to engender conversations that would also illuminate who is responsible for monitoring these areas, who extinguishes them, and what agency records the damages from the fires.

3.4 Analyze how EXINN's system fits into current fire protection practices

Our previous objectives establish the context of forest fire frequencies, the locations of these fires, the roles in forest fire management of different government divisions, and prevention, monitoring, and extinguishing methods of firefighters and rangers. With this context, we asked all interviewees about their thoughts and concerns surrounding the use of EXINN's system for fire prevention. The main questions we hoped to gain information about were:

- How would EXINN's system fit into current fire monitoring and prevention strategies?

- What are the perceived benefits and concerns regarding EXINN's system?
- Under what conditions, motivations and desired functions would the government or private businesses consider EXINN's solution to be valuable to invest in?

Appendices C, D, E, F, G, H, I, and J note a full list of interview questions that cover the above inquiries. After providing interviewees with an overview of EXINN's system, the team asked them about the benefits and limitations they saw in the system. For experts who were knowledgeable in emergency management and firefighting procedures, we asked questions regarding the role that EXINN's system would serve in the overall system of fire prevention and monitoring in Albania. These interviews also inquired about possible implementation models that may be appropriate for EXINN's model such as Public Private Partnerships, public buy-out, or private investment. Our investigation considered this to gain insight into possible options for EXINN to fund the use of their project. Additionally, we provided interviewees with explanations of alternative fire prevention systems that used varying combinations of drones or sensors and obtained their opinion regarding which systems seemed the most effective, expensive, and realistic. These explanations were present in our interviews to observe the interest of key stakeholders in similar set-ups to EXINN's system. Since BRIGAID had experience with supporting innovative climate change related projects, the team specifically asked Mrs. Lalaj questions regarding the factors that have allowed for the implementation of projects like EXINN's.

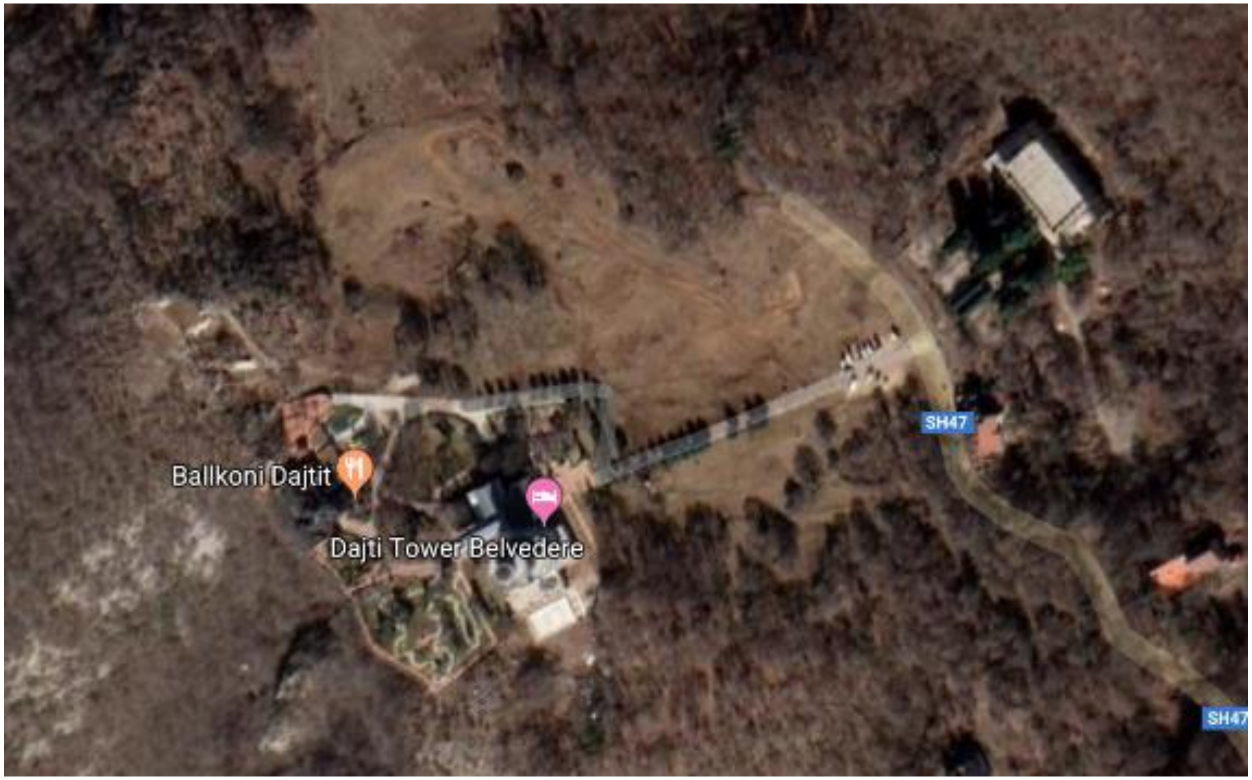

Figure 26: Google Maps Satellite image of Dajti Mountain National Park resort area (Google Maps, 2019)

3.5 Investigate the potential for the implementation of EXINN's system in Dajti Mountain National Park

In addition to gathering data regarding forest fires and fire prevention strategies in the entire country of Albania, we performed a case study of Dajti Mountain National Park (shown in Figure 26). Our project centered around this area for the case study because it is a WUI. The intention of EXINN's system is to prevent forest fires in areas that may be inaccessible to firefighters. Thus we selected this national park as an area that may benefit from EXINN’s system. Our team also chose this area due to ease of location, in order to gather as much data as quickly as possible. Over the course of two visits, we interviewed business owners and a park ranger near the top of the Dajti Express cable car and followed up with them as we developed additional questions. The group also questioned IGEWE about data and statistics they collected in regard to fire risk at the park. From the interviews, we answered the following questions:

- How frequent and destructive have forest fires been in Dajti Mountain National Park over the past few decades?
- What fire prevention and monitoring strategies do rangers practice?
- Do business owners and rangers at the park perceive the area to be at risk of fires and in need of improvements in fire prevention and firefighting?
- How do business owners and rangers at the park perceive the usefulness and feasibility of EXINN's system and similar fire prevention and monitoring systems?

Appendices H, I, and J detail the full list of interview questions related to this objective. Our project looked to document the recent history of fire occurrences in the area, including their frequency and resulting damages to decide if the area would benefit from EXINN's system. Our interviews also asked Dajti businesses about what steps they take when they detect fires and who is responsible for helping them. This was meant to gain information about what firefighters and rangers currently do to handle fires in a WUI such as Dajti Mountain National Park, for purposes of identifying where EXINN’s system can supplement these current practices. The team spoke with business owners and rangers about preventive measures to evaluate the potential EXINN's system supplementing existing methods. By asking interviewees about their confidence in and concerns regarding EXINN's system and alternative systems that use drones or sensors, our investigation would gather the perceptions of using drones and technology for fire monitoring and prevention and identify perceived obstacles to its implementation in Dajti Mountain National Park.

3.6 Data Analysis

Throughout the course of the project, we summarized information from the interviews and created transcripts. Our process used coding to review the data from interview notes and recordings. Our team used pattern matching to find common themes in the data and categorize the information accordingly (Renner & Taylor-Powell, 2003). We initially preset categories based on background research and included: Forest fire trends, emergency management, current fire prevention, monitoring, and firefighting strategies, and information regarding the implementation of EXINN's system into current emergency management procedures.

By using these as a starting point, our group created new categories as we came across new codes in the data and reworked previous categories accordingly. If certain categories became very large or broad, the team formed subcategories to better represent the data. Our analysis compared and contrasted responses between and within groups of interviewees to ascertain any patterns that were group dependent. With the organization of these connections and themes, our project analyzed the significance of data to create overarching claims, conclusions, and recommendations (Renner & Taylor-Powell, 2003).

Figure 27: Main Fire station in Tirana

This chapter describes and synthesizes the data our team collected through archival research and interviews with various stakeholders and experts. First, we examine forest fire trends and the gaps in fire protection practices in Albania. The next section re-examines the same topics in a case study of Dajti Mountain National Park, located at the edge of Tirana. This resort area in the national park is located adjacent to a large national forest, classifying it as a WUI. From our interviews, the third section identifies how EXINN’s drone system could improve current prevention, monitoring and extinguishing practices.

Our research also identified interviewee concerns about the system’s implementation, as well as their opinions on government versus private investment. Finally, in the instance that funding limits EXINN's system in scope, our research determined which functions were the most useful, the most realistic, and had the most potential. The analysis highlights gaps in our collected data due to difficulties in finding interviewees. Our team was unable to conduct interviews with employees of the National Civil Protection Agency, the Ministry of Environment, and the Ministry of Defense to discuss what these stakeholders valued in a civil protection system. We also were unable to interview rural firefighters and additional ranger to confirm the experts’ claims regarding current fire protection practices in WUIs and rural areas. These gaps in our data suggest areas for further research to gain more conclusive results.

4.1 Identifying Fire Trends and Gaps in Fire Prevention, Monitoring, and Extinguishing Practices at the National Level

Forest fires occur most frequently in southern Albania.

When our team asked various experts about specific regions of Albania that experience the highest frequency and damages from fires, their answers were broad due to the lack of access to fire statistics. Experts agreed that the most common and destructive fires occur in southern Albania, since the region's climate is warmer and drier than the rest of the country. Based on his research, Dr. Pasho identified Lezhë, Vlorë, and Gjirokaster as areas with frequent forest fire occurrences. Additionally, Mrs. Lalaj noted that farms and sloped areas are especially at risk of facilitating the spread of forest fires.

Though Mr. Goxhaj only provided brief anecdotes of notable fires around the country, he shared information about recent fires occurring around Tirana. He stated that “in recent years, no house burnings or deaths have occurred due to fires in the Tirana region”. Consequently, he has generally not seen any increase in the number of forest fires in the Tirana urban area. However, he explained that 2017 included a very hot and dry fire season which led to frequent fires all across Albania. This correlates with reports from the Tirana Times discussed in section 2.1 about the harsh 2017 wildfire season. During that year, the Tirana region experienced over 500 fires, but these fires only spread in forests and did not reach urban areas.

Records on forest fires in Albania are not consistently available to the General Directorate of Civil Emergencies.

Interviews with experts and additional archival research revealed conflicting information regarding the existence and availability of records and risk maps related to total fires and burned areas per region, causes of forest fires, and predicted forest fires trends. From interviewing Mr. Dhima, our team learned that the National Civil Protection Agency lacks much of this data, especially fire risk maps. The agency is understaffed and there is a lack of bylaws for central government agencies, leading to miscommunication and overlaps in responsibilities.

Our interview with Ramiz Metaliaj, a professor from the Agricultural University of Tirana specializing in fire protection, confirmed this lack of data within the General Directorate of Civil Emergencies. Professor Metaliaj highlighted his own personal struggles extracting fire statistics collected by municipalities for his own research, calling them "inaccessible" and "guarded". He explained that, starting in the 1990s, ministries responsible for fire protection underwent constant restructuring, and it has continued to hinder the consistency of data collection related to forest fire occurrences and damages. Government agencies lost records during these transitions, so most of the reliable data related to forest fire statistics only account for years before 2000.

Municipalities often only collect a limited amount of statistics about forest fires within their borders, though the records are sometimes incomplete.

Though there are limited centralized records present, Professor Metaliaj stated that municipalities often keep track of the hectares of burned land within their borders and the value of wood lost annually in the Disaster Loss Database. However, they do not calculate additional statistics such as the records of damages, costs of damages and firefighting operations, and ecological effects. Municipality data is often incomplete or inaccurate due to a lack of surveying equipment or access to rural areas. This lack of consistent data was prevalent to Dr. Pasho when he traveled to 150 towns and locations to record total burnt areas in the aftermath of the rampant 2017 fire season. An excerpt of his records on forest fire damage is shown in Table 4. The table displays total

Dega Rajonale	Nr	Data dhe ora e rënies së zjarrit	Data dhe ora e fikjes	Ekonomia pyjore	Ngastra ose ngastrat	Siperfaqja e pershkuar në pyje (ha)									Siperfaqja e djegur (ha)						
							Pronësia			Përbërja e grumbullit					Pronësia			Përbërja e grumbullit			
						Totali	Shtetërore	Komunale	Private	Halorë	Fletorë	Cungishte	Shkurre	Totali	Shtetërore	Komunale	Private	Halorë	Fletorë	Cungishte	Shkurre
Korçe	1	7.05	7.05	Përpa- Dardh	138a	1	1			po											
Korçe	2	12.07	12.07	Goricë	38/ 51	2.5	2.5				Po	PO		0.5	PO				Po	Po	
Korçe	3	13.07	13.07	Mesmal	110	1	1			Po				1	Po			po			
Korçe	4	13.07	14.07	Zëmb- Verlen	23/24	75.5	75.5														
Korçe	5	31.07	1.08	Pirg	57 a	10.9	10.9				po	po		10.9	po				po	po	
Korçe	6	1.08	1.08	Përpa- Dardh	16 a	0.8	0.8				po										
Korçe	7	1.08	1.08	Përpa- Dardh	125 b	1.5	1.5				po										
Korçe	8	7.08	7.08	Panarit-Tresk	11 b	0.1	0.1			po	po										
Korçe	9	15.08	15.08	Panarit-Tresk	19/20 b	22.3	22.3			po				1.5	po			po			
Korçe	10	15.08	29.08	Voskopoje		378	378			po	po			65	po			po	po		
Tirane	5	16/7/2017 Ora 11.00	19/7/2017 ora 16.00	Krrabe-Gurre(Ibe)	43/a	0								10		10		10			
Tirane	6	18/7/2017 Ora 10.00	28/7/2017 ora 19.00	Peze(Rapaçesh)	26/c	3		3					3	1		1					1
Tirane	7	21/7/2017 Ora 12.00	23/7/2017 ora 01.00	Verri (M.Derjes)	6	21	21			21											
Tirane	8	23/7/2017 Ora 11.00	24/7/2017 ora 02.00	Dajt(Antena Vodafon)	39	0.2	0.2						0.2								
Tirane	9	24/7/2017 Ora 08.00	29/7/2017 ora 17.00	Krrabe-Gurre(Ibe)	90/d,91/c	0								5		5					5
Tirane	10	25/7/2017 Ora 10.00	25/7/2017 ora 22.00	Rove-Lunxhe Vishaj	1/c	0.05		0.05					0.05								

Table 4: Excerpt of Dr. Pasho's data on forest fire damages from the 2017 fire season. The rightmost highlighted column is total burnt area for each village.

forest land for each village in a given prefect. The rightmost highlighted column is total burnt area per village, demonstrating the extent of missing data that municipalities could not provide to him.

Experts believe that climate change is causing drier and more frequent fire seasons in Albania, which increases the risk of forest fires.

Our interviewees noted that climate change has a large influence on the state of the forests and risk of forest fires. Fire seasons where temperatures are high and humidity is low are becoming more frequent and harder to predict. This matches with studies by the World Bank (2011) and Raftoyannis et al (2014) arguing that lowered precipitation, a leading indication of the season, will become more erratic due to climate change. For example, the Albanian fire season is typically from mid-May to mid-October. In 2019, however, the fire season started in February with an unusual number of fires occurring between then and April. Increased dryness has also caused increased fires in areas that are usually not at risk and has affected trees that are relatively resistant to burning such as Fagus sylvatica, or the common beech. These changing meteorological conditions contribute to the steady rise of forest fires in Albania.

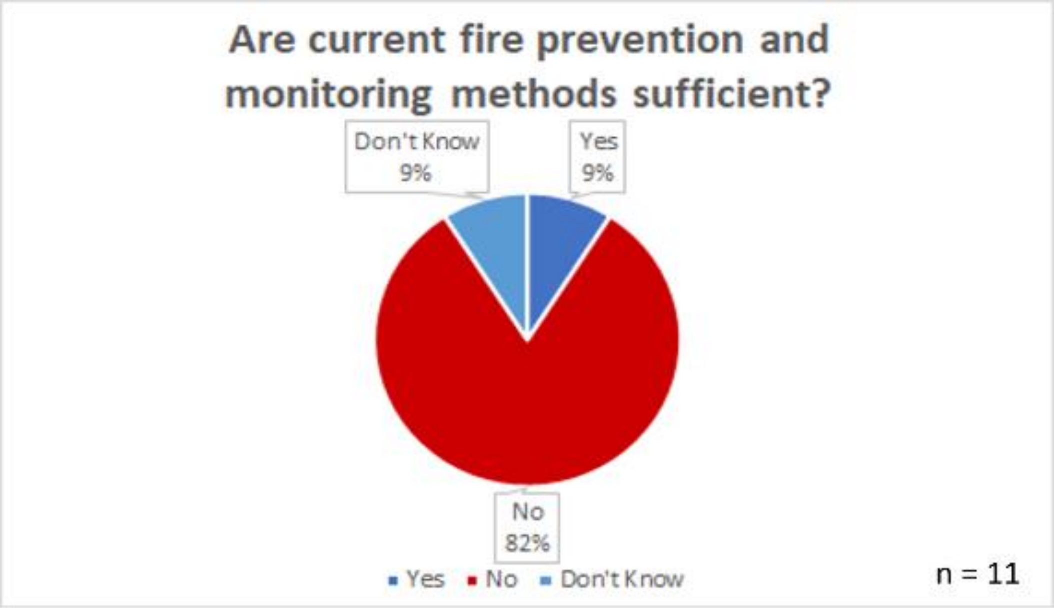

Figure 28: Interviewees' perceptions on the sufficiency of fire prevention and monitoring

Current fire prevention, monitoring and extinguishing methods are insufficient.

Figure 28 demonstrates that a majority of our interviewees believed that current fire prevention and monitoring methods are not sufficient. There are multiple gaps in these practices that experts expressed to us.

Rural firefighters and rangers rarely implement the fire prevention and risk reduction strategies outlined in the National Civil Emergency Plan and the Law 45 on Civil Protection.

The Council of Ministers developed the National Civil Emergency Plan in 2004 to provide the framework for government and non-government structures to abide by legal responsibilities relating to civil emergencies. They approved Law 45 in 2019 to create a multi-stakeholder national platform for disaster risk reduction. Despite disaster risk reduction and civil protection policies being passed and approved by the Council of Ministers, our experts expressed frustration with the government's ability to coordinate and implement these plans. Mr. Dhima, Professor Metaliaj, Mr. Goxhaj, and Mrs. Lalaj all confirmed that the NCPA does not utilize risk maps to inform efficient resource allocation and preventative firefighting strategies. Additionally, Professor Metaliaj, Mrs. Lalaj and Mr. Goxhaj believed that currently rangers do not employ fire prevention methods, such as prescribed burning and fire breaks, in forest areas with high risk of fires. Dr. Pasho recalled conversations he previously had with rangers in which they mentioned performing prescribed burning and constructing fire breaks, but as reactive actions to contain fires that were already burning. Each expert had a different opinion when asked the reason for this discrepancy between the written policies and what is currently practiced. Mr. Dhima pointed to enormous staffing shortages. While he was General Director of the Civil Protection Agency, he outlined a plan for his department to hire 136 employees in order to have a sufficient number of resources. However, there were at most 8 employees working at any given time. He attributed this staffing issue to the lack of programs focusing on civil protection in Albanian universities, as this career path requires those with degrees and education in the field of study. Professor Metaliaj spoke of the lack of organization and communication between civil protection agencies at the local level and the central level. Such instances include the existence of little structure and professionalism in municipalities, tendencies to avoid use of risk maps for guidance, and improper data collection. Mrs. Lalaj pointed to the lack of funding as the largest barrier to implementing prevention strategies.

The National Agency of Protected Areas is understaffed, and rangers are unequipped to effectively monitor forests to detect fires and provide early warning.

Rangers are the field employees responsible for forest monitoring, and Mr. Dhima and Professor Metaliaj claim that the National Agency of Protected Areas employs one ranger to monitor 10,000 hectares of forests for fire risk. Mrs. Lalaj adds, however, that rangers only act in response to forest fires, and that most fire detection arises from residents upon recognition of black smoke above the treetops. Dr. Pasho recalls from his conversations with rangers that their programs are poorly funded, causing them to lack the equipment and infrastructure to detect fires. Most rangers lack access to watchtowers, patrol vehicles, cameras or sensors to surveil the forest.

The Institute of GeoSciences, Energy, Water, and Environment creates daily and monthly risk bulletins, but they have encountered limits in accuracy and scope. Municipality employees and firefighters do not utilize bulletins to inform forest monitoring strategies.

Through interviews with Mrs. Lalaj and Mrs. Hiraldo, we learned that the Institute of GeoSciences, Energy, Water and Environment makes use of a mix of international database tools and 20-25 Institute owned meteorological stations scattered around the country to develop daily and monthly risk bulletins. Rather than only using their risk model and data, the IGEWE relies heavily on online tools such as the Copernicus Emergency Management Services (EMS). On this website, the IGEWE collects data from two services: The Global Wildfire Information System (GWIS), and the European Forest Fire Information System (EFFIS). These systems, which operate largely on satellite, GIS, and meteorological data, allow the user to track areas at risk of fires, burnt areas, active fires, and vegetation fuel. Figure 29 displays the dashboard screen of the Copernicus tool.

The IGEWE bases its evaluations of fire risk on internationally used indices such as the Canadian Forest Fire Weather Index, which considers temperature, humidity, rainfall, and wind. EFFIS uses this data to assign risk ratings to different areas, which the IGEWE then uses to inform its risk ratings. In addition, they collect data from sensor stations across the country, although the stations are understaffed and not maintained well, leading to the heavy reliance on other forms of data. Mrs. Lalaj explained that nearly half of the rainfall sensors at these stations are not functioning properly. This reduces the accuracy of the bulletins and only allows Institute researchers to determine fire risk at a prefect level, without data from specific towns for a higher level of detail. Additionally, Mrs. Jaupay identified some potential weaknesses in using EFFIS for the bulletins. The system uses the Canadian Forest Fire Weather Index, which assumes that the area being evaluated contains a uniform spread of one type of vegetation: pine trees. This constraint may misrepresent the density and diversity of biomass in an area and lead to inaccurate risk ratings. Furthermore, when monitoring Europe, North Africa, and the Middle East, EFFIS only maps about 80% of the total area burnt by forest fires since they do not consider burnt areas less than 30 hectares. As a result, EFFIS often underestimates total fire damage and the IGEWE's records present higher amounts of burnt area, leading to a disconnect between the IGEWE's data and the records of the monitoring tools they use.

Both employees at the Institute of GeoSciences confirmed that they did not send their daily fire bulletins directly to municipality civil emergency agencies or field employees, but only to the National Civil Protection Agency. Despite the fact that the fire bulletins are accessible through the Institute of GeoSciences's website, Mrs. Lalaj pointed out that awareness of the existence and utility of the bulletins for monitoring purposes is very low. Since the risk maps only analyze risk at the prefect level, municipality employees and fire fighters cannot utilize these maps to inform which forests to dedicate resources to monitor more closely.

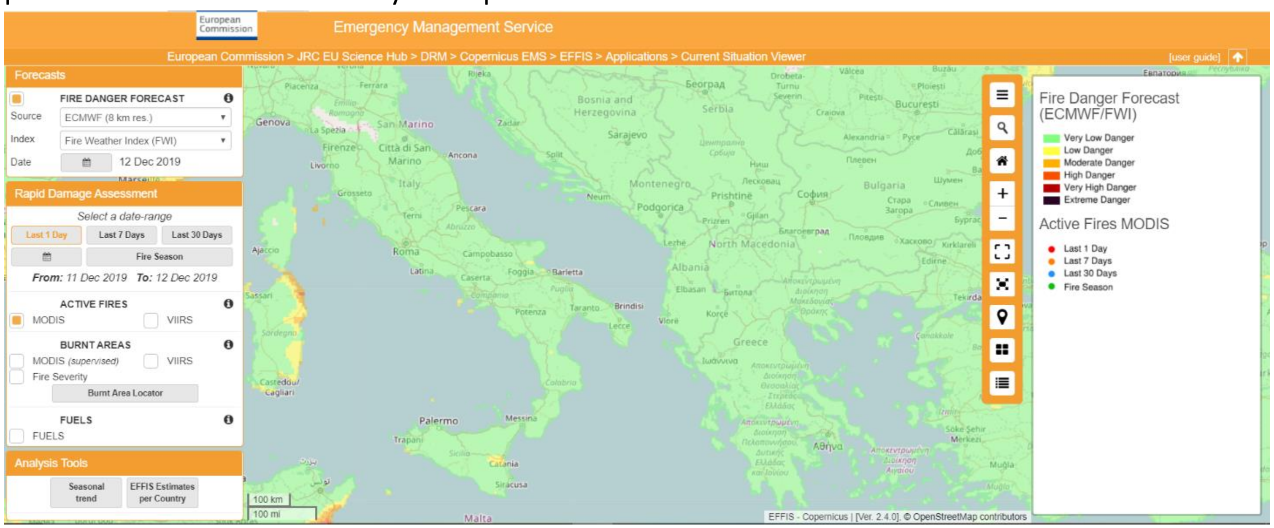

Figure 29: The dashboard screen of the online Copernicus tool (EFFIS, n.d.)

Forest fires located in mountainous areas are the most damaging and expensive for traditional Albanian fire response teams.

Mr. Goxhaj was confident in the department's ability to respond to fires in urban areas, but expressed concern about its ability to respond to forest fires. Rural volunteer firefighters lack the basic equipment to effectively put out these fires. There are no roads/corridors within forests to drive fire trucks and tankers with adequate water capacity to help extinguish forest fires. Mountainous regions are even less accessible via firetruck, and both Professor Metaliaj and Mr. Dhima informed us that such a situation forces Ministry of Defense rent helicopters from private owners or neighboring nations in these scenarios. Often, these responses are too slow to effectively contain fires, which leads to widespread burned areas

Starting in 2020, Ministries, Prefects and Municipalities plan to spend between 2% and 4% of their annual budget on disaster risk reduction and civil protection. It is unclear if this will improve proactive fire protection practices.

Law 45 mandates that municipalities and prefects must dedicate 4% of their total annual budget to civil emergency structures and activities that ensure disaster risk reduction and civil protection beginning in the next fiscal year, January 1st, 2020. In addition, every ministry in the "Line of Ministries" (such as the Ministry of Defense, the Ministry of Tourism and the Environment, the Ministry of Education, the Ministry of the Interior, etc.) must also dedicate 2%-4% of their budget to civil emergency structures and activities. According to Mr. Dhima, this is an important step in changing the mentality of civil emergency agencies from reactive strategies to proactive strategies. Proper funding of civil protection agencies will allow for investments in equipment, staff and infrastructure (i.e. watchtowers), enabling rangers to more effectively monitor forests and researchers to collect ecological data as well as bolster the collection of meteorological data. Our investigation did not include interviews with employees of Line Ministries, which limits our ability to make accurate assessments on the specifics of their prospective spending plans. The Ministry of Finance still needs to propose the budget change to the Prime Minister and Albanian Parliament for approval, but Mr. Dhima expressed his optimism when asked about the likelihood of the budget being changed before the deadline, stating that he "doesn't see any reason why it would not be approved." However, due to the catastrophic earthquake that affected Albania in November 2019, we foresee that the majority of resource allocation will go to recovery efforts and improving earthquake risk reduction.

4.2 Identifying Fire Trends and Gaps in Fire Prevention, Monitoring, and Extinguishing Practices at Dajti Mountain National Park

During the interview with Mr. Goxhaj, he revealed that Dajti Mountain National Park is difficult to manage in terms of forest fires because it is a challenge to reach, given that corridors are not very prominent in mountainous areas. Therefore, it takes longer for trucks to arrive at the scene of the fire. This intriguing fact compelled our investigation to shift its focus from fire protection in rural areas such as remote villages, to an in-depth case study on the forest fire trends at Dajti National Park to gain more insight on how an Albanian National Park conducts fire protection work, along with damage assessment in the aftermath. In doing this, the team hoped to determine which areas would benefit the most from drone usage.

Unfortunately, many businesses in the park either did not have English-speaking employees, as we lacked a translator, or they were not available due to it being off-season. Many tourist attractions, such as the Adventure Park and the Visitors Center, were closed as well. This limited the number of opinions that our team gathered, leaving us unable to conduct the case study as in-depth as the team intended.

Dajti Mountain National Park has a history of significant fires.

Forest fires are not an often-occurring event in the area, though they are still imminent and have been significant in the past. The anonymous business owner the team interviewed indicated that over time not much damage had impacted his business, but he spoke about the big fire that happened around 2017 in the forest due to human negligence. The frequent wind at the elevation of the mountain and the vast number of trees worsened small fires in the park area and allowed them to spread easily.

In addition, the Dajti resort and restaurant employees the group interviewed, who both have served as volunteer firefighters on the mountain, remembered a vast fire that happened around 2012. The team spoke to a ranger from the park visitor center who added that fires in the past have proven significant enough to cause damage to the lower areas of the cable car. Aside from these big fires, forest fires have not been a primary concern of these workers in the park.

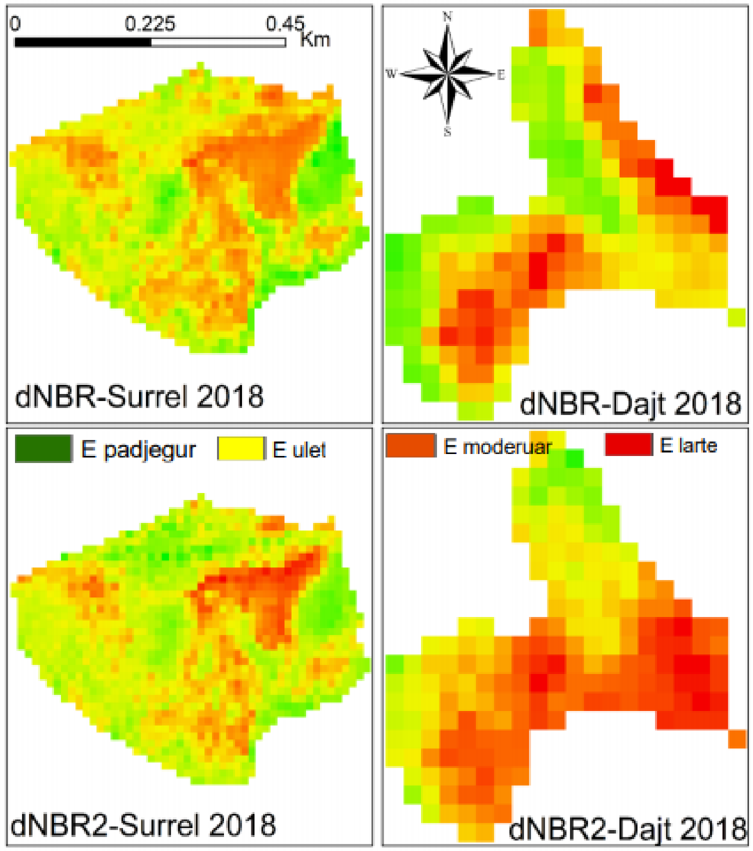

Figure 30: Thermal maps created by GIS of the extent of damage to forest areas affected by fires in the year 2018, by both indices in Surrel and Dajt.

Dr. Pasho shared a report that provided more insight into forest fires in Dajti Mountain National Park. The report aimed to estimate the location, size, and extent of fire impacts on forest surfaces in the park as one of his main objectives. Fires became more frequent during the summer of 2017, though there were some sporadic cases during March to April of 2018. Additionally, fires occurred in the park during the first quarter of 2019. In the Dajt region, the location of Mount Dajti and the resort in Dajti Mountain National Park, the report discovered severe fire-affected surfaces using thermal maps created by GIS software (see Figure 30). The report also found the same results in Surrel, an area nearby. This reinforces the concept that forest fires present heath and property risks to those in the Dajti Mountain area.

No personnel are responsible for carrying out preventive measures such as prescribed burning and creating fire breaks to segment continuous areas of vegetation.

Interviews with Dajti employees and a ranger illuminated that there are few fire prevention strategies that rangers practice at the park. One of the responsibilities of rangers is to engage in fuel reduction by cleaning dry wood from forests. However, they do not carry out other preventative measures such as prescribed burning and creating fire breaks to segment continuous areas of vegetation. Three out of the four Dajti employees that the team interviewed, included the Dajti ranger, believed fire prevention strategies at the park were inadequate. When our group asked interviewees to elaborate on the reasons why this was the case, they cited common themes of ranger shortages, lack of equipment and no technology.

Rangers do not prioritize fire detection when they monitor the forest.

Through our interview with the Dajti ranger, our team acquired information about the strategies rangers employ to detect fires. Rangers at Dajti Mountain National Park patrol the forests with the general goal of keeping the forests clean. They are held responsible for parts of the forests, so they search through them often for any hazards or trash that they can remove. In completing this activity, rangers may find fires. However, rangers do not prioritize monitoring areas that may be at risk of fires.

Furthermore, they are not aware of risk maps or daily bulletins from the IGEWE and cannot refer to them to investigate specific areas of the forest. Due to the uneven terrain and lack of funding, rangers often lack vehicles to effectively travel in forested areas. This limits their ability to quickly find and report fires that may occur in areas without roads. Most Dajti employees were not aware of details regarding fire monitoring except that rangers were involved in the practice.

Near the Dajti resort area, responders have been relatively quick at reacting to fires in the past, and there are procedures in place to extinguish small fires. However, fires in remote areas within the park are often left unchecked.

The Dajti business owner informed us that when the big Dajti fire in 2017 occurred, businesses called the "higher part of the government." Firefighters responded quickly and even arrived with helicopters. The Dajti resort employee added to this information, stating that when there is a fire, response time is relatively quick and that people in the area help in putting the fire out so it does not spread. It usually takes a couple of hours to extinguish the fire, which is quick enough in his opinion. According to the restaurant employee, the people who volunteer to put out fires in this area, such as himself, usually use buckets of water. However, the Dajti employees shared concerns regarding fire extinguishing in remote areas far away from the resort. In these areas, Dajti residents do not suppress fires unless the fires endanger their property. Many of these fires are left to burn out, causing significant environmental damage.

4.3 Integration of EXINN's System into Current Fire Protection Practices

This section details the eleven interviewee's perceptions on EXINN's system's ability to fill gaps in current fire prevention, monitoring and extinguishing practices throughout Albania. Subsequently, interviewees expressed any concerns they had with the process of the system's implementation. Our team followed up this discussion by asking for their opinions on whether the public sector or the private sector should be responsible for bringing this technology to fruition. Our team also took notice of the confusion amongst some interviewees when explaining the multifunctionality aspect of the drone system. Finally, the interviewees answered three questions regarding their perceptions of the most important individual function of fire protection drones.

EXINN's system has the potential to improve fire protection practices by filling gaps in current fire prevention, monitoring and extinguishing practices.

All interviewees saw potential in the system's ability to extinguish small fires before they become a threat, as a method of improving fire prevention practices. In addition, experts such as Mr. Dhima and Mrs. Lalaj responded positively to the idea that the drones could perform fuel reduction during idle times. In terms of filling gaps in forest monitoring practices, all interviewees saw value in the system's ability to improve early fire detection. The employees at the Institute of GeoSciences were interested in the possibility of forest data collection such as temperature, humidity, wind speed, vegetation structure. The experts believed that there were significant gaps in fire response in mountainous regions, while the Dajti employees felt that these gaps were insignificant. However, all interviewees were in consensus that the drone system should work in tandem with traditional fire response. An example of this includes the scenario in which the Ministry of Defense calls a helicopter to drop water to extinguish a fire within a forested mountainous region. EXINN's drone system would be well suited to detect residual fires at the perimeter of the drop zone and extinguish them.

Interviewees had concerns about the high initial cost, the government's role and the technical feasibility of EXINN's system.

Although all interviewees saw potential in EXINN's drone system, eight out of ten interviewees were concerned about obstacles that might prevent the system from reaching the final stage of implementation, as shown in Figure 31. Four interviewees held the opinion that the government does not prioritize proactive fire prevention and monitoring methods. Professor Metaliaj, and Mrs. Lalaj were the most unsure, as they have witnessed the government manage several innovative projects that they never completed. Three interviewees were concerned about the high initial cost of the system. Mr. Dhima did not believe that there would be enough return on investment to entice investors. Mrs. Hiraldo was the only interviewee to doubt the drone system's ability to carry out all the functions that the group described to her. She also had concerns regarding the legality of using drones for fire protection purposes, stating that she was unaware of any regulations in place for drones. However, Mr. Dhima and Mrs. Lalaj were confident that this would not present an issue.

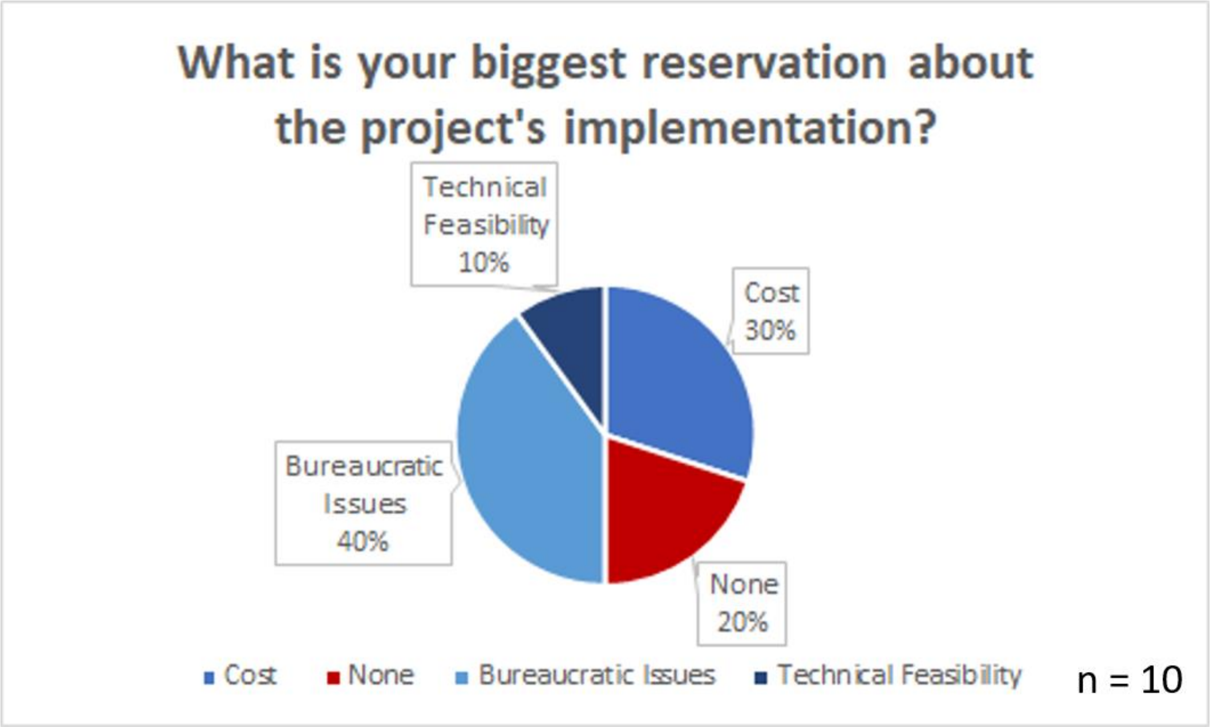

Figure 31: Interviewees' biggest reservations about EXINN's system's implementation

Interviewees viewed Public Private Partnerships as the most successful path to implementing EXINN's system.

For a system of this scale, it is important to assess the most appropriate financial implementation strategy. As shown in Figure 32, we asked seven interviewees if they thought partnering with the public sector, the private sector, or a public private partnership would be the most successful project management strategy. Mr. Dhima and Mr. Goxhaj believed that the government would possess the necessary funds to manage the project entirely on its own. This is even more likely to be the case due to Law 45 since each ministry is obligated to allocate 2%-4% of their budget to disaster

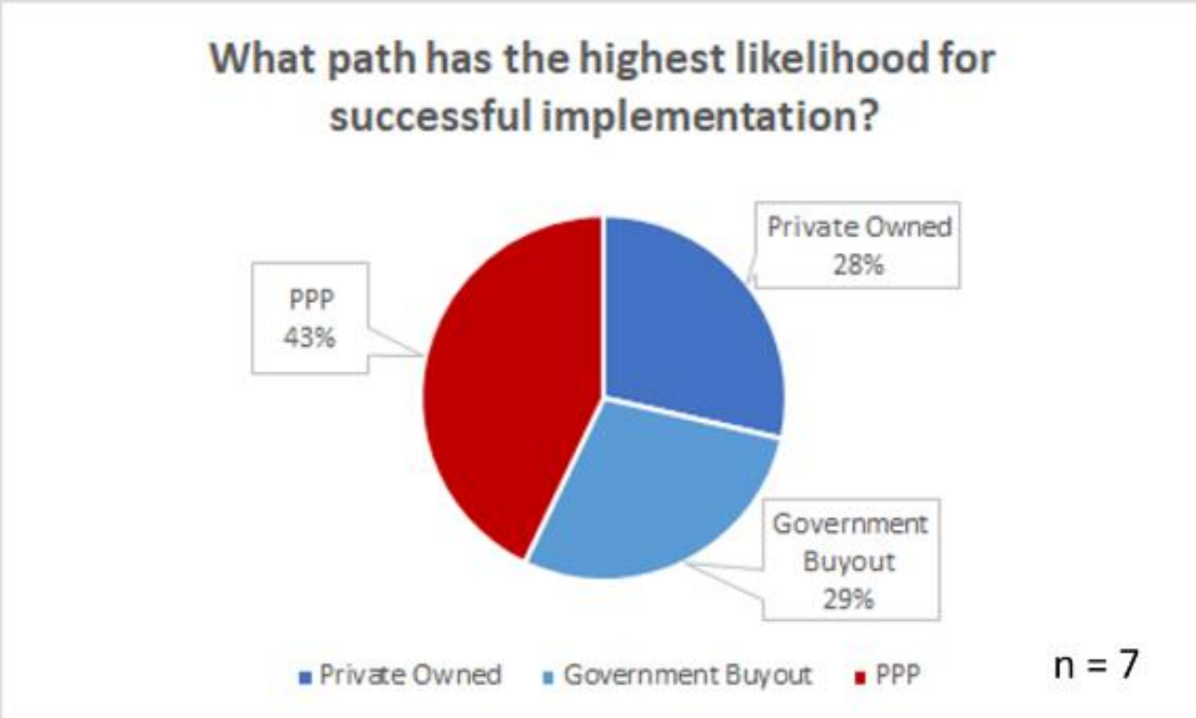

Figure 32: Interviewees' opinions on which path has the highest likelihood for successful implementation of EXINN's system

risk reduction. Professor Metaliaj and the Dajti business owner recommended offering it directly to private businesses, citing the government's failure to prioritize proactive fire protection practices. Mrs. Lalaj, Dr. Pasho and Mrs. Amparo believed a Public Private Partnership would be the best way to introduce the system. In this type of partnership, a private entity purchases the system and then through a contract, the government pays a fee for service to use the system as a public service. This can allow the private entity to assume most of the risk by making the initial investment and managing the system, while the government provides financial incentives to the private entity.

In the case of limiting EXINN's drone system's multifunctionality, stakeholders view fire monitoring as the most realistic individual function of the drone.

EXINN's system aims to address all aspects of fire protection through the combination of thermal cameras and drones, but the high initial cost may be limiting. To provide insight on the outcome if this happened, our team explored perceptions of using drones for each individual function: prevention, monitoring, and extinguishing. Eight of the eleven interviewees were available to answer whether they believed which of these functions was the most realistic for a drone, would be the most useful, and had the most potential. Interviewees were allowed to choose the same function for multiple questions.

Figure 33 shows that most interviewees viewed monitoring as the most realistic function for drones by a significant margin, while extinguishing was the least realistic. In a monitoring system, drones would observe this area and detect the fires much more quickly than a human could. Monitoring may be the most preferred, realistic function because most people know drones for their ability to monitor and take pictures, rather than extinguishing or preventing fires.

During our explanations of EXINN's system, three interviewees interrupted our team when our mentioned thermal cameras were connected to drones. They believed we were going to say the drones would be monitoring the forest with thermal cameras attached to them similar to how emergency responders commonly use drones. In some cases, it took several explanations to convey the full extent of the system's capabilities. Four interviewees expressed surprise that EXINN was considering functions other than monitoring for drones.

Interviewees considered fire prevention and extinguishing as having the most potential, possibly due to interviewees being optimistic in EXINN's system's ability to reduce forest fires in Albania. They considered prevention and monitoring to be the most useful, rather than extinguishing the fires. This may be the case because the Dajti employees we interviewed believed that their current extinguishing methods are adequate, and therefore would not need to have drones perform this task.

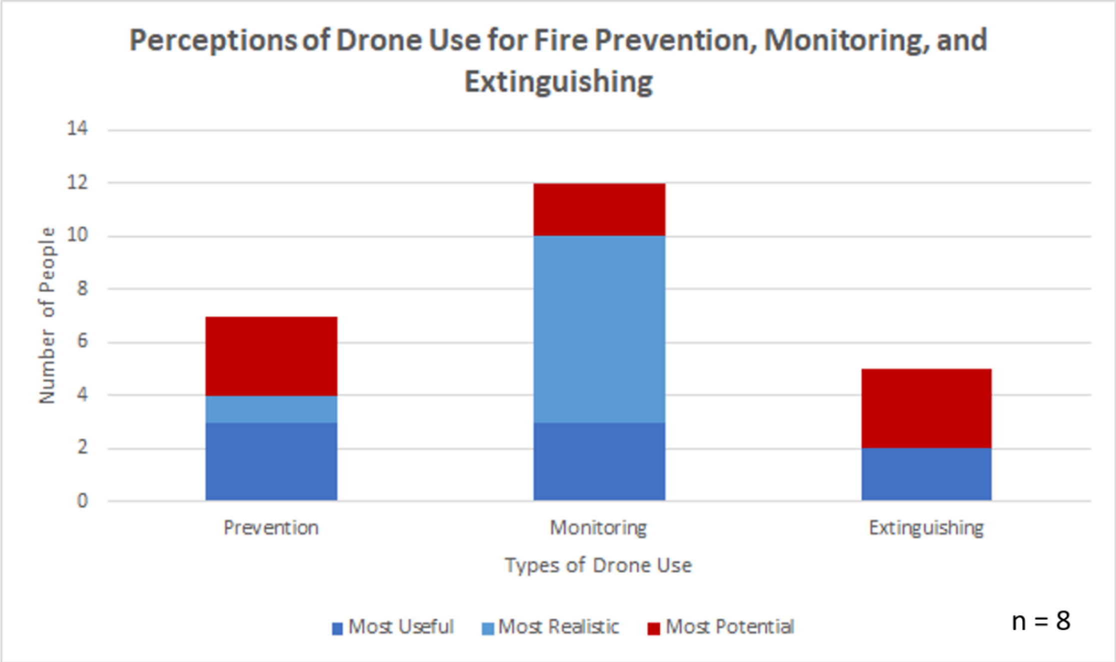

Figure 33: Interviewees' responses to most useful, realistic, and potential applications for drones

CHAPTER 5: CONCLUDING THOUGHTS

Figure 34: Drone used for monitoring forest fires (Nene, 2018)

Conclusions

Experts anticipate the growth of forest fires in Albania in both frequency and intensity due to negligent human acts, climate change, and development of WUIs. This is especially concerning in Albania's southern, mountainous rural areas where temperatures are higher and fighting fires is difficult due to inaccessible terrain and limited resources. Albania fire departments do not have adequate equipment and air support to extinguish forest fires, forcing them to turn to the Ministry of Defense and other countries for aid and assistance.

At the local level, rangers lack access to watchtowers, patrolling vehicles, and monitoring technology to better detect fires and provide early warning. Additionally, rangers rarely carry out fire prevention strategies such as prescribed burning and fire breaks. Municipalities often submit incomplete and incorrect fire statistics to the Disaster Loss Database, and the IGEWE has not been able to create precise risk maps to inform monitoring strategies of rangers. Through the Dajti Mountain National Park WUI case study, our interviews concluded that the area has a history of forest fires, and the inadequate fire prevention and monitoring procedures puts valuable real estate investments at risk.

Our research has shown that EXINN's system can improve fire prevention practices by extinguishing small fires before they become a threat and performing fuel reduction during its idle time. The drone system can enhance monitoring practices by collecting valuable forest data and improving early fire detection. Finally, the drone system can potentially work alongside traditional fire response strategies to aid the extinguishing of larger fires. When looking at separate drones functions, interviewees considered fire monitoring to be the most realistic use, though extinguishing and prevention have the greatest potential for the future because technology is progressing rapidly towards automating jobs that put lives at risk.

Interviewees were generally optimistic about EXINN's system, although there were concerns about technical feasibility, the high initial cost, and the government's role in overseeing its implementation. Bureaucratic issues are the largest obstacle for implementation, as interviewees felt the government may not have the necessary funding and motivation to support EXINN's system. This is related to why the majority of interviewees believed a Public Private Partnership would be the most effective method to finance EXINN's system.

Recommendations

As a result of this research, our team has come up with some recommendations for EXINN in regard to their fire protection system.

EXINN should perform extensive testing to prove its technical capabilities to potential investors. Initial interviewee confusion indicates that there are no similar systems to reference to, so potential investors may be skeptical of the system's ability to successfully complete its task.

We suggest that EXINN considers implementing their system incrementally, beginning with utilizing drones for fire monitoring purposes. Stakeholders and experts considered fire monitoring to be the most realistic function for drones.

Our team suggests that EXINN considers a collaboration with the Institute of GeoSciences, Energy, Water, and Environment and the National Environmental Agency to analyze burn area statistics and fire trends to identify an appropriate pilot testing site.

Our limited research indicates that Dajti Mountain National Park has the potential to be an appropriate pilot testing site, based on its status as a mountainous WUI. However, EXINN should conduct further research into the case study to gain more knowledge and confirm this.

We recommend that EXINN explores the benefits and drawbacks of using multiple small sensors connected in an Internet of Things system instead of a single thermal camera for fire detection. This would eliminate the single point of failure within the thermal camera.

We recommend that EXINN meet with members of the Ministry of the Environment and Tourism, as well as the National Civil Protection Agency, to identify functionalities that the public sector would value in EXINN's fire protection system.

Additional interviews with rural volunteer firefighters and rangers can confirm the experts' claims regarding current fire protection practices in WUIs and rural areas.

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APPENDIX A: INTERVIEW FORMAT

Introduction:

Hello!

Thank you for meeting with us. We are a team of WPI university students from the United States. For this study, we are working with the company EXINN Technology Center, which is developing a new fire prevention system to quickly detect and extinguish small forest fires. This system involves using thermal cameras to monitor surrounding forest areas for fires. When a fire is detected, the system activates a group of drones to fly to and extinguish the fire. The system uses swarm artificial intelligence to control the drones, meaning they can coordinate with each other without requiring someone to control them. Although this project is still in development, we would like to interview you about your interest and thoughts on the use of this drone technology. Your answers will help us identify opportunities to use this emerging technology to monitor and prevent forest fires and to assess under what conditions drones would be a feasible approach.

First, we would like to remind you that your participation in this interview is completely voluntary and you may opt out at any time. We will abide by any limits you request in regard to confidentiality. Would you like us to keep your name and any identifying information about you private? Do we have your permission to directly quote you in our report? We plan to record this interview on one of our phones so that we could make sure that we do not miss any details. Do we have your permission to record this interview? If not, we are completely fine with just taking written notes on the interview. Do you have any concerns about how we will use the information we record from this interview? You can also contact us directly at gr-EXINN-B19@wpi.edu if you have any questions later. The report will be available online once it is finished and can be emailed to you in the future if you would like. Do you have any questions for us before we start this interview?

Questions:

Questions for each interview are specified in Appendices B, C, D, E, F, G, H, I, and J depending on who is being interviewed.

End of Interview:

That is all our planned questions for this interview. Do you have any questions or comments for us? Is there anything else that we should know about the topics discussed in this interview? Would you like to review the transcript of the interview? Again, you can contact us directly at gr-EXINN-B19@wpi.edu. Thank you very much for your time.

APPENDIX B: INTERVIEW QUESTIONS FOR ANDREA PAPA (*CHIEF INNOVATION OFFICER OF EXINN TECHNOLOGY CENTER- CREATOR OF UFPUS PROJECT*)

1. Why did EXINN start their Unified Fire Protection Units and System project?
2. What led to the solution of using thermal cameras and drones?
3. Has EXINN worked on any projects related to forest fires or drones before?
4. Are there other similar projects that EXINN's project was inspired by?
5. Can you briefly describe the goal of the project?
6. What areas of Albania experience the most fires?
    a. What areas of Albania would benefit most from using drones for this?
    b. What are the predicted changes in frequency, intensity and damages of fires in the near future?
7. What is the estimated savings for using this technology as opposed to just traditional firefighting strategies to prevent forest fires from escalating into large wildfires?
8. Are Public Private Partnerships feasible for implementing the project?
    a. What role should each party (government, private agencies) take in a PPP? What would EXINN be in this?
    b. How should they be structured (who owns the project, who runs the operation, how is the contract drawn up, how accountability is maintained, how incentives are employed)
    c. Are there any examples related to fire prevention or similar climate projects?
    d. Have they been successful in Albania?
    e. What are the benefits and drawbacks?
    f. How does EXINN view collaborating with a PPP for implementing this project?
9. Are there any special motivations or incentives you've considered when planning how to gain consumer interest?
10. How does EXINN's fire prevention system work?
    a. What functionalities would the ideal drone have? Are there any specific models being considered?
    b. What is the farthest travel distance of the drones?
        i. Approximately what area of land can each fire extinguishing ball cover?
    c. Have you determined what type of thermal camera you would use?

d. Is the system centralized or decentralized?
e. How does the camera communicate with the drones (ie- WiFi, Bluetooth, smart device, etc)?
f. How is it impacted by weather, foliage and altitude?
g. What sort of security will the drone station have?

11. What are some potential limitations of using the new technology/drones?
    a. Are there any limitations related to materials or algorithms?
    b. What concerns do people have about using drones for this purpose?
12. What has been done and what still needs to be done in the project?
13. How has the project changed over time as EXINN has progressed on it?
14. What information needs to be collected to monitor and prevent fires, in addition to location?
15. How would the drones fit into current fire monitoring and prevention strategies?
16. At what point are other firefighting techniques required to help fight a forest fire? Could EXINN's system initially start on its own, or would it need to be integrated with other firefighting techniques at first?
17. What kind of training and maintenance is required for operating this system?
18. How does EXINN take into consideration the needs of rural communities that would be affected by their project?

APPENDIX C: QUESTIONS FOR MAKSIMILJAN DHIMA *(FORMER DIRECTOR OF PLANNING AND COORDINATION FOR CIVIL EMERGENCIES–GENERAL DIRECTORATE OF CIVIL EMERGENCIES, TIRANA, ALBANIA)*

1. How long were you director of Civil Emergencies?
2. Are you still involved in the disaster relief?

Questions relating to objective 3.1

1. What are the primary causes of fires in Albanian forests?
2. What areas of Albania experience the most fires?
    a. Is this different from where they cause the most damage?
    b. What areas of Albania would benefit most from using drones for this?
    c. What are the predicted changes in frequency, intensity and damages of fires in the near future? (based on climate change and development patterns)
    d. What are the costs due to fire damage?
3. Where are Wildland Urban Interfaces in Albania?
    a. How have WUIs changed over the past few years?

Questions relating to objective 3.2

1. What were your primary responsibilities as director?
2. Can you describe the government hierarchy structure in regard to responding to forest fires? How is the communication and collaboration organized?
3. Can you clarify the differences in roles and responsibilities between the Ministry of Defense and The National Civil Protection Agency? Is the difference clear and organized?

4. Is the National Civil Protection Agency in the process of being restructured?
5. Which organizations are in charge of monitoring forest fires?
    a. What information needs to be collected to monitor forests and prevent fires?
6. How large is the budget associated with forest management and fire prevention?
    a. How does the government allocate resources to areas with different fire risks?
    b. Has the Ministry of the Interior previously invested in innovative technological solution for natural disaster management?
7. Can you walk us through the steps that are taken in the event of a civil emergency in Albania?
    a. Does this follow the four main phases of emergency management, which are mitigation, preparedness, response, and recovery?
8. Is Law 45 on Civil Protection currently a work in progress or is it already approved and implemented?
9. What government groups still need to approve the new 4% budgetary provision for civil emergencies?
    a. What are the steps to its implementation?
    b. Do you believe it will be successfully implemented by January 1st, 2020?
10. In terms of compensation for damages from disasters, how much do municipalities pay vs. the Council of Ministers? How is this difference in compensation affected by the size and ownership of the damaged land and infrastructure?

<u>Questions relating to objective 3.3</u>

1. How effective do you feel Albania has been able to respond to civil emergencies?
2. How closely are Albanian firefighters able to follow prevention, monitoring and extinguishing procedures, due to resource restraints, lack of communication, geographic difficulties, etc?
    a. Are there improvements that need to be made?
3. How are areas at risk of fires identified?
    a. Is satellite monitoring used for this purpose?
    b. Does the Civil Protection Agency refer to risk maps and daily fire risk bulletins provided by the Institute of GeoSciences, Energy, Water and Environment?
4. How are fires handled in WUIs?
5. How do firefighters bring water to fire fires in remote areas within forests? Are they transported on a truck, pumped from lake, etc?

<u>Questions relating to objective 3.4</u>

1. How familiar are you with EXINN and their project related to fire prevention?
2. How would EXINN's project fit into current fire monitoring and prevention strategies?
    a. What benefits do you believe drones could provide in fighting forest fires?
    b. What limitations could you foresee in utilizing drones?
3. Under what conditions, motivations and desired functions would the government consider EXINN's solution to be valuable?
    a. Which level of government would use this technology?
4. Do you know of any private sector industries that may be at higher risk for forest fire damages?
    a. Are there any that may consider investing in fire prevention solutions such as EXINN's project?
    b. What concerns do you think would turn consumers away from investing in drones?
5. Are Public Private Partnerships feasible for implementing disaster relief projects?
    a. What role should each party (government, private agencies) take in a PPP?
    b. How should they be structured (who owns the project, who runs the operation, how is the contract drawn up, how accountability is maintained, how are incentives employed)
    c. Are there any examples related to fire prevention or similar climate projects?
    d. Have they been successful in Albania?
    e. What are the benefits and drawbacks?
6. Are there legal restrictions on airborne disaster relief equipment?

APPENDIX D: QUESTIONS FOR RAMIZ METALIAJ (*FORESTRY MANAGEMENT FACULTY / AGRICULTURAL UNIVERSITY OF TIRANA*)

1. How long have you worked for the Agricultural University of Tirana?
2. What areas of forest management do you specialize in?
3. What research have you done relating to forest management?

<u>Questions relating to objective 3.1</u>

1. What are the different causes of fires in Albanian forests?
2. What areas of Albania experience the most fires?
    a. How often do fires occur in these areas?
    b. How do forest fires cause the most damage (ie- property loss, human injuries, environmental effects, etc)?
    c. What are the current and predicted changes in frequency, intensity and damage of fires in the near future? (based on climate change and development patterns)
3. Where are Wildland Urban Interfaces in Albania?
    a. How have WUIs changed over the past few years?

<u>Questions relating to objective 3.2</u>

1. Who owns different types of forests? Who is responsible for maintaining the forest's integrity?
    a. Who handles forest issues in remote areas like Theth?
    b. How does the maintenance of public forests and parks get funded?
2. How are fires handled in WUIs?
3. Could you explain some scenarios about how fires are handled in forests near urban areas vs. how they are handled in more rural areas that may not be part of municipalities?
4. What information is used by the Institute of GeoSciences, Energy, Water, and Environment to develop daily fire risk bulletins?
    a. Who uses these bulletins (researchers, firefighters, government)?

Questions relating to objective 3.3

1. How many rangers are available to maintain the forested areas?
2. How are fires currently monitored and prevented in forests?
3. How are the strategies affected by how fire prone the area is and how much financial support the surrounding municipality receives?
    a. How are areas with high fire risk identified?
    b. Are these strategies effective? Are there improvements that need to be made?
    c. What information needs to be collected to monitor and prevent fires?
4. What kind of technology is currently used for firefighting and how is it used?
    a. Do firefighters in Albania have access to this technology and if so, do they receive special training on how to use it?
    b. Is satellite monitoring used to determine what areas are at risk for fires?

Questions relating to objective 3.4

1. How would EXINN's project fit into current fire monitoring and prevention strategies?
    a. What benefits do you believe drones could provide in fighting forest fires?
    b. What limitations could you foresee in utilizing drones?
    c. What concerns do people have about using drones for this purpose?
    d. What industries in the private sector are at high risk of damage from forest fires?
    e. What would EXINN's project have to accomplish for it to be a worthwhile investment?
2. Are Public Private Partnership feasible for implementing EXINN's project?
    a. What role should each party (government, private agencies) take in a PPP?
    b. How should they be structured (who owns the project, who runs the operation, how is the contract drawn up, how accountability is maintained, how incentives are employed)?
    c. Any examples related to fire prevention or similar environmental issues?
    d. Have they been successful in Albania?
    e. What are the possible benefits and drawbacks?

APPENDIX E: QUESTIONS FOR EDMOND PASHO (*FORESTRY MANAGEMENT FACULTY / AGRICULTURAL UNIVERSITY OF TIRANA*)

<u>Questions related to objective 3.1</u>

1. What are the current and predicted changes in frequency, intensity and damage of fires in the near future?
    a. How is this affected by climate change?
    b. How is this affected by development patterns and agricultural clearing?

<u>Questions related to objective 3.2</u>

1. Are property damages and infrastructure damages recorded in the Disaster Loss Database compiled by municipalities and the National Environmental Agency?

<u>Questions related to objective 3.3</u>

1. How are areas at risk of fires identified?
    a. Has satellite monitoring been used for this purpose? Has GIS been used to help prevention strategies?
    b. Do you refer to risk maps and daily fire risk bulletins provided by the Institute of GeoSciences, Energy, Water and Environment?
    c. Who uses these bulletins (researchers, firefighters, government)?

<u>Questions related to objective 3.4</u>

Our project involves using a thermal camera to monitor a large area of forest. This thermal camera will detect fires, locate their coordinates, and communicate with firefighting drones to navigate to the area and extinguish fires before they get too large.

1. Given the three possible uses for drone use for forest fires- *monitoring (during and after fire), prevention (prescribed burning), or extinguishing*- which method do you think is the:

a. Most useful
b. Most realistic
c. Has the most potential

2. Another solution for fire prevention is the use of multiple sensors that are connected on the same network and spread throughout forests to measure meteorological data like temperature and humidity. How do you think this type of monitoring compares to using drones for monitoring in terms of:

a. Most useful
b. Most realistic
c. Has the most potential

3. Another solution would be using drones for extinguishing and sensors for monitoring in combination. How do you think this compares to using drones alone or sensors alone in terms of:

a. Most useful
b. Most realistic
c. Has the most potential

APPENDIX F: INTERVIEW QUESTIONS FOR NENSI LALAJ *(PROJECT MANAGER OF BRIGAID, NATIONAL TERRITORIAL PLANNING AGENCY, TIRANA, ALBANIA)*

1. What is the primary function of the National Territorial Planning Agency?
2. What is your connection with BRIGAID?
3. What are your responsibilities as a project manager?
4. How did you become interested in this field of work?
5. How does BRIGAID support projects to reduce the effects of climate change?
6. What role does your organization take in aiding efforts to fight forest fires?

Questions related to objective 3.2

1. Who owns different types of forests?
    a. Who handles forest issues in remote areas like Theth?
2. Where are Wildland Urban Interfaces in Albania?
    a. How have WUIs changed over the past few years?
    b. How are fires handled in WUIs?
    c. What industries in the private sector are at high risk of damage from forest fires?

Questions related to objective 3.3

1. How does territorial planning divide different areas of forest? (Uses? Quality of land? Relation to other spaces? etc)
    a. What requirements are there?
    b. Restrictions?
2. How is spatial data collected and analyzed?
3. What information do you look for when doing spatial data? Human use/interaction? Growth areas of different species? Development changes? Water? Damaged area?

4. How do you currently plan for forest fires in Albania?
    a. What methods work well?
    b. What geographical difficulties do you encounter while planning for forest fire relief?
    c. What financial difficulties do you encounter?

<u>Questions related to objective 3.4</u>

1. Have you seen drones being used in any aspects of disaster relief?
    a. Are they similar to EXINN's project?
    b. Are there any legal or territorial issues you foresee impacting EXINN's ability to implement their project in forested areas?
    c. What would EXINN's project have to accomplish for it to be a worthwhile investment?
2. Are Public Private Partnerships feasible for implementing disaster relief projects?
    a. What role should each party (government, private agencies) take in a PPP?
    b. How should they be structured (who owns the project, who runs the operation, how is the contract drawn up, how accountability is maintained, how are incentives employed)
    c. Are there any examples related to fire prevention or similar climate projects?
    d. Have they been successful in Albania?
    e. What are the benefits and drawbacks?

APPENDIX G: INTERVIEW QUESTIONS FOR SHKELQIM GOXHAJ (*DIRECTOR OF FIREFIGHTING DEPARTMENT OF TIRANA*)

1. How long have you been in your profession?
2. How many firefighters in your unit are volunteers?

Questions Relating to Objective 3.1:

1. What areas of Albania experience the most fires?
    a. Is this different from where they cause the most damage?
    b. What are your predictions about changes in the frequency, intensity and damage of fires in the near future?
        i. Is this based on your belief in climate change?
        ii. Is this based on development and construction patterns?
2. How has the frequency or intensity of forest fires been increasing over the past few years?
3. What are the different causes of fires in Albanian forests?

Questions Relating to Objective 3.3:

1. What areas is the Tirana fire department responsible for?
    a. Do they manage fires in nearby forests?
2. How do volunteers aid professional firefighters?
    a. How many volunteers are there compared to paid firefighters?
3. Does the fire department have an adequate amount of equipment?
4. In what aspects can firefighting strategies in Albania be improved?
5. How does the fire department utilize technology to fight fires?
6. How does the Tirana fire department compare to fire departments in rural areas outside of the city?
7. How do firefighters transport water to different areas?

8. What strategies do firefighter employ to extinguish fires?
9. How quickly can you respond to a forest fire situation?
10. How effectively are fires currently being monitored and prevented in forests?
    a. What information needs to be collected to monitor and prevent fires?
11. What are the methods by which firefighters monitor areas at risk of fires and prevent fires from spreading out of control?

Questions Relating to Objective 3.4:

1. Has the fire department used drones before for any purpose?
    a. Do you believe drone technology can make fire prevention more effective?
    b. What obstacles do you foresee in the implementation of firefighting drones?
    c. Do you have concerns about the safety of utilizing drones?
2. What region would benefit the most from this EXINN's project?
    a. What benefits would this provide over traditional fire prevention methods?
    b. What concerns do you have about the effectiveness of this drone system?
    c. Do you think having these drones would decrease the need for firefighter?
    d. Do you think this is more useful than drones that strictly monitor fires?

APPENDIX H: INTERVIEW QUESTIONS FOR THE INSTITUTE OF GEOSCIENCES, ENERGY, WATER AND ENVIRONMENT (IGJEUM)

1. What is your job in the Institute and what are your responsibilities?
2. How has your work related to forest fire prevention?

Questions Relating to Objective 3.1:

1. What overall trends have you noticed in Albania over the past decade in regard to temperature, precipitation and humidity?
2. What areas of Albania experience the most fires?
    a. Is this different from where they cause the most damage?
    b. How often do fires occur in these areas?
    c. What are the current and predicted changes in frequency, intensity and damage of fires in the near future? (based on climate change and development patterns)
3. Is there any data that you can provide to us about forest fire trends in Albania?

Questions Relating to Objective 3.3:

1. How do you identify the risk of fires in various areas?
    a. What information/data (meteorological and ecological) is required to calculate risk?
    b. Are you missing any information/data that may help calculate more accurate risk assessments?
2. Does the institute create fire risk maps that are more specific than the prefect level maps?
    a. What are the current barriers to the creation of risk maps?
3. What information is used to create the fire risk bulletins?
    a. How is this information disseminated?
    b. Is this information used effectively to monitor areas with high fire risk and prevent fires from starting and spreading?
    c. How is this information used by firefighters and rangers in the field?
4. How are fires currently monitored and prevented in forests?

   a. How are the strategies affected by how fire prone the area is and how much financial support the emergency structures within the municipality receives?
   b. Are these strategies effective? Are there improvements that need to be made?
   c. What information needs to be collected to monitor and prevent fires?
   d. Do rangers monitor the forest to detect fires? If so how?

Questions Relating to Objective 3.4:

1. Do you think it could be beneficial for the IGJEUM to coordinate with EXINN on their project?
2. What kinds of areas would benefit the most from the drone?
3. Would you imagine that the government would fund the project, or would it be funded by private businesses?
4. How would EXINN's project fit into current fire monitoring and prevention strategies?
   a. What benefits do you believe drones could provide in fighting forest fires?
   b. What limitations could you foresee in utilizing drones?
   c. What concerns do people have about using drones for this purpose?

Questions Relating to Objective 3.5:

1. What are notable fires that occurred over the past decade in Dajti Mountain National Park?
   a. Are there areas within the park that are especially at risk of fires?
2. Are there any specific or unique risks in Dajti in regard to fire?
3. How fires currently monitored and prevented, specifically in Dajti Mountain National Park?

APPENDIX I: INTERVIEW QUESTIONS FOR DAJTI NATIONAL PARK EMPLOYEES

1. How long has the business been operating?

Questions Related to Objective 3.5:

1. Have forest fires occurred in this area?
    a. How often do they occur?
    b. Are they becoming more or less frequent?
    c. Have much damage have they caused to surrounding forests (cost and area burned)?
    d. How much damage have the fires caused the business, if any?
    e. How many times has the business had to call the fire department?
2. How are the surrounding forest areas monitored for fires?
    a. Is any technology used for this purpose such as normal cameras, thermal cameras, or satellite technology (GIS)?
3. Does the Dajti Mountain National Park have rangers?
    a. What are their responsibilities?
    b. Are risk maps or weather data used by rangers in the park?
4. What steps are taken when a forest fire is detected in the national park?
    a. Do you handle the fire yourselves and if so, with what equipment and strategies?
    b. Who do you call to handle fires?
        i. How long does it take for them to help?
        ii. How much does it cost?
5. Do people assess the damage after the fire? If so, who?
    a. Are you compensated for damages? Is there insurance?
6. Do you think current fire prevention and firefighting strategies are adequate to control fires in this area?
7. What would you want most in a fire fighting system?
8. Given the three possible uses for drone use for forest fires- *monitoring (during and after fire), prevention (prescribed burning), or extinguishing*- which method do you think is the:
    a. Most useful

    b. Most realistic
    c. Has the most potential
9. Another solution for fire prevention is the use of multiple sensors that are connected on the same network and spread throughout forests to measure meteorological data like temperature and humidity. How do you think this type of monitoring compares to using drones for monitoring in terms of:
    a. Most useful
    b. Most realistic
    c. Has the most potential
10. Another solution would be using drones for extinguishing and sensors for monitoring in combination. How do you think this compares to using drones alone or sensors alone in terms of:
    a. Most useful
    b. Most realistic
    c. Has the most potential

APPENDIX J: INTERVIEW QUESTIONS FOR DAJTI NATIONAL PARK RANGER

<u>Questions Related to Objective 3.5:</u>

1. Have forest fires occurred in this area?
    a. How often do they occur?
    b. Are they becoming more frequent?
    c. Have much damage have they caused to surrounding forests (cost and area burned)?
    d. How much damage have the fires caused the business, if any?
    e. How many times has the business had to call the fire department?
2. What are some of the reasons that fires start in the national park?
3. Do people assess the damage after the fire? If so, who?
    a. Are you compensated for damages? Is there insurance?
4. How are the surrounding forest areas monitored for fires?
    a. How do thermal cameras on the cable cars assist in monitoring?
5. What are the responsibilities of rangers?
6. What preventative measures are taken to lessen the chances of forest fires occurring in Dajti Mountain National Park?
7. What is your opinion of EXINN's firefighting system?
8. Given the three possible uses for drone use for forest fires- *monitoring (during and after fire), prevention (prescribed burning), or extinguishing*- which method do you think is the:
    a. Most useful
    b. Most realistic
    c. Has the most potential
9. Another solution for fire prevention is the use of multiple sensors that are connected on the same network and spread throughout forests to measure meteorological data like temperature and humidity. How do you think this type of monitoring compares to using drones for monitoring in terms of:
    a. Most useful
    b. Most realistic
    c. Has the most potential

10. Another solution would be using drones for extinguishing and sensors for monitoring in combination. How do you think this compares to using drones alone or sensors alone in terms of:
    a. Most useful
    b. Most realistic
    c. Has the most potential

APPENDIX K: SCENARIO QUESTIONS

1. The area near the cable car in Dajti Mountain National Park in Tirana is an example a Wildland Urban Interface (WUI). Who monitors the forest to detect fires in high risk areas? Are risk maps and meteorological data used to predict the occurrence of fires? When a fire is detected, who is called to extinguish it and what methods are used? Are fuel breaks and selective burning used as preventative methods to contain fires from spreading? What agency is responsible for recording the damage and compensating those with property damage?

2. A remote village is surrounded by forest. There is no organized fire department in the area, and the village is hours away from other villages or cities. Who monitors the forest to detect fires in high risk areas near the village? How are high risk areas identified? Do they have any equipment to aid them such as sensors or thermal cameras, and are there procedures that they follow? When a fire is detected, who is called to extinguish it and how quickly can they respond to the situation? Are fuel breaks and selective burning used as preventative methods to contain fires from spreading? What extinguishing methods are used? What agency is responsible for recording the damage statistics? Are residents and business owners compensated for property damage, and if so where does the money come from?

3. A mountainous national park has very little human activity nearby besides hiking and a few small businesses. There are no properly maintained roads or other infrastructure. The summer season has been especially dry, and there has been no rainfall for the last three weeks. The temperature has been approximately 30°C and moderate winds are blowing up the slope westwards. What organization employs the rangers that monitor the forest? How is this meteorological data used to inform prevention and monitoring practices? How quickly are fires detected in the forest, and how quickly can a response be organized? What procedures and equipment do they use to monitor the forest? Are fuel breaks and selective burning used as preventative methods to contain fires from spreading? How does the fire department bring manpower and equipment to extinguish the flames? How do they bring sufficient water? What agency is responsible for recording the damage the fires incur?