

<b>Commissioned by:</b>	UN Environment, CTCN, Adaptation Fund
<b>Project Title:</b>	Building up integrated monitoring and early warning forest fires detection system in the Borjomi - Kharagauli National Park by innovative remote sensing tools, in Georgia
<b>Implemented by:</b>	International Business and Economic Development Center
<b>Country:</b>	Georgia
<b>Deliverable:</b>	<p>2.1. a. Benchmark the most representative forest fires detection systems, including terrestrial, aerial, and satellite methods.</p> <p>2.1. b. Report summarizing all components requested for each category</p> <p>2.1.c. Cost analysis overview of each system</p> <p>2.1.d Draft prioritization of the most suitable method(s) for the use in Borjomi - Kharagauli National Park</p>

**BENCHMARKING**  
**the most representative forest fire detection systems**

**Contents**

<b>1. General Context .....</b>	<b>4</b>
<b>2. Methodology .....</b>	<b>4</b>
<b>3. Presentation of the existing integrated monitoring and early warning forest fires and smoke detection systems – technical considerations.....</b>	<b>5</b>
<b>3.1. Video / Thermo Cameras .....</b>	<b>5</b>
<b>3.2. Wireless Sensor Networks.....</b>	<b>11</b>
<b>3.3. Surveillance drones .....</b>	<b>12</b>
<b>3.4. Satellite system.....</b>	<b>17</b>
<b>3.5. LIDAR/ Laser Systems .....</b>	<b>17</b>
<b>3.5.1. LIDAR Systems .....</b>	<b>18</b>
<b>3.5.2. Laser Systems .....</b>	<b>19</b>
<b>3.6. Spectroscopy .....</b>	<b>20</b>
<b>3. Economic analysis regarding three main options suitable for the target area .....</b>	<b>21</b>
<b>4. Matrixes to support the decision – making process.....</b>	<b>22</b>
<b>ANNEXES .....</b>	<b>24</b>
<b>ANNEX 1 – General estimate for the main three options.....</b>	<b>24</b>
<b>ANNEX 2 – Estimate of running costs .....</b>	<b>27</b>
<b>ANNEX 3 – Use of land in the target area.....</b>	<b>28</b>

**List of tables**

Table 1 - Indicative investment cost for video / thermo cameras .....	10
Table 2- Indicative investment costs for wildfire sensors system.....	12
Table 3 - Technical characteristics of the drone .....	15
Table 4 - Economic indicators .....	21
Table 5 - Main characteristics of each system.....	22
Table 6 - Comparison matrix between the systems .....	23

**List of figures**

*Figure 1 – Custom mast in Portugal*.....6

*Figure 2 – Automatic detection of smoke* .....7

*Figure 3 – Technical specifications of the camera*.....8

*Figure 4 – Potential location of a 6-meter mast for fire surveillance* ..... 10

*Figure 5 – Wireless sensor* ..... 11

*Figure 6 - UAV Galka, for aerial reconnaissance* ..... 14

*Figure 7 - Drone JOUAV CW-15* ..... 16

*Figure 8 - Drone E455*..... 16

## 1. General Context

This report is part of the deliverables of the contract for the provision of services no. UNEP/2022/177 (Umoja # 4700023379) concluded between The United Nations and International Business and Economic Development Center (IBEDC).

The aim of the contract is to provide technical assistance in order to benchmark, select, design, and test a suitable integrated monitoring and early warning forest fire detection system in Borjomi - Kharagauli National Park. The beneficiary of the contract outputs is the National Agency for Protected Areas in Georgia.

The objective of this deliverable is to present a comparison between the most representative forest fires detection systems that can detect or monitor active fire or smoke incidents in real / near-real-time and to analyze the potential use of each system in the context of the Borjomi-Kharagauli National Park. An estimation of the costs of implementation and maintenance of each system is done in order to support the prioritization process. The results are summarized in a matrix in order to determine the most suitable method(s) for the use in Borjomi - Kharagauli National Park.

The protected territory of Borjomi - Kharagauli is in a central part of the Caucasian throat and includes eastern part of the Lesser Caucasus mountains. It spans over an area of 107 000 ha with a total length of 95 km from west to east and a width between 3 and 26 km. Borjomi-Kharagauli National Park and Borjomi State Nature Reserve are bordered by the Mtkvari river and Tbilisi-Akhaltzikhe motorway and railway from the south-east to the north. To the north, the protected area extends over the Achara - Imereti Ridge and, from east to west, the River Tskaltsiteli Valley borders the park to the distance of 30 km. Nedzvi Managed Reserve is located on the right bank of the river Mtkvari, at the south-east border of the Borjomi-Kharagauli National Park.

The problem the project aims to address is reducing the danger of uncontrolled forest fires upon the ecosystem of the protected target area.

## 2. Methodology

The technical experts involved in the contract performed a desk review of existing international and national data regarding different systems aimed at early detection of forest fires, comparing their benefits and their failures, their opportunities and limitations with regard to the target area of the project. As part of the diagnostic, a financial analysis, including CAPEX and OPEX costs was conducted by the financial expert.

### **3. Presentation of the existing integrated monitoring and early warning forest fires and smoke detection systems – technical considerations**

Forest fires pose a significant threat to ecosystems, human life, and property. To mitigate these risks, it is crucial to detect and respond to forest fires at the earliest possible stage. An integrated monitoring and early warning system leverage multiple technologies to provide comprehensive surveillance and rapid response capabilities.

Depending on the acquisition level, there are three broad categories of widely used systems that can detect or monitor active fire or smoke incidents in real/near-real-time, namely terrestrial, aerial, and satellite.

This case study explores the components and effectiveness of such a system, focusing on video/thermal cameras, wireless sensor networks, surveillance drones, satellite imaging, LIDAR/laser systems, and spectroscopy.

All of the above technologies have its own advantages and usage scenarios. Let's consider them:

#### **3.1. Video / Thermo Cameras**

Video and thermal cameras are essential for real-time monitoring and early detection of forest fires and smoke. Video cameras capture visible light images, which help in visual surveillance and documentation. Thermal cameras, on the other hand, detect heat signatures, allowing the identification of hot spots and flames, even through smoke or in low-light conditions.

In order to increase overall effectiveness of such a system i.e., to provide full visibility from different camera locations and cover maximum target area, camera locations are pinpointed on the map using GIS system. Accordingly, video cameras are installed at the selected locations, with uninterrupted power supply and internet connection. Existing internet / mobile provider masts or other public buildings can be used for the installation of video cameras. On the other hand, custom masts can be built as in the example bellow (Figure 1 - Portugal). The mast is equipped with a set of video cameras, solar panels and protected closet for equipment.



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*Figure 1 – Custom mast in Portugal*

Video stream from cameras is fed to the central processing center. By use of AI system, streams are processed for smoke/fire identification/detection. By use of GIS system identified cases are pinpointed on the map. Figure 2 depicts automatic detection of smoke. Distance from camera 5 km. During the testing, camera was mounted on the providers mast located on the territory of Abastumani Observatory.

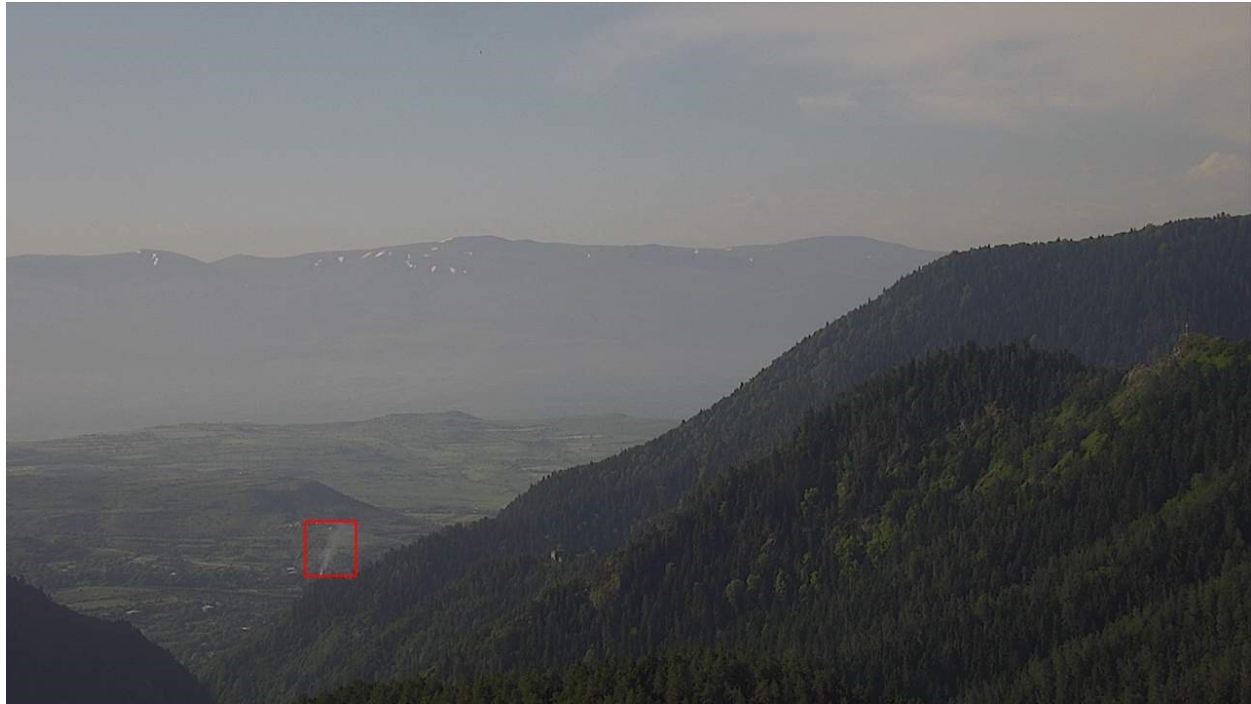
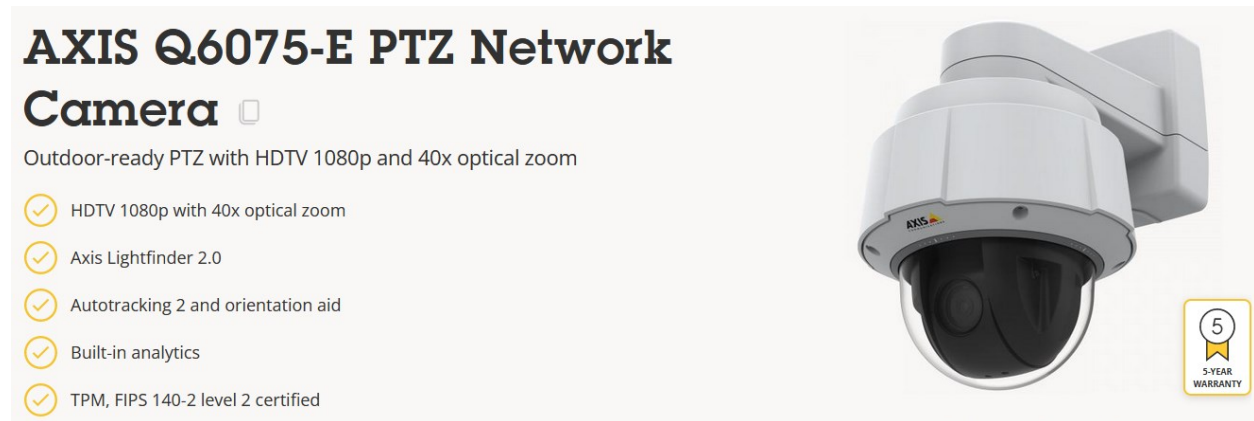


Figure 2 – Automatic detection of smoke

AXIS Q6075-E PTZ Network Camera is used in this case. Technical specification of the camera can be found: <https://www.axis.com/products/axis-q6075-e#technical-specifications> .



*Figure 3 – Technical specifications of the camera*

This video camera comes with an uninterruptable power supply and internet connection, which sends the video image in real time to the central control system.

Operator has a full control over video camera through the central stations console:

- Enable the cameras automated patrolling mode (360 degrees);
- Viewing objects / area zoom;
- Automatic determination of the distance from the camera to the object.

The centralized management system is a software complex. Main functionality of management system is a web portrait where responsible users have access with pre-defined rights. An example of the interface is presented in *Figure 2*.

The system is built on GIS.

Various agencies have access to real-time information and process management. Rangers and other responsible personnel have the ability to get a video and photo image online.

It provides:

- Automatic detection of smoke and fire;
- Incident fixation and subsequent response;
- Sending automatic notifications;

- Analytics and statistics.

Notifications will be sent to the responsible personnel through the management system and the process of liquidation of smoke/fire is carried out.

The centralized management system should have the possibility to integrate with third-party systems to improve the accuracy of smoke detection and locations:

- ✓ Various meteorological systems to obtain data on temperature, humidity, and wind direction.
- ✓ Wireless Sensor Management systems.
- ✓ Drone Management systems.

The fire and smoke detection system through video cameras has following advantage over other systems:

- Less dependent on climatic conditions;
- Detection and management are carried out in real time;
- It is possible to produce video/photo history of the forest;
- Technology is well known, the hardware complex is widespread, it is possible to use cameras from different manufactures, therefore the system service is simplified and it is possible to get the optimal price;
- The system is highly scalable;

Last but not least, it is easy to get staff, system operators, administrators.

The full cost of monitoring the selected location with video cameras directly depends on the number of cameras and therefore the masts.

For the scope of the analysis, a potential location was selected together with the contract Beneficiary, i.e. the Agency for Protected Areas, on the following coordinates in Abastumani:

- ✓ Latitude 41.8230806;
- ✓ Longitude 42.8486678;

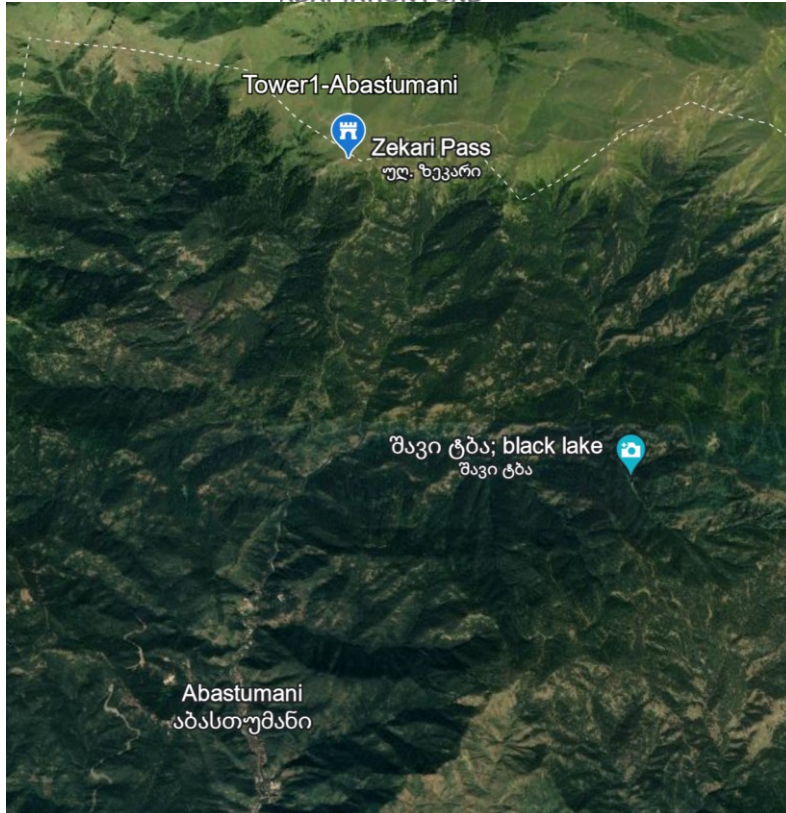


Figure 4 – Potential location of a 6-meter mast for fire surveillance

The mast is equipped with a solar panel, secure cabinet, network equipment and an Internet connection. Subsequent costs are presented in the **Error! Reference source not found.**:

Table 1<sup>1</sup>Indicative investment cost for video / thermo cameras

Tower and equipment	
Tower's construction and installation in the selected area. Lightning rod and fence arrangement around tower	\$ 20,000.00
Secure cabinet for power, network equipment.	\$ 10,000.00
Installation of the solar panels and power management system	\$ 10,000.00
Video camera, installation and configuration	\$ 10,000.00

<sup>1</sup> General estimate in Annex 1



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<b>SUM, tower and equipment</b>	<b>\$ 50,000.00</b>
<b>Software, Central Management System</b>	<b>\$ 100,000.00</b>
<b>Total cost, Tower and Management system</b>	<b>\$ 150,000.00</b>

### 3.2. Wireless Sensor Networks

A Wireless Sensor (Figure 5) is designed to detect forest fires during the early stages (even during the smoldering phase, within the first 60 minutes) and to monitor the microclimate, measuring temperature, humidity and air pressure.

Figure 5 – Wireless sensor



The sensor combines ultra-low-power Air Quality sensing with a precise gas sensing mode. It detects Hydrogen, Carbon Monoxide and Carbon Dioxide and other gases at the ppm level with built-in artificial intelligence in order to reliably detect a fire and avoid false positives.

The sensor uses LoRaWAN communications for wireless data transmission and can run maintenance - free for several years without the need of batteries. Harsh environmental conditions, such as extreme temperatures, humidity, and exposure to the elements, can reduce the lifespan of sensors and their power sources. In practice, battery-powered wireless smoke detection sensors in forests typically last between 1 to 5 years before requiring battery replacement. Solar-powered sensors, if well-maintained, can operate for much longer periods, potentially over a decade.

However, "maintenance-free" doesn't necessarily mean never checking the sensor. While some sensors might not need battery replacements for their lifespan, it's still recommended to:

- Periodically check for functionality through remote monitoring or on-site inspection.
- Ensure the sensor hasn't been damaged by weather, animals, or other factors.

It's important to note that the actual number of sensors needed may vary depending on several factors, including the specific sensor's range, the topography of the mountain region, and the desired level of forest coverage. It should be noted that in the mountainous region there are many inaccessible places where it will be impossible to install and further service sensors. Average a sensor can cover a radius of 30 meters, which means that in order to cover the territory of one hectare, an average of 4 - 5 sensors are required.

The LoRaWAN communication network and its connection to the Internet network has to be built as well. According to technical documentation, one LoRaWAN Gateway can support up to 100 sensors, but the actual number of LoRaWAN Gateway and sensors depends on the geography of a particular area.

For the time being, it is practically impossible to determine the detailed budget of the monitoring area, but it is possible, for example, to calculate the necessary equipment for 170 hectares (which is covered by two video cameras), see **Error! Reference source not found.:**

*Table 2<sup>2</sup>- Indicative investment costs for wildfire sensors system*

<b>N</b>	<b>Description</b>	<b>Price, USD</b>
1	Wireless Sensors, 900 pieces	\$225,000.00
2	LoraWAN gateway 50 pieces	\$ 17,500.00

The cost of Internet hardware and installation works is not included.

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<sup>2</sup> General estimate in Annex 1

### 3.3. Surveillance drones

Currently, the Emergency Situation Management Agency has several DJI drones. These drones are used for short range area surveillance and are not used for fire and smoke detection.

In order to monitor forest arrays in the mountainous region industrial, long-distance FPV (First Person View) and non-FPV drones are required. Drones equipped with autopilot functions are increasingly used in various surveillance and monitoring applications, including in forest smoke and/or fire detection. These professional grade drones will provide:

- Real-Time Monitoring - drones provide real-time video feeds to operators, allowing them to see exactly what the drone sees. This live video feed can be crucial for detecting smoke or fire in remote forest areas;
- Autopilot Capabilities - Autopilot functions enable drones to fly predefined routes autonomously, covering large areas efficiently without constant manual control. This feature is particularly useful for extended surveillance missions;
- Precision and Stability - Autopilot systems enhance flight stability and precision, ensuring smoother and more reliable operation in challenging environments like mountainous regions;
- Improved Situational Awareness - Operators can focus on analyzing video footage and making decisions rather than continuously piloting the drone, which can lead to quicker detection and response to fire incidents;
- Flexibility and Versatility - FPV drones can be equipped with a variety of sensors (such as thermal imaging cameras) to enhance their ability to detect heat signatures associated with fires, even at night or in dense forest area;
- Reduced Risk to Personnel - By keeping operators at a safe distance, FPV drones mitigate risks associated with traditional methods of fire detection and monitoring, especially in hazardous conditions.

It is necessary to take into account that drones have following limitations:

- Complexity of Operations - Operating FPV/non-FPV drones with autopilot requires skilled personnel trained in both drone piloting and mission planning. The complexity

increases when integrating various sensors and analyzing data in real-time. Training such staff takes a lot of time and financial resources.

At present, there are no drone operator training centers in Georgia and therefore there is no professional staff. Warranty services and repair of such types of drones should also be taken into account, and today there are no relevant technical bases in Georgia.

- Regulatory Compliance - Operating FPV/non-FPV drones, especially in forested or mountainous areas, requires compliance with airspace regulations and obtaining necessary permissions. This regulatory landscape can be challenging and may restrict operational flexibility.

- Weather Sensitivity - Drones, like other UAVs, are sensitive to weather conditions such as high winds, rain, or fog, which can affect flight stability and compromise surveillance effectiveness. The mountain region is particularly problematic in this regard, where wind gusts and weather conditions are rapidly changing.

In conclusion, FPV drones with autopilot functions offer significant advantages for surveillance and monitoring tasks, including forest fire detection in mountainous regions. However, they also present challenges related to endurance, operational complexity, regulatory compliance, and environmental factors that need to be carefully managed to maximize their effectiveness in fire prevention and response efforts.

The models and prices of these drones differ from each other and depend on what equipment, video/thermo cameras are equipped. An example of one of the models is presented below with the price range is \$ 15.000 - \$ 150.000.<sup>3</sup>

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<sup>3</sup> A general estimate is included in Annex 1



Figure 6 - UAV Galka, for aerial reconnaissance

Table 3 - Technical characteristics of the drone

Dimensions	1600 mm / 730 mm
Takeoff weight	3,7 kg
Cruising speed	60 km/h
Flight duration	120+ mins
Telemetric and video signal range	45 km
Launching	Automatic, by means of a Bungee cord
Landing	Automatic, aircraft-like
Navigation system	GPS, autopilot with inertial system
Power unit	Brushless electromotor
Airframe material	EPP, carbon frame, composite
Power supply system	Lithium-ion batteries with a capacity up to 30000 mAh
Climate conditions	All-weather



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Detail specification

<https://warbirds.com.ua/en/product/galka/>



*Figure 7 - Drone JOUAV CW-15*

JOUAV CW-15 long-endurance full electric vertical take-off and landing fixed-wing UAV system, which brings the disruptive technology innovation in the UAV industry in flight safety, avionics system, overall machine performance, and operation experience.

For detail specification see this link: <https://www.jouav.com/products/cw-15.html>

Drone E455, is a fully autonomous fixed-wing VTOL drone with multiple power configurations and a heavier payload. For detail specification see this link: [Drone E455](#)



Figure 8 - Drone E455

### 3.4. Satellite system

Satellite systems for detecting smoke or fire in forest areas utilize advanced technology to monitor large swaths of land from space. These systems typically employ satellite imagery coupled with specialized algorithms to identify heat signatures, smoke plumes, or changes in vegetation indicative of fires. There are two primary types of satellite systems used for this purpose:

- Optical Satellites - optical satellites capture visible and infrared light reflected or emitted from Earth's surface. They can detect smoke and fire based on the distinct thermal signatures produced by burning vegetation or biomass. These satellites provide high-resolution imagery that enables precise identification and monitoring of fire incidents;
- Synthetic Aperture Radar (SAR) Satellites - SAR satellites use microwave radar signals to create images of the Earth's surface, independent of weather conditions and daylight. SAR can penetrate clouds and smoke, allowing for continuous monitoring even in adverse weather or nighttime conditions. SAR imagery can detect changes in forest structure or terrain caused by fires, aiding in fire progression mapping and damage assessment.

**Advantages of satellite systems** include their wide coverage area, ability to monitor remote and inaccessible regions, and capability for near-real-time data acquisition. They provide crucial information for fire detection, rapid response coordination, and post-fire assessment.

**Challenges** include the need for specialized data processing and interpretation, as well as data available only if satellite is above the area (a few times per day) and occasional limitations due to cloud cover or atmospheric conditions affecting image clarity. Also, we

should also consider the cost and accessibility, the initial cost of satellite imagery and data acquisition can be high, especially for high-resolution data, making it challenging for some regions or organizations to afford continuous monitoring.

### 3.5. LIDAR/ Laser Systems

LIDAR (Light Detection and Ranging) and laser systems are advanced technologies used to detect smoke and fire in forest areas. Here's an overview of how they work:

#### 3.5.1. LIDAR Systems

Principle of Operation:

**Emission:** LIDAR systems emit laser pulses into the environment. These pulses are usually in the near-infrared or ultraviolet range.

**Reflection:** The laser pulses travel through the air and reflect off various objects, including particles in smoke or fire.

**Detection:** The reflected pulses are detected by sensors, which measure the time it takes for the pulses to return (time of flight). This information is used to calculate distances and create detailed 3D maps of the environment.

Smoke Detection:

**Particle Interaction:** When LIDAR pulses encounter smoke particles, they scatter and reflect differently compared to clear air. This scattering is detected by the LIDAR system.

**Density Measurement:** By analyzing the intensity and pattern of the scattered light, the system can determine the density and presence of smoke particles.

Fire Detection:

**Heat and Flame Detection:** LIDAR can also detect the heat and flames associated with a fire. The intense heat and combustion gases cause changes in the air's refractive index, which can be detected by LIDAR.

**Spectral Analysis:** Some LIDAR systems use multi-wavelength lasers to perform spectral analysis, identifying the specific wavelengths associated with flames and hot gases.

**Data Processing:**

**Real-time Monitoring:** The data collected by the LIDAR system is processed in real-time to identify and locate smoke and fire. This involves complex algorithms and pattern recognition techniques.

**Mapping and Alerting:** The system creates detailed maps showing the location and spread of smoke and fire, and can generate alerts to notify authorities and firefighting teams.

### 3.5.2. Laser Systems

**Principle of Operation:**

**Laser Beams:** Similar to LIDAR, laser systems use focused beams of light. These can be continuous or pulsed lasers.

**Absorption and Scattering:** The lasers interact with particles in the air. Smoke particles and combustion gases absorb and scatter the laser light in specific ways.

**Detection Mechanisms:**

**Smoke Particles:** Laser systems can detect the scattering of light caused by smoke particles. The amount and pattern of scattered light indicate the presence and concentration of smoke.

**Gas Analysis:** Certain laser systems are designed to detect specific gases produced by combustion (such as CO<sub>2</sub> and CO) by measuring their absorption spectra.

**Advanced Techniques:**

- **Differential Absorption LIDAR (DIAL):** This technique uses two different laser wavelengths to measure the concentration of gases like CO<sub>2</sub> and water vapor, which are indicators of fire.
- **Laser-induced Fluorescence (LIF):** Some systems use lasers to excite molecules in the smoke, causing them to emit light (fluoresce). This fluorescence can be detected and analyzed to identify specific substances in the smoke.

**Applications:**

**Early Detection:** These systems are highly sensitive and can detect smoke and fire at early stages, even in low concentrations.

**Monitoring and Surveillance:** They are often used for continuous monitoring of large forest areas, providing real-time data and early warning of potential fires.

### **Advantages of LIDAR/Laser Systems**

- **High Sensitivity:** Capable of detecting low concentrations of smoke and early-stage fires.
- **Real-time Monitoring:** Provides continuous, real-time data for quick response.
- **Accurate Mapping:** Generates detailed 3D maps of the forest area, helping in pinpointing the exact location of smoke and fire.
- **Remote Sensing:** Can cover large areas and difficult-to-access regions without the need for ground-based sensors.

### **Challenges**

- **Cost:** These systems can be expensive to install and maintain.
- **Environmental Factors:** Weather conditions like fog, rain, or heavy smoke can affect the accuracy of LIDAR and laser systems.
- **Technical Complexity:** Requires sophisticated technology and expertise to operate and interpret the data.

Overall, LIDAR and laser systems are powerful tools for detecting and monitoring smoke and fire in forest areas, providing critical information for early intervention and firefighting efforts, but currently the technology is still in an experimental phase. There is no established and widespread production of this equipment.

### **3.6. Spectroscopy**

Spectroscopy is a powerful technique for detecting smoke and fire in forest areas by analyzing the light and other electromagnetic radiation emitted, absorbed, or scattered by materials.

**Spectroscopy:**

- can detect the presence of combustion gases and smoke particles at very low concentrations, enabling early detection of fires;

- provide real-time data, allowing for rapid response to potential fires;
- can determine the chemical composition of smoke and gases, providing information about the type of fire and the materials burning;
- Infrared spectroscopy can help estimate the temperature of the fire, which is crucial for assessing its intensity and potential spread;
- can be used to monitor air quality in forested areas, detecting pollutants and hazardous gases produced by fires.

The technology is difficult to be implemented in the target area spectroscopic instruments require regular calibration and maintenance to ensure accurate measurements. Analyzing spectroscopic data can be complex and requires specialized knowledge.

The effectiveness of the technology depends on the weather. Rain, fog, and other weather conditions can affect the accuracy of spectroscopic measurements. Natural sources of infrared and ultraviolet radiation can create background noise that interferes with the detection of smoke and fire.

Overall, spectroscopy is a highly effective method for detecting smoke and fire in forest areas, offering precise, real-time information. But to this day, this technology is expensive, difficult to implement in a real-life environment. For proper operation solution requires specialized knowledge and appropriate qualifications staff.

### 3. Economic analysis regarding three main options suitable for the target area

Based on the availability of data, three scenarios were compared in more detailed financial terms, i.e. Wireless sensors networks (wild fire sensors), Video / Thermo Cameras and surveillance drones system.

The economic analysis of the three scenarios is based on the assumptions presented in Annex 3 and using the data in Annexes 1 and 2 for the estimate of investment and running costs.

*Table 4 - Economic indicators*

		<b>Scenarios</b>
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		Wildfire Sensors	Video / Thermo Cameras	Surveillance drones
Investment	('000) \$	460	212	550
Total running costs	('000) \$	9.53	9.53	20.91
Internal rate of economic return on investment (ERR)	%	24.39%	25.07%	24.05%
Expected net present value (ENPV)	('000) \$	37074.07	37352.93	36843.03
Benefit - cost ratio (BCR)		1.88	1.89	1.87
Update factor	3%	3%	3%	3%
Reference period	years	20	20	20
Expected external benefits	('000) \$	10105.94	10105.94	10105.94
Discounted future earnings	('000) \$	69129.65	69129.65	69129.65
Expected external costs	('000) \$	41656.93	41656.93	41656.93
Expected total costs	('000) \$	504.60	225.73	735.64

Based on the economic analysis, the best value of main indicators, i.e. Expected net present value (ENPV) and Internal rate of economic return on investment (ERR) belongs to the Video / Thermo Cameras scenario.

#### 4. Matrixes to support the decision – making process

The following table compares the main pluses and minuses of each of the above - mentioned systems taking into account the constraints of the target area:

Table 5 - Main characteristics of each system

Assessment factor	Video / thermo cameras	Wireless sensor networks	Surveillance drones	LIDAR/ laser system	Sattelite system	Spectroscopy
Investment	low	low	medium	mediu	Very high cost of high – resolution data	high
Operational costs	Low	Low	Expensive	Expensive	N/A	Expensive



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<b>Labour force</b>	Monitoring operators	Monitoring operators	Skilled operators for surveillance	Specialized staff for data processing and interpretation	Specialized staff for data processing and interpretation	Specialized staff for data processing and interpretation
<b>Monitoring and maintenance</b>	Low	Low	Expensive	Expensive	N/A	Expensive
<b>Availability of service facilities in the area</b>	Widely available	N/A	Scarce	Scarce	N/A	Absent in Georgia
<b>Resilience to harsh weather conditions</b>	Less dependent on climatic conditions	Harsh environmental conditions reduce life span	Sensitive to weather conditions which can affect stability and effectiveness of surveillance	Weather conditions affect accuracy	Occasional limitations due to cloud cover or atmospheric conditions affecting image clarity	Weather conditions affect accuracy
<b>Other aspects</b>	(+) Best values for the economic indicators	(-) Very big number of sensors to cover large areas	(-) Need of compliance with regulatory framework	(+) Accurate mapping	(+) Ability to cover very large areas	(-) Spectroscopic instruments require regular calibration and maintenance to ensure accurate measurements

Table 6 - Comparison matrix between the systems

Performance factor	Video / thermo cameras	Wireless sensor networks	Surveillance drones	LIDAR/ laser system	Sattelite system	Spectroscopy
<b>Level of investment and operational costs</b>	Low	Low	Medium	High	Very High	High
<b>Availability of infrastructure components and maintainance</b>	High	Medium	Medium	Low	Low	Low
<b>Availability of labour force</b>	High	Medium	Low	Low	Low	Low



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<b>Sensitivity to weather conditons in the target area</b>	Low	Medium	High	Medium	Medium	Medium
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The above matrixes aims to provide a foundation for and informed decision-making process, encouraging the adoption of the most effective early detection of forest fire system under the specific circumstances of the Borjomi - Kharagauli National Park.

## ANNEXES

### ANNEX 1 – General estimate for the main three options

#### Video / Thermo cameras

<b>Abstract for the General Estimate</b>						
In GEL at the official exchange rate		<b>2.73</b>				<b>14/07/2024</b>
No.	Category of costs	Value without VAT	VAT	Total Value with VAT	Value without VAT	Total Value with VAT
		GEL	GEL	GEL	USD	USD
1	2	3	5	6	6	7
<b>CHAPTER 1: Costs of land and site preparation works</b>						
<b>TOTAL Chapter 1</b>		<b>5,460.00</b>	<b>982.80</b>	<b>6,642.80</b>	<b>2,000.00</b>	<b>2,360.00</b>
<b>CHAPTER 2: Cost of utilities (electric energy supply basically)</b>						
<b>TOTAL Chapter 2</b>		<b>27,300.00</b>	<b>4,914.00</b>	<b>32,214.00</b>	<b>10,000.00</b>	<b>11,800.00</b>
<b>CHAPTER 3: Cost of planning</b>						
<b>TOTAL Chapter 3</b>		<b>2,730.00</b>	<b>491.40</b>	<b>3,221.40</b>	<b>1,000.00</b>	<b>1,180.00</b>
<b>CHAPTER 4: Cost of main investment (hardware and software)</b>						

<b>TOTAL Chapter 4</b>	<b>382,200.00</b>	<b>68,796.00</b>	<b>450,996.00</b>	<b>140,000.00</b>	<b>165,200.00</b>
<b>CHAPTER 5: Other costs if the case</b>					
<b>TOTAL Chapter 5</b>	<b>106,470.00</b>	<b>19,164.60</b>	<b>125,634.60</b>	<b>39,000.00</b>	<b>46,020.00</b>
<b>CHAPTER 6: Cost of testing</b>					
<b>TOTAL Chapter 6</b>	<b>54,600.00</b>	<b>9,828.00</b>	<b>64,428.00</b>	<b>20,000.00</b>	<b>23,600.00</b>
<b>TOTAL GENERAL</b>	<b>578,760.00</b>	<b>104,176.80</b>	<b>682,936.80</b>	<b>212,000.00</b>	<b>250,160.00</b>

1. **CHAPTER 1: Costs of land and site preparation works - conducting geological surveys, examining the soil at the mast installation site and creating the documents of a mast architectural structure**
2. **CHAPTER 2: Cost of utilities (electric energy supply basically) - planning and installation of an electrical power system based on solar panels**
3. **CHAPTER 3: Cost of planning - selection of optimal locations for installing towers and video cameras**
4. **CHAPTER 4: Cost of main investment (hardware and software) - included:**
  - a. **Tower's construction (with Lightning rod) and installation in the selected area.**
  - b. **Secure cabinet for power, network equipment.**
  - c. **Network equipment's and internet connection**
  - d. **Video camera, installation and configuration**
5. **CHAPTER 5: Other costs if the case - Yearly support of the system, including internet connection cost.**
6. **CHAPTER 6: Cost of testing - included staff training and system testing**

## Wildfire Sensors

<b>Abstract for the General Estimate</b>						
In GEL at the official exchange rate		<b>2.73</b>				<b>14/07/2024</b>
No.	Categories of costs	Value without VAT	VAT	Total Value with VAT	Value without VAT	Total Value with VAT
		GEL	GEL	GEL	USD	USD
1	2	3	5	6	6	7
<b>CHAPTER 1: Costs of land and site preparation works</b>						

TOTAL Chapter 1	13,650.00	2,457.00	16,107.00	5,000.00	5,900.00
<b>CHAPTER 2: Cost of utilities (LoRaWan and GSM Network)</b>					
TOTAL Chapter 2	54,600.00	9,828.00	64,428.00	20,000.00	23,600.00
<b>CHAPTER 3: Cost of planning</b>					
TOTAL Chapter 3	13,650.00	2,457.00	16,107.00	5,000.00	5,900.00
<b>CHAPTER 4: Cost of main investment (hardware and software)</b>					
TOTAL Chapter 4	955,500.00	171,990.00	1,174,690.00	350,000.00	413,000.00
<b>CHAPTER 5: Other costs if the case</b>					
TOTAL Chapter 5	163,800.00	29,484.00	193,284.00	60,000.00	70,800.00
<b>CHAPTER 6: Cost of testing</b>					
TOTAL Chapter 6	54,600.00	9,828.00	64,428.00	20,000.00	23,600.00
<b>TOTAL GENERAL</b>	<b>1,255,800.00</b>	<b>226,044.00</b>	<b>1,481,844.00</b>	<b>460,000.00</b>	<b>542,800.00</b>

1. CHAPTER 1: Costs of land and site preparation works - Preparing sites for installation of critical equipment
2. CHAPTER 2: Cost of utilities - Strengthening Internet provider coverage areas and installing appropriate equipment
3. CHAPTER 3: Cost of planning - Planning coverage areas and sensor installation locations
4. CHAPTER 4: Cost of main investment (hardware and software) - included:
  - a. Wildfire sensors – 1000 sensors
  - b. Mesh gateway for sensors to implement LoraWan network
  - c. Border gateway – connection to Internet
  - d. Management system – cloud - based system
5. CHAPTER 5: Other costs if the case - Yearly support of the system, including internet connection cost.
6. CHAPTER 6: Cost of testing - included staff training and system testing

### Surveillance drones

<b>Abstract for the General Estimate</b>	
In GEL at the official exchange rate	<b>2.73</b>
	<b>14/07/2024</b>

No.	Categories of costs	Value without VAT	VAT	Total Value with VAT	Value without VAT	Total Value with VAT
		GEL	GEL	GEL	USD	USD
1	2	3	5	6	6	7
<b>CHAPTER 1: Costs of land and site preparation works</b>						
<b>TOTAL Chapter 1</b>		<b>163,800.00</b>	<b>29,484.00</b>	<b>193,284.00</b>	<b>60,000.00</b>	<b>70,800.00</b>
<b>CHAPTER 2: Cost of utilities (GSM Network and communication)</b>						
<b>TOTAL Chapter 2</b>		<b>81,900.00</b>	<b>14,742.00</b>	<b>96,642.00</b>	<b>30,000.00</b>	<b>35,400.00</b>
<b>CHAPTER 3: Cost of planning</b>						
<b>TOTAL Chapter 3</b>		<b>54,600.00</b>	<b>9,828.00</b>	<b>64,428.00</b>	<b>20,000.00</b>	<b>23,600.00</b>
<b>CHAPTER 4: Cost of main investment (hardware and software)</b>						
<b>TOTAL Chapter 4</b>		<b>655,200.00</b>	<b>117,936.00</b>	<b>773,136.00</b>	<b>240,000.00</b>	<b>283,200.00</b>
<b>CHAPTER 5: Other costs if the case</b>						
<b>TOTAL Chapter 5</b>		<b>409,500.00</b>	<b>73,710.00</b>	<b>483,210.00</b>	<b>150,000.00</b>	<b>177,000.00</b>
<b>CHAPTER 6: Cost of testing</b>						
<b>TOTAL Chapter 6</b>		<b>136,500.00</b>	<b>24,570.00</b>	<b>161,070.00</b>	<b>50,000.00</b>	<b>59,000.00</b>
<b>TOTAL GENERAL</b>		<b>1,501,500.00</b>	<b>270,270.00</b>	<b>1,771,770.00</b>	<b>550,000.00</b>	<b>649,000.00</b>

7. **CHAPTER 1: Costs of land and site preparation works - Preparing an office for storage and technical support of drones**
8. **CHAPTER 2: Cost of utilities (GSM Network and communication ) - Strengthening mobile Internet coverage of relevant monitoring areas**
9. **CHAPTER 3: Cost of planning - Planning the schedule and flight zones of drones and coordinating flights with the Aviation Agency**
10. **CHAPTER 4: Cost of main investment (hardware and software) - included:**
  - a. **Industrial surveillance drones – 4 drones**
  - b. **drone control system**
  - c. **component materials**
11. **CHAPTER 5: Other costs if the case - Yearly support of the system.**
12. **CHAPTER 6: Cost of testing - included staff training and system testing**

## ANNEX 2 – Estimate of running costs



ADAPTATION FUND



CTCN

CLIMATE TECHNOLOGY CENTRE &amp; NETWORK

<b>Video / Thermo cameras</b>	<b>Price, USD, without VAT</b>	<b>Price with VAT</b>
<b>Outsource company (Monthly Maintenance Costs)</b>	\$ <b>3,600.00</b>	\$ <b>4,248.00</b>
Monthly pay/support of the mast	\$ 500.00	\$ 590.00
Internet cost, monthly	\$ 550.00	\$ 649.00
Central management System, monthly support	\$ 2,000.00	\$ 2,360.00
Solar panel system support	\$ 550.00	\$ 649.00
<b>In house, Agency staff salary</b>		
System operators, 2 persons	\$ <b>3,903.00</b>	\$ <b>4,605.54</b>

<b>Wildfire Sensors</b>	<b>Price, USD, without VAT</b>	<b>Price with VAT</b>
<b>Outsource company (Monthly Maintenance Cost)</b>	\$ <b>5,630.00</b>	\$ <b>6,643.40</b>
System on-site support	\$ 3,750.00	\$ 4,425.00
Internet cost, monthly	\$ 380.00	\$ 448.40
Cloud service cost, monthly	\$ 1,500.00	\$ 1,770.00
<b>In house, Agency staff salary</b>		
System operators, 2 persons	\$ <b>3,903.00</b>	\$ <b>4,605.54</b>

<b>Drones</b>	<b>Price, USD, without VAT</b>	<b>Price with VAT</b>
<b>Outsource company (Maintenance costs)</b>	\$ <b>15,709.00</b>	\$ <b>18,536.62</b>
System on-site support	\$ 11,709.00	\$ 13,816.62
Equipments, drones support	\$ 4,000.00	\$ 4,720.00
<b>In house, Agency staff salary</b>		
System operators, 2 persons	\$ <b>5,204.00</b>	\$ <b>6,140.72</b>

### ANNEX 3 – Use of land in the target area

#### 1. Water bodies

Out of which:

- construction of artificial basins for drinking water reserves
- construction of artificial basins for water reserves used for industrial activities, energy production, leisure, fishing

## 2. Land and built areas

Out of which

- special constructions for urban waste management
- recreational areas arranged for tourism
- extraction of ballast materials
- administrative lands

## 3. Roads

## 4. Electricity supply lines

## 5. Other types of utilities supplies

## 6. Forest

Out of which

- Forest for logging
- Forest affected by poaching
- 7. wooded pasture
- 8. Permanent pasture
- 9. Agriculture land
- 10. Barren land
- 11. Land for game feed
- 12. Forest vegetation, underwood

## 13. LAND OWNERS

- Public property
- Physical persons
- Legal entities
- Georgian State
- Property under litigation (disputed land)

## 14. LAND ADMINISTRATORS

- Associations
- Local authorities
- Physical persons
- Legal entities
- Forest Administration
- Property under litigation (disputed land)

#### 15. Pastures and grassland areas – hectares

- Number of large cattle units
- Cattle Animal Units (AU) / ha
- Income from milk production – ('000) USD/year
- Income from meat production - ('000) USD/year
- Value of forage yield on a short term - ('000) USD/year

#### 16. Companies according to field of activity

- Commerce
- Tourism
- Agrotourism
- Leisure facilities
- Restaurants
- Light industries
- Food processing
- Logging
- Wood processing
- Building and services
- Mining
- Process industries
- Agriculture
- Other

#### 17. Tourist accommodation units

- Existing accommodation capacity
- Functional accommodation capacity / year
- Arrivals of tourists in tourism facilities
- Overnight stays in tourism facilities

Comparative data were used to analyze the use of land and the economic importance of activities, and the trends of the identified economic activities.

#### 18. Water resources

- Cost of water treatment for the public water supply system – ('000) USD
- Cost of treatment for bottled water - ('000) USD
- The estimate value of economy due to supply of fresh water

The protected area ecosystems in the target region provide a number of important regulatory services, including preventing soil erosion and regulating water flow and quality.

19. Cost of treatment for drinking water delivered in the public water supply system

- Specific energy consumption to provide 1,000 cubic meters of drinking water

Quantity of treated water for the public water supply system

Out of which :

- households

- public organizations and companies (excepting the water providers)

Cost of electric energy at the final user – USD

Cost of energy for water treatment

Percentage of costs for water treatment at the level of the water supplier

Value of energy for water treatment

Percentage of the target area as compared to the whole area that provides water for the public water supply system

20. Cost of treatment for bottled water

Quantity of water and water- based beverages bottled in the area

Specific energy consumption to provide 1,000 cubic meters of bottled water

Cost of electric energy at the final user – USD

Cost of energy for water treatment

Percentage of costs for water treatment at the level of the water supplier

Value of energy for water treatment

Percentage of the target area as compared to the whole area that provides water for bottling

By comparison to similar sites, the identified data support the estimation of energy consumption reduction for water treatment as a result of regulating water flow and water quality.