Implementation of integrated monitoring and early warning forest fire detection system

For the Borjomi-Kharagauli National Park

Activity 4.1. Define a draft standard operation procedure (SOP) for efficient use of the designed integrated monitoring and early warning forest fires detection system.

Contents

1. Scope and purpose

This Standard Operating Procedure (SOP) establishes procedures for the effective operation and management of the Integrated Monitoring and Early Warning Forest Fires Detection System implemented in the Borjomi-Kharagauli National Park. This document provides comprehensive instructions for system administrators, operators, and end-users to ensure optimal utilization of the system's capabilities for early fire detection, monitoring, and response.

This SOP framework provides a solid foundation that can be tailored to the specific terrain, infrastructure, visitor patterns, and administrative structure of the Borjomi-Kharagauli National Park and all other forest ecosystems of Georgia.

2. Definition of the component/systems

The Integrated Monitoring and Early Warning Forest Fires Detection System is a comprehensive solution designed to enhance early detection capabilities, provide real-time monitoring, and facilitate quick response to potential fire incidents within the Borjomi-Kharagauli National Park. The system utilizes remote sensing technologies, video surveillance, and artificial intelligence to detect and verify potential fire events.

The system enhances early detection capabilities, provides real-time monitoring, and facilitates quick response to potential fire incidents. The system will be installed on the Customer's local server and will provide secure access to authorized users through a web interface.

The system will consist of the following main components:

1. Data Acquisition Layer.
2. Processing and Analysis Layer.
3. User Interface Layer.
4. Communication Layer.
5. Storage Layer.

All these components are in detail described in the report provided by contractor1 to Client. The system in general is responsible for real-time video processing and fire detection of identified forest areas. It includes AI-based algorithms for smoke detection and fire source visualization at

[1] **Assignment Activity 3.2.2** Implementation Report

the very initial stage, issue off alarm signals to operators upon fire detection and generate patrol routes for automatic territory inspection.

The requirements of the administrators of the system are to ensure proper and stable functioning of all components of the system as well as to ensure that **all the users (system service personnel, forestry personnel and others with a right to access system data) are adequately trained.**

Detailed draft operational handbook for the operation of the integrated monitoring and early warning forest fire detection system is attached to the report as Annex 1.

3. Emergency response procedure

The main objective of this report is also to define detailed emergency response procedure in order to ensure the consistent implementation of necessary actions after receiving confirmed information about a forest fire from the early warning system, in our case that is information received from the camera and provided by the system administrator to relevant users.

Simply put, we need to know what a forest manager will do when he receives a warning about the danger of a forest fire and what information he must have to properly conduct the entire forest fire extinguishing process.

All actions against wildfire's to be organized in line of existing legal rules, which was reviewed in the previous report "Risk assessment of forest fires procedure s and technologies used in Borjomi - Kharagauli National Park" (Report under Activity 1.3). According to the risk assessment report, Emergency Management Service (EMS) under the Ministry of Internal Affairs is the leading state institution in charge for forest fire in Georgia. Decree #85, 31.12 2021 approved by the Minister of Internal Affairs "On approval of the Rules for conducting fire extinguishing and emergency rescue operations/rescue operations" article 49, p.4 provides in detail required emergency measures to be conducted against forest fires (see box one below):

Box one. "On approval of the Rules for conducting fire extinguishing and emergency rescue operations/rescue operations" (Decree of the Minister of Internal Affairs #85, 31.12.2021)

Article 4. When extinguishing forest fires, it is necessary to:

a) conduct reconnaissance over a large area using motor transport and aircraft, as well as using cartographic materials or aerospace images of the area.
b) conduct reconnaissance of local outbreak accompanied by forestry specialists and people who are well acquainted with the area.
c) determine the type and extent of the fire, the terrain of the area, predict the spread of the fire according to weather reports, and determine the areas where its intensive development is possible.
d) **develop a tactical plan** for extinguishing the fire, determine the boundaries of the localization and the necessary forces and means of response, distribute them to fire extinguishing areas (sectors), organize communication, and adjust the plan considering changes in the situation.
e) Determining the method of extinguishing the fire, determining the presence and use of access roads, as well as natural water sources.
f) Arranging natural barriers for organizing protective barriers or support lines for the oncoming fire;
g) Indicating fire shelters and access routes for service units and other response forces, appointing persons responsible for fulfilling safety requirements.
h) Organizing interaction with emergency services.
i) Agreeing decisions made by the head with relevant agencies.

According to the above-mentioned rule EMS organizes emergency measures only after forest fire is detected and they are officially required to take part in the forest fire extinguishing activities.

At the same, considering the best international experience, effective control of forest fires aims for establishment of the system, which may ensure prevention and early detection of forest fires. Considering this, state agencies responsible for the management of the forests in Georgia, like Agency of Protected Areas (APA) or National Forestry Agency (NFA) are in the process of developing specific rules against forest fire which is focused on elaboration of forest fire management plans (FFMP).

The Forest Fire Management Plan is a document for a specific forest area, which identifies duties and responsibilities of the forest management authority in each phase of the emergency (prevention, preparedness, response, and the restoration work in the emergency zone).

The main objective of the plan is:

- Implementation of organizational measures for the protection and safety of employees of the forest management authority from forest fires.

- Development and organization of measures for the prevention/mitigation of forest fires, preparedness for them, and in case that this happens, response and recovery.

- To protect local population from forest fires determination of the measures to be taken, their scope, implementation procedure and the forces and means of the main and auxiliary entities responsible for their implementation.

Below is a brief description of the basic components of the FFMP?

3.1 Forest fire prevention

Fire prevention is one of the most essential functions of fire control service. The main goal of prevention is to ensure preventive measures for emergencies with the participation of municipal bodies, organizations, and the population in cooperation with forest management bodies, to protect the life, health, property of the population and environmental condition where they live. The organization of preventive measures for forest fires to be conducted based on forest fire management plans, according to the estimated scenarios of forest fire development.

Forest fire preventive measures are identified as follows:

- Maintenance and repair of forest fire roads.
- Tree canopy formation in coniferous forests removing/cutting lower branches to avoid risk of fire.
- Cleaning of forest stands from fallen and dead trees.
- Posting warning banners and signs.
- Public awareness campaign.
- Arrangement/maintenance of bonfire platforms.
- Development of early warning systems based on modern technologies.
- Monitoring the forests with high fire risk.

3.2 Preparedness

Fire preparation includes the detection and mobilization (pre-positioning) of suppression resources before a wildfire occurs, as well as training, staff planning and the provision of appropriate equipment. An effective fire preparation should be based on integrated fire management (IFM) planning, which includes consideration of all land resources, stakeholders and values at risk and should consider year-to-year variations in funding, weather, and human activities. Ensuring that professionally trained and equipped personnel are present at key locations will increase the effectiveness of the objective. The safety of firefighters is dependent on their understanding of fire characteristics and local weather; good training in these aspects, therefore, is a key part of fire preparedness. Training in the effective use of equipment and fire suppression techniques is also important, and supervisors and managers should be well trained in the effective deployment of suppression resources. It is essential to provide firefighters with proper protective equipment, such as helmets, gloves, fire-resistant clothing, and safety boots.

Following activities to be included in FFMP:

- In cooperation with EMS involvement of forest management employees in forest fire management training.
- Purchase of appropriate forest fire, medicinal and personal safety equipment.
- Considering indicative costs when planning the budget for preventive and/or preparedness measures.

3.3 Response

The first response is the first phase of fire suppression, and its success or failure may determine the success of the entire IFM objectives. If it is successful, this indicates that most other management plan elements have also been successful. Initial activities are less likely to succeed in the absence of appropriate planning, policies, prevention, fuel management, community involvement and detection. The IFM plan should provide firefighters with clear instructions on how fires are to be fought, whether some are allowed to burn to benefit the environment and resources, and the tactics and strategies to be used to protect ecosystems. Initial-attack actions should be based on expected fire behavior, difficulty of control, and availability of suppression resources.

Therefore, measures to ensure emergency response management, important for consideration in the process of elaboration of the FFMP's are:

- Declaring and reporting an alarm.
- Organizing a field operations center and staffing emergency response teams.
- Receiving and processing information from emergency zones, assessing the emergency and planning appropriate measures.
- Coordination of operations.
- Logistic support.
- Issuance of orders and control of their execution.
- Information management.
- Processing requests for national assistance.
- Receiving and managing resources.
- Ensuring the safety and health of personnel of the response forces.
- Fiscal management.
- Conducting intelligence operations, deploying assessment personnel or teams, and implementing geographic information systems (GIS).

Many of the measures listed above are like measures from the Decree "On approval of the Rules for conducting fire extinguishing and emergency rescue operations/rescue operations" article 49, p.4, which is important and will ensure more efficient implementation of the official firefighting protocol.

3.4 Restoration work in the emergency zone

Burnt area recovery can be divided into three categories: (1) repair of damage caused by suppression efforts; (2) measures to assess and reduce risk to lives, property and resources; and (3) the longer-term rehabilitation and restoration of the burnt area and infrastructure. Immediate rehabilitation actions can be undertaken in conjunction with fire suppression actions as part of the post-fire recovery phase. For example, a fire line constructed along a steep slope may be prone to erosion and further damage if immediate steps are not taken to interrupt the flow of water along it.

Strategic recovery actions may include the following:

- Every fire suppression plan should consider the need for timely corrective actions to mitigate damage to the resource resulting from suppression actions such as firebreak construction and other ground-disturbing activities. Such actions should be undertaken before the suppression resources leave the fire area.
- Burnt area emergency response plans should be based on an evaluation of post-fire soil and watershed conditions.
- Where possible, mitigation measures should be taken to prevent the loss of lives and property in post-fire flood and landslide events, including through public education and warning systems.
- Burnt area rehabilitation and restoration plans should be based on the planned or natural fire regime in the area with a view to ensuring a healthy, sustainable ecosystem or cultural area.
- Where natural processes are not expected to provide adequate regeneration, rehabilitation plans should be developed that include the active planting or seeding of plants (e.g., trees, shrubs, and grasses) native to the ecosystem that will assist ecological recovery.
- Care should be taken to ensure that seed sources are free of contaminants such as the seeds of invasive species.

4. Forest fire control in BKNP

Like most regions of the world, Georgia is also experiencing the effects of climate change. One of the consequences of climate change is the increase in the area and intensity of forest fires. Forest fires are becoming larger, which makes it more difficult to fight them. Borjomi-Kharagauli National Park is particularly vulnerable to fires. In 2017, the largest fire in recent years occurred in Borjomi-Kharagauli National Park, characterized by rapid spread and high fire intensity, which made it difficult to extinguish it. This trend is likely to continue.

4.1 Existing instruments

Considering the fires that have occurred in recent years, Borjomi-Kharagauli National Park has deemed it necessary to review its fire management program and take specific measures to strengthen its capabilities. This Fire Management Plan presents measures that should be taken to prevent forest fires, prepare for response, and ensure a safe and effective response.

For the Borjomi-Kharagauli National Park FFMP is elaborated in 2021 (see our previous report[2]) with support of US Forest Service.

The Borjomi-Kharagauli National Park Fire Management Plan is a guided document for the implementation of fire management activities by the Borjomi-Kharagauli National Park and the Agency for Protected Areas. The Fire Management Plan:

1. Defines functions and responsibilities.

2. Discusses the importance of inter-agency coordination and cooperation for fire management including adjacent to the BKNP territories.

3. Defines measures to prevent human-caused fires.

4. Describes preparatory work for extinguishing and managing forest fires; and

5. Defines standard operating procedures for responding to and extinguishing forest fires.

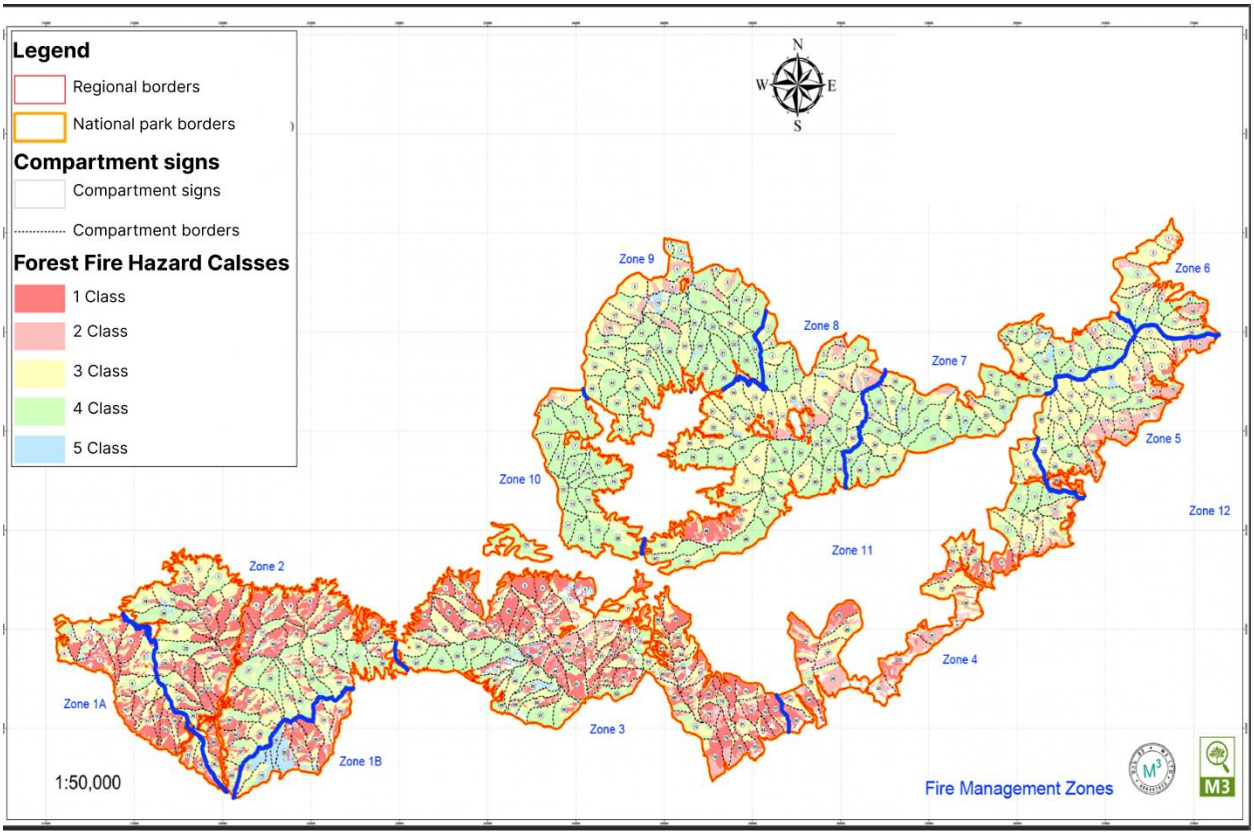
Even though this document provides general guidance and has more declarative content without considering technical details. The table of content of the document is in Box 2 below. English version of the full document is not available.

Box two. Table of content of BKNP Forest fire management plan

[2] Risk assessment of forest fires procedures and technologies used in Borjomi -Kharagauli National Park (Report under Activity 1.3)

According to the forest management plan elaborated in 2021 for BKNP, the total area of BKNP is 56 112 hectares of which almost 50% is composed of forests with fire risk due to the coniferous species are predominant here. Distribution of the BKNP by forest fires hazard classes is given in figure 1 below:

Figure 1. Distribution of the BKNP forests by forest fire hazard classes



According to Forest Fire management plan for the BKNP Fire risk priority zones are assessed for each admiration district/forest unit of the protected area (see box 3). Priorities and recommended management measures were determined based on factors such as vegetation flammability, wildfire risk, and protected values.

Box three. Forest fire management priority zones of the BKNP

1A – Eastern part of Kurtskhana - high priority

This fire management zone contains high fire danger class vegetation. At the southern border of the zone and on the road to the observatory, which crosses the zone, there is a high probability of fire occurrence due to intensive human activity. The values surrounding the Abastumni Astrophysical Observatory are at risk.

Management measures:

• Targeted preventive and educational program.

• Consideration of the possibility of treating hazardous vegetation due to their proximity to agricultural fields.

• Discussing the possibility of installing cameras to detect fires.

• Consideration of the possibility of increasing the number of personnel and equipment. Due to the presence of a road in this area, it is possible to use fire trucks and all-terrain vehicles.

• Study and improve access roads according to their priority.

1B – Western part of Kurtskhana - medium priority

This fire management zone contains high and medium fire hazard vegetation. There is an area affected by fire in this territory. This is a medium priority area due to the insignificant values at risk and the low probability of ignition.

Management measures:

• Consideration of the possibility of using ATV (quadrocycles) in this area to extinguish border fires.

2 - Abastumani - high priority

This fire management zone contains high fire danger class vegetation. This is a high priority area, as important values are at risk, including valuable deer habitat, and it is located close to an urban settlement. The high potential for fire is due to the presence of residents and visitors to the park and the impact of the forest, which has repeatedly caused fires in this area.

Management measures:

• Removal of dangerous vegetation from the point of view of fire outbreak, such as felled-broken trees, undergrowth, pruning of lower branches in a conifer grove.

• Targeted preventive and educational program.

• Discussing the possibility of installing cameras to detect fires.

• Consideration of the possibility of increasing the number of personnel and equipment. In this area, due to the presence of the road, it is possible to use fire engines and quadrocycles.

• Study and improvement (repair and maintenance) of access roads according to their priority.

3 - Aksuri - high priority

In this zone, there is vegetation of high fire danger class, and at its southwestern border - medium fire danger classes. In this zone there are areas covered with grass above the forest belt. This is a high-priority area, as it is characterized by vegetation of biodiversity importance and potential for ignition after lightning. The eastern part of this zone is bordered by an urban settlement.

Management measures:

• Removal of dangerous vegetation from the point of view of fire outbreak, such as felled-broken trees, undergrowth, pruning of lower branches in a conifer grove near the border in the extreme eastern part.

• Targeted preventive and educational program.

• Study and improve access roads according to their priority.

• Discussing the possibility of installing cameras to detect fires.

• Inventory of water resources that can be used during firefighting.

• Considering the possibility of increasing the number of personnel and adding Qcycles since this area is accessible by road.

4 – Borjomi – high priority

This fire management zone contains high fire danger class vegetation. The probability of human-caused fires is high along the border where settlements are located. At risk are values such as population and urban infrastructure, as well as important plant diversity in the nearby Borjomi nature reserve.

Management measures:

• Removal of dangerous vegetation from the point of view of fire outbreak, such as felled-broken trees, undergrowth, pruning of lower branches in a conifer grove near the border.

• Targeted preventive and educational program.

• Study and improve access roads according to their priority

• Inventory of water resources that can be used during firefighting.

• Discussing the possibility of installing cameras to detect fires.

• Consideration of the possibility of increasing the number of personnel and equipment. In this area, due to the presence of the road, it is possible to use fire engines and Qcycles.

5 - Zanavi - medium priority

In this fire management zone, vegetation of medium fire danger class is present. Except for the southern border, where high fire danger class vegetation dominates, human-caused fires can occur on agricultural land and around the Zanawi community. At risk are values such as population and urban infrastructure,

Management measures:

• Removal of dangerous vegetation from the point of view of fire outbreak, such as felled-broken trees, undergrowth, pruning of lower branches in a conifer grove near the border.

• Targeted preventive and educational program.

• Study and prioritize access roads.

• Accounting of water resources.

6 – Kvishkheti – medium priority

This fire management zone contains low-high fire danger class vegetation. The average probability of fire occurrence is due to human activities on the sand and surrounding agricultural beds. Population and urban infrastructure are at risk,

Management measures:

• Removal of dangerous vegetation from the point of view of fire outbreak, such as felled-broken trees, undergrowth, pruning of lower branches in a conifer grove near the border.

• Targeted preventive and educational program.

• Study and prioritize access roads.

• Accounting of water resources.

7 – Nunisi – low priority

The fire management zone is represented by vegetation of low fire danger class. Low fire danger is due to lightining and manufactured fires. Important values are not at risk.

Management measures:

• Studying access roads.

• Inventory of water resources that can be used during firefighting.

8 - Marelisi - low - medium priority

This zone has medium-low fire danger class vegetation. Low fire danger is due to lightining and manufactured fires. Important values are not at risk.

Management measures:

• Studying access roads.

• Accounting of water resources.

9 – Sachondria, 10 – Lashuri – low priority

These zones contain vegetation of low fire danger class. Low fire danger is due to lightining and manufactured fires. Important values are not at risk.

Management measures:

• Studying access roads.

• Accounting of water resources.

Borjomi nature reserve - high priority

The fire hazard class is not defined as medium-low. The fire is expected to start first after lightining. There are almost no roads in this area. Important values are at risk: diverse vegetation, critical wildlife habitat, and management of the area without human intervention. It is possible to reach the territory only by horse. If a fire is detected in this area, the rangers will not be able to reach the fireplace in the time it takes to extinguish the fire.

Management measures:

• Discussing the possibility of automatically contacting the emergency management service and using aviation to assess the situation and extinguish the fire.

• Discussing the possibility of installing cameras to detect fires.

Nedzvi habitat management area – Medium Priority

The fire hazard class is not defined as medium-high. Fires can occur because of lightining and different human activities including logging along the northwestern border. The zone should be managed with minimal human intervention, although many roads cross the zone.

Management measures:

• Studying access roads.

• Inventory of water resources that can be used during firefighting.

• Discussing the possibility of installing cameras to detect fires.

• Implementation of preventive and educational programs in the communities of Kvibisi and Akhaldaba.

Thus, for the forest fire management on the territory of BKNP we have the following legal documents:

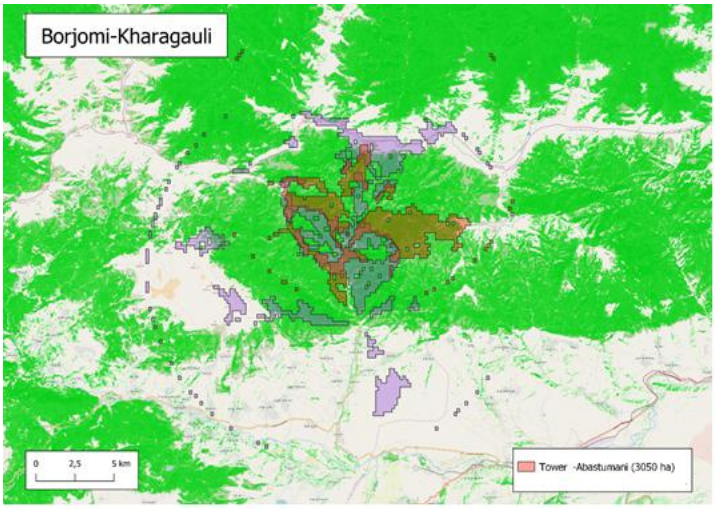
- Georgia Law on Civil Security (2018).
- Decree of the Ministry of Internal Affairs "On approval of the Rules for conducting fire extinguishing and emergency rescue operations/rescue operations" (2018).
- Technical Regulation - Borjomi-Kharagauli Protected Areas management plan (2014).
- Technical Regulation - Borjomi-Kharagauli Protected Areas, Ktsia-Tabatskuri habitat management area and Goderdzi fossil forest natural monument (2021).
- Borjomi-Kharagauli National Park Forest management Plan (2021).
- Borjomi-Kharagauli National Park Forest fire management Plan[3] (2021).

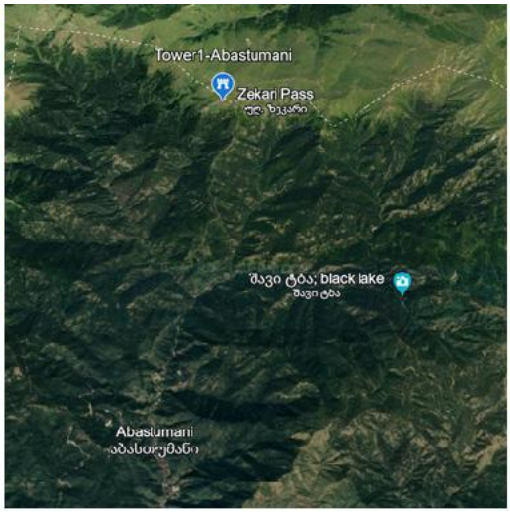
4.2 Measures proposed by project.

Within the scope of the assignment in close consultation with APA and BKNP managers Abastumani forest unit were selected as a project testing/pilot site and a 6-meter mast has been installed in Zekari Pass, from which camera covers 3050 hectares of this unit out of total 9247 hectares.

Figure 2. Camera mast location in Abastumani forest Unit of the BKNP

[3] Has no official status





We suggest also to strengthen management planning system through development of the annual forest fire monitoring and extinguishing operational plan (AOP). In the case of the BKNP for each administrative district/forest unit separate AOP to be elaborated and updated annually as a part of the entire FFMP. Template of the AOP is attached as Annex 1. It consists of all the information required for the prevention and preparedness including Procedure of communication and evacuation of the exposed population depending on the level of risks as well as procedures of communication and operation with firefighters and many other technical details.

The following sections are part of the AOP:

- General provisions.
- Forest fire preventive infrastructure at the territory of target area.
- Organization for monitoring fire danger in forests and forests fires.
- The list and composition of forest fire formations, fire-fighting equipment and machinery, fire-fighting gear and inventory, other means of preventing and extinguishing forest fires in the relevant territory.
- Activities to coordinate work related to extinguishing forest fires.

Also, it is reasonable, that for the initial assessment of the forest fire BKNP personnel (as well as other forest management bodies personnel) is using Situation Assessment Form (see Annex 2), recommended by BKNP forest fire management plan, Annex A.

It is important to note, that information derived from both documents will significantly support elaboration of the Tactical Plan by EMS as it is required by their rule #85 "On approval of the Rules for conducting fire extinguishing and emergency rescue operations/rescue operations".

An example/case study of the practical application of the proposed approach is provided in Annex 3 to the report.

5. References

Technical Regulation - Borjomi-Kharagauli Protected Areas management plan (2014).

Climate change adaptation guide, USAID, Tbilisi, 2016.

Georgia's National Disaster Risk Reduction Strategy Action Plan, 2017.

Georgia law on Civil Security (2018).

Technical Regulation - Borjomi-Kharagauli Protected Areas, Ktsia-Tabatskuri habitat management area and Goderdzi fossil forest natural monument (2021).

Borjomi-Kharagauli National Park Forest fire management Plan (2021).

Wildland fire management, handbook for trainers, FAO, 2010

Integrated fire management voluntary guidelines, FAO, 2024

Annex 1 - Handbook for the operations (SOP - standard operation procedures) of the integrated monitoring and early warning forest fire detection system

Handbook for the operations (SOP - standard operation procedures) of the integrated monitoring and early warning forest fire detection system

Contents

1. Definitions of the Component / Systems

1.1. System Overview

The Integrated Monitoring and Early Warning Forest Fires Detection System is a comprehensive solution designed to enhance early detection capabilities, provide real-time monitoring, and facilitate quick response to potential fire incidents within the Borjomi-Kharagauli National Park. The system utilizes remote sensing technologies, video surveillance, and artificial intelligence to detect and verify potential fire events.

1.2. Key Components

1.2.1. System operation video

As described in the previous documents, The System is based on the geographic information system, integrated with video surveillance cameras. It utilizes artificial intelligence video

stream processing for smoke and fire detection. An incident involving automatic smoke detection using a video camera. The smoke area is visible in the red square (bonfire).

System Video:

- https://www.youtube.com/watch?v=vR56b6pDsLU

1.2.2. Hardware Components

- **Video Surveillance Cameras**: High-resolution cameras with pan-tilt-zoom capabilities and night vision functionality strategically placed throughout the park to monitor for smoke and fire.
- **Camera Mounting Masts**: Weather-resistant structures that support cameras at optimal heights for maximum coverage.
- **Server Infrastructure**: Local server(s) hosting system software, data storage, and processing capabilities.
- **Network Infrastructure**: Communication networks that connect all system components, including wired and wireless connections.
- **Power Supply Systems**: Primary and backup power systems ensuring continuous operation.
- **Workstations**: Computer terminals equipped with displays for system operators.

1.3. Software Components

- **Core Detection Software**: AI-powered software that processes video feeds to automatically detect smoke and fire indicators.
- **Web Interface**: Browser-based interface that allows authorized users to access the system remotely.
- **User Management System**: Software module that manages user access rights and permissions.
- **Alert Management System**: Module responsible for processing and distributing alerts to appropriate personnel.
- **Video Storage and Retrieval System**: Software that manages the storage and retrieval of video footage.
- **Patrolling Route Generator**: Module that creates automated camera patrol routes for systematic area surveillance.
- **Mapping System**: GIS-based system that displays camera locations, fire detections, and other relevant geographic data.
- **Weather Integration Module**: Component that integrates local weather data to enhance detection accuracy and fire risk assessment.

1.4. System Functions

1.4.1. Fire Detection Functions

- **Automatic Detection**: AI-based algorithms that analyze video feeds to identify smoke and fire patterns.
- **Manual Detection**: Operator-initiated detection through visual inspection of video feeds.
- **Smoke Analysis**: Specialized processing of smoke patterns to distinguish between fire-related smoke and other phenomena.
- **Fire Source Visualization**: Enlarged display of detected fire sources on operator monitors.

1.4.2. Monitoring Functions

- **Automated Patrolling**: Systematic camera movement along predefined routes to ensure comprehensive coverage.
- **Area Inspection**: Targeted examination of specific areas of interest or concern.
- **Video Recording**: Continuous or event-triggered recording of video feeds for documentation and analysis.

1.4.3. Alerting Functions

- **Fire Alarm**: Critical alerts indicating detection of potential fire.
- **Supervisory Signal**: Alerts indicating system status requiring attention but not indicating immediate fire threat.
- **Trouble Signal**: Alerts indicating system malfunction or failure.
- **User Notification**: Distribution of alerts to designated personnel via multiple channels.

1.4.4. Decision Support Functions

- **Fire Verification**: Tools and procedures to verify potential fire detections.
- **Location Mapping**: Precise plotting of detected fires on interactive maps.
- **Response Planning**: Tools to assist in planning appropriate response actions.
- **Statistical Analysis**: Data collection and analysis for performance monitoring and improvement.

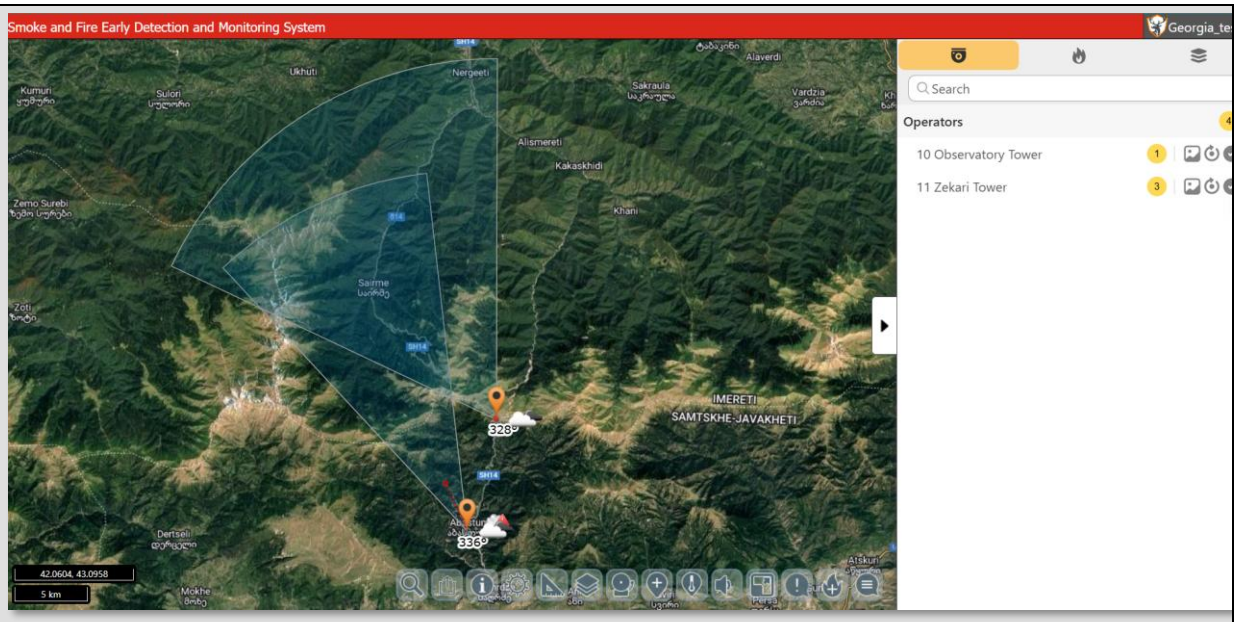


Figure 1 - Smoke and Fire Early Detection and Monitoring - 4 Alerts (Different Cameras 3+1)

1.5. System Interfaces

- **User Interface**: Web-based interface accessible through standard internet browsers.
- **Camera Control Interface**: Interface for controlling camera movement, zoom, and other functions.
- **Administrative Interface**: Advanced interface for system configuration and management.
- **Emergency Service Interface**: Communication protocols for alerting external emergency services.
- **Weather Data Interface**: Connection to weather information services for real-time weather data.

1.6. Alert Classification

- **Fire Alarm**: Indicates detection of potential fire requiring immediate attention and response.
- **Supervisory Signal**: Indicates abnormal condition that requires attention but not immediate emergency response.
- **Trouble Signal**: Indicates system fault or malfunction that requires technical attention.

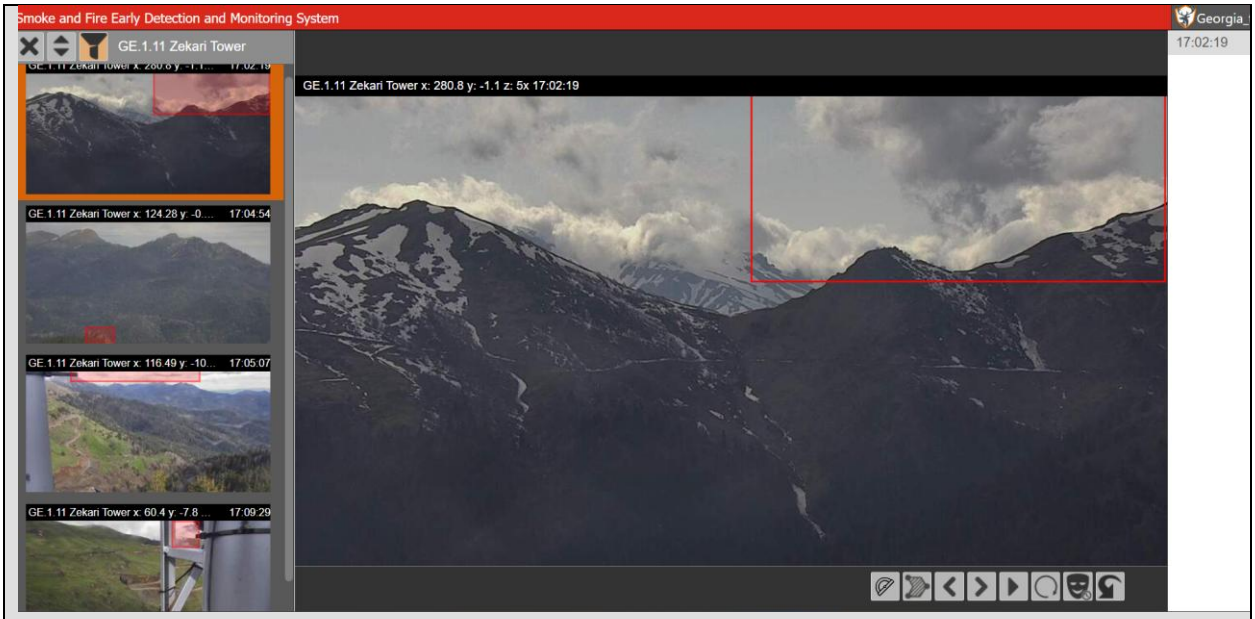


Figure 2 - Alert Detail view.

1.7. System Boundaries

The system is designed to monitor and detect potential fire events within the boundaries of the Borjomi-Kharagauli National Park and its immediate surroundings. The system is not intended to replace human judgment but to enhance and support decision-making processes during fire management activities.

2. Requirements of the Administrators of the System

2.1. System Administrator Roles and Responsibilities

2.1.1. Primary Responsibilities

- Overall technical management and maintenance of the entire system
- Installation and configuration of system updates and upgrades
- User account management and access control
- System performance monitoring and optimization
- Database management and data integrity assurance

- Troubleshooting and resolution of technical issues
- Implementation of cybersecurity measures and protocols
- Regular system backups and disaster recovery planning
- Documentation of system changes and configurations
- Coordination with vendors for technical support and maintenance

2.1.2. Entity in Charge

The System Administrator role shall be assigned to the IT Department of the Borjomi-Kharagauli National Park Administration or a designated technical agency as determined by the park management authority. The System Administrator should report directly to the park Director or designated Technology Manager.

2.2. Technical Qualifications

2.2.1. Education and Experience

- Bachelor's degree in computer science, Information Technology, or related field
- Minimum 3 years of experience in system administration
- Experience with server management, network infrastructure, and security protocols
- Knowledge of database management systems
- Understanding of GIS and remote sensing technologies
- Experience with video surveillance systems and related software

2.2.2. Technical Skills

- Proficiency in server operating systems (Linux/Windows Server)
- Network administration and security implementation.
- Database management (PostgreSQL, MySQL)
- Web server administration (Apache, Nginx)
- Firewall configuration and management.
- Backup and recovery procedures
- Knowledge of API integration and system interfaces
- Understanding of video streaming protocols
- Basic programming/scripting skills for automation and customization

2.3. Administrative Procedures

2.3.1. System Access Control

- Implement role-based access control for all system users.
- Maintain and regularly update user accounts and permissions.
- Enforce strong password policies and two-factor authentication where applicable.
- Document and authorize all access privilege changes.
- Conduct quarterly access rights reviews.
- Immediately revoke access for terminated employees

2.3.2. System Monitoring and Maintenance

- Perform daily system health checks and performance monitoring.
- Schedule and implement regular maintenance during low usage periods.
- Maintain a minimum of 30 days of system logs.
- Conduct weekly review of system logs for anomalies.
- Perform monthly security vulnerability assessments.
- Update system software and security patches within 7 days of release.
- Maintain documentation of all maintenance activities.

2.3.3. Backup and Recovery

- Implement automated daily backups of all system data.
- Store backup copies in an off-site location or secure cloud storage.
- Test backup restoration procedures quarterly.
- Maintain a detailed disaster recovery plan.
- Update recovery procedures after any significant system changes.

2.3.4. Incident Management

- Establish an incident response protocol for system failures.
- Maintain a log of all system incidents and their resolutions.
- Conduct root cause analysis for all critical incidents.
- Implement preventive measures based on incident analysis.
- Report critical incidents to park management within 1 hour.

2.4. System Administrator Workflow

2.4.1. Daily Tasks

- Review system health dashboards and alerts.
- Check storage capacity and performance metrics.
- Verify successful completion of automated backups.
- Monitor network connectivity and camera status.
- Review and respond to user support requests.
- Document any system anomalies or issues.

2.4.2. Weekly Tasks

- Analyze system logs for potential issues.
- Review user activity logs for suspicious behavior.
- Perform necessary system updates and patches.
- Test communication channels with emergency services.
- Update documentation for any system changes.

2.4.3. Monthly Tasks

- Conduct comprehensive system performance review.
- Generate and analyze system usage reports.
- Review and update user access rights.
- Perform security vulnerability assessments.
- Conduct camera calibration checks.
- Update system documentation as needed.

2.4.4. Quarterly Tasks

- Test backup restoration procedures.
- Conduct full system security audit.
- Review and update disaster recovery plans.
- Perform system load testing.
- Review and update system administration procedures.

2.5. Documentation Requirements

- Maintain complete technical documentation of the system.
- Document all system configurations and changes.

- Maintain current network diagrams and infrastructure maps.
- Keep updated inventory of all system components.
- Document all maintenance activities and system modifications.
- Maintain user manuals and training materials.
- Document all backup and recovery procedures.
- Maintain incident response and escalation procedures.

2.6. Compliance and Reporting

- Ensure compliance with relevant cybersecurity standards.
- Maintain compliance with data protection regulations.
- Generate monthly system performance reports.
- Produce quarterly security assessment reports.
- Document annual system review and recommendations.
- Report critical incidents to park management and relevant authorities.
- Maintain audit trails for all system activities.

3. Requirements of the Administrators of the System

3.1. System Administrator Roles and Responsibilities

3.1.1. Primary Responsibilities

- Overall technical management and maintenance of the entire system
- Installation and configuration of system updates and upgrades
- User account management and access control
- System performance monitoring and optimization
- Database management and data integrity assurance
- Troubleshooting and resolution of technical issues
- Implementation of cybersecurity measures and protocols
- Regular system backups and disaster recovery planning
- Documentation of system changes and configurations
- Coordination with vendors for technical support and maintenance

3.1.2. Entity in Charge

The System Administrator role shall be assigned to the IT Department of the Borjomi-Kharagauli National Park Administration or a designated technical agency as determined by

the park management authority. The System Administrator should report directly to the park Director or designated Technology Manager.

3.2. Technical Qualifications

3.2.1. Education and Experience

- Bachelor's degree in computer science, Information Technology, or related field
- Minimum 3 years of experience in system administration
- Experience with server management, network infrastructure, and security protocols
- Knowledge of database management systems
- Understanding of GIS and remote sensing technologies
- Experience with video surveillance systems and related software

3.2.2. Technical Skills

- Proficiency in server operating systems (Linux/Windows Server)
- Network administration and security implementation.
- Database management (PostgreSQL, MySQL)
- Web server administration (Apache, Nginx)
- Firewall configuration and management.
- Backup and recovery procedures
- Knowledge of API integration and system interfaces
- Understanding of video streaming protocols
- Basic programming/scripting skills for automation and customization

3.3. Administrative Procedures

3.3.1. System Access Control

- Implement role-based access control for all system users.
- Maintain and regularly update user accounts and permissions.
- Enforce strong password policies and two-factor authentication where applicable.
- Document and authorize all access privilege changes.
- Conduct quarterly access rights reviews.
- Immediately revoke access for terminated employees

3.3.2. System Monitoring and Maintenance

- Perform daily system health checks and performance monitoring.
- Schedule and implement regular maintenance during low usage periods.

- Maintain a minimum of 30 days of system logs.
- Conduct weekly review of system logs for anomalies.
- Perform monthly security vulnerability assessments.
- Update system software and security patches within 7 days of release.
- Maintain documentation of all maintenance activities.

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- Maintain audit trails for all system activities.

4. Requirements of the Users

4.1. User Classification

4.1.1. System Operators

- **Primary Responsibilities**: Daily system monitoring, alert verification, first-level response coordination
- **Required Skills**: Proficiency in system operation, ability to interpret video feeds and alerts, basic troubleshooting skills.
- **Training Requirements**: Complete initial comprehensive training and quarterly refresher courses

4.1.2. Park Rangers/Field Staff

- **Primary Responsibilities**: Field verification of alerts, initial response to fire incidents, reporting field conditions
- **Required Skills**: Knowledge of park terrain, understanding of fire behavior, communication proficiency.
- **Training Requirements**: Basic system operation training, fire response training, communication protocols

4.1.3. Park Management

- **Primary Responsibilities**: Oversight of system utilization, resource allocation decisions, external communications
- **Required Skills**: Decision-making authority, understanding of system capabilities and limitations.
- **Training Requirements**: Executive summary training, decision support tools training

4.1.4. Emergency Response Personnel

- **Primary Responsibilities**: Specialized response to verified fire incidents, coordination with park staff.
- **Required Skills**: Professional firefighting training, emergency response protocols.
- **Training Requirements**: System interface training, alert interpretation training

4.2. User Access and Permissions

4.2.1. System Operators

- Full access to monitoring functions
- Alert management and verification rights.

- Camera control capabilities
- Access to video archives
- Limited system configuration rights
- Patrol route creation and modification.

4.2.2. Park Rangers/Field Staff

- Limited monitoring access
- View-only access to alerts and camera feeds
- Mobile application access for field reporting
- Access to evacuation and response protocols

4.2.3. Management

- Dashboard access for system overview
- Report generation and statistics viewing.
- Resource allocation tools
- Limited camera viewing access.
- System performance monitoring

4.2.4. Emergency Response Personnel

- Alert notification access.
- Fire location mapping access.
- Limited camera viewing during active incidents.
- Access to pre-defined response plans

4.3. User Training Requirements

4.3.1. Initial Training

- System overview and purpose
- User interface navigation
- Alert interpretation and verification.
- Fire detection procedures.
- Camera control operations
- Documentation and reporting procedures
- Troubleshooting common issues
- Emergency response protocols
- Communication procedures

4.3.2. Refresher Training

- Quarterly refresher training for all users
- Updates on system changes and improvements
- Review of incidents and lessons learned.
- Practice scenarios and simulations.
- Performance feedback and improvement

4.3.3. Specialized Training

- Advanced camera operations for system operators
- Advanced alert verification techniques
- Customized training for field staff based on terrain responsibility.
- Specialized training for emergency response coordination

4.4. User Workflows

4.4.1. System Operator Workflow

- Log in to system at beginning of shift.
- Review system status and any pending alerts.
- Conduct routine surveillance using predefined patrol routes.
- Monitor real-time feeds and automated alerts.
- Verify alerts using multiple camera views when available.
- Document observations and actions taken.
- Coordinate with field staff for alert verification.
- Escalate verified fire alerts according to protocols.
- Log up all activities and shift handover information.

4.4.2. Park Ranger/Field Staff Workflow

- Receive alerts through mobile applications or radio.
- Communicate receipt of alert information.
- Proceed to the location for field verification when directed.
- Report on findings for system operators
- Implement initial response measures if appropriate.
- Document observations and actions taken.
- Assist with evacuation if necessary.
- Provide ongoing situation updates.

4.4.3. Park Management Workflow

- Review system performance metrics regularly.
- Authorize resource allocation for response activities.
- Approve external communications regarding incidents.
- Review incident reports and approve action plans.
- Coordinate with external agencies as needed.
- Evaluate system effectiveness and approve improvements.

4.4.4. Emergency Response Personnel Workflow

- Receive and acknowledge alert notifications.
- Access system for location and situation details
- Coordinate response strategy with park management.
- Implement fire suppression activities.
- Provide status updates through designated channels.
- Document response activities and outcomes.

4.5. User Performance Standards

4.5.1. System Operators

- Alert verification within 3 minutes of detection.
- Documentation of all alerts and actions taken
- Adherence to communication protocols
- Maintenance of system log accuracy
- Regular system checks according to schedule.

4.5.2. Park Rangers/Field Staff

- Response to verification requests within established periods
- Accurate reporting on field conditions
- Proper implementation of initial response protocols
- Compliance with communication procedures
- Complete documentation of field activities

4.5.3. Park Management

- Timely decision-making during incidents
- Regular review of system performance metrics

- Approval of necessary system improvements
- Effective coordination with external agencies
- Support for ongoing training and improvement initiatives

4.5.4. Emergency Response Personnel

- Timely response to verified alerts.
- Effective implementation of response strategies
- Clear communication with park staff
- Comprehensive documentation of response activities
- Participation in post-incident reviews

4.6. User Support and Feedback

4.6.1. User Support

- Dedicated support channel for system users
- Technical support availability during all operational hours
- Documentation and knowledge base accessibility
- Regular user group meetings for issue discussion

4.6.2. Feedback Mechanism

- Structured feedback form for system improvement suggestions
- Regular user surveys for system evaluation
- Incident debriefing sessions following noteworthy events.
- Continuous improvement process incorporating user feedbac.

5. How to Interpret the Data Provided by the System

5.1. Types of System Data

5.1.1. Video Feed Data

- **Live Video Feeds**: Real-time visual information from cameras throughout the park
- **Recorded Video**: Archived footage stored for review and analysis.
- **Thermal Imaging Data**: Heat signature detection for identifying potential fire sources.
- **Night Vision Data**: Enhanced visibility images for nighttime monitoring

5.1.2. Alert Data

- **Fire Alerts**: Notifications of potential fire detection by AI algorithms.
- **Smoke Detection Data**: Identification of smoke patterns and characteristics.
- **Alert Confidence Levels**: Probability ratings for detection accuracy.
- **Alert Location Data**: Geographic coordinates of detected potential fire events.

5.1.3. System Performance Data

- **Camera Status Information**: Operational status of all cameras
- **Network Performance Metrics**: Data transmission effectiveness.
- **System Health Indicators**: Overall system functionality status
- **Storage Capacity Metrics**: Available recording and data storage space

5.1.4. Environmental Data

- **Weather Conditions**: Temperature, humidity, wind speed and direction
- **Fire Risk Indices**: Calculated risk levels based on environmental factors.
- **Historical Data Comparisons**: Current conditions compared to historical patterns.
- **Seasonal Risk Factors**: Adjusted risk assessments based on seasonal conditions.

5.2. Data Interpretation Guidelines

5.2.1. Video Feed Interpretation

- **Smoke Identification**:
  - Gray or white plumes rising consistently from a fixed location.
  - Differentiate from fog, dust, or cloud formations by observing behavior and dispersion.
  - Verify using multiple camera angles when available.
  - Note color characteristics: white smoke often indicates early-stage fires, dark smoke suggests more established fires.
- **Fire Identification**:
  - Look for visible flames, especially during night observations.
  - Observe color variations indicating temperature and fuel type.
  - Note the rate of spread and direction.
  - Compare with known controlled burn locations.
- **Video Quality Factors**:
  - Consider weather conditions affecting visibility.
  - Account for camera limitations in extreme conditions.
  - Note time of day and lighting conditions affecting image quality.

- Recognize potential interference from wildlife or vegetation movement.

5.2.2. Alert Interpretation

- **Confidence Level Assessment**:
  - High confidence (85-100%): Immediate verification required.
  - Medium confidence (60-84%): Priority verification
  - Low confidence (below 60%): Routine verification during normal operations
- **Alert Pattern Analysis**:
  - Multiple alerts from same location: Higher probability of actual fire
  - Progressive alerts showing movement: Indicates potential fire spread.
  - Isolated single alerts: May require additional verification.
  - Recurring alerts in the same location: May indicate smoldering or controlled activity.
- **False Positive Recognition**:
  - Sun reflections on water or metal surfaces
  - Dust clouds from vehicles or natural causes.
  - Steam from thermal features or geothermal areas
  - Morning fog or cloud formations in valleys

5.2.3. Weather Data Integration

- **Wind Factor Analysis**:
  - Wind speed affects fire spread rate (higher speeds = faster spread)
  - Wind direction indicates potential spread trajectory.
  - Shifting winds may indicate changing risk zones.
  - Intense winds may affect camera stability and alert accuracy.
- **Temperature and Humidity Correlation**:
  - Hot temperature + low humidity = increased fire risk
  - Sudden humidity drops may indicate approaching fire conditions.
  - Temperature inversions may trap smoke and affect detection.
  - Seasonal norms vs. current conditions should inform response urgency.
- **Precipitation Effects**:
  - Recent rainfall reduces immediate fire risk.
  - Long dry periods increase vulnerability.
  - Lightning activity without rainfall indicates elevated risk.
  - Snow cover provides temporary fire risk reduction.

5.2.4. Geographical Context

- **Terrain Considerations**:

- Uphill fire spreads typically faster than downhill.
- Ridge lines often accelerate fire movement.
- Valleys can channel winds and increase fire intensity.
- Water bodies may serve as natural firebreaks.

- **Vegetation Assessment**:
  - Dense forest areas produce different smoke patterns than grasslands.
  - Coniferous forests typically burn more intensely than deciduous.
  - Dry grass ignites more easily but may burn quickly.
  - Seasonal vegetation changes affect fire behavior prediction.

5.3. Decision Support Interpretation

5.3.1. Fire Risk Level Indicators

- **Level 1 (Low Risk)**:
  - Normal monitoring protocols
  - Routine patrol scheduling
  - Standard verification procedures
- **Level 2 (Moderate Risk)**:
  - Enhanced monitoring frequency
  - Lower threshold for alert verification
  - Preparedness notification to response teams
- **Level 3 (High Risk)**:
  - Continuous monitoring of high-risk zones
  - Heightened alert verification priority
  - Pre-positioning of response resources
  - Increased communication frequency
- **Level 4 (Extreme Risk)**:
  - Maximum system vigilance
  - Immediate verification of all potential alerts
  - Full response team readiness
  - Consideration of preventive evacuations

5.3.2. Response Time Calculations

- **Detection to Verification Time**: Typically, 2-5 minutes based on alert confidence.
- **Verification to Dispatch Time**: Target of 3-7 minutes dependent on risk level
- **Dispatch to On-Scene Time**: Variable based on terrain and access (15-60 minutes)
- **Total Response Window**: Critical for containment effectiveness (under 30 minutes optimal)

5.3.3. Fire Spread Prediction

- **Initial Spread Rate Calculation**:
  - Based on fuel type, terrain, wind, and humidity
  - Measured in meters per minute.
  - Used to establish immediate evacuation zones.
- **Extended Projection Modeling**:
  - 1-hour, 3-hour, and 6-hour spread projections
  - Identify communities and assets at risk.
  - Determines resource allocation priorities.
  - Guides evacuation decision periods

5.4. Data Validation Procedures

5.4.1. Cross-Verification Methods

- Verify alerts using multiple cameras when available.
- Compare thermal and visual data for confirmation.
- Correlate with weather data for contextual validation.
- Request field verification for medium/low confidence alerts.

5.4.2. Historical Comparison

- Compare it with previous fire events in similar conditions.
- Analyze past false positive patterns for recognition.
- Reference seasonal fire behavior patterns
- Review successful containment strategies for similar events.

5.4.3. Expert Consultation

- Consult with fire behavior specialists for complex scenarios.
- Engage meteorologists for weather trend interpretation.
- Seeking input from experienced park rangers familiar with local conditions
- Utilize forestry experts for vegetation-specific interpretations.

5.5. Information Display and Reporting

5.5.1. Dashboard Interpretation

- Critical alerts displayed with red indicators.
- Supervisory signals shown in yellow.

- Normal operations in green
- System health status indicated through icon system.
- Weather data integrated via sidebar display.
- Historical trend graphs for context

5.5.2. Map Interface Reading

- Camera locations shown with field of view indicators.
- Alert locations marked with confidence-level color coding.
- Terrain features displayed with fire spread potential indicators.
- Access routes highlighted for response planning.
- Population centers and critical infrastructure marked for prioritization.

5.5.3. Report on Generation and Analysis

- Daily summary reports on system activity
- Incident-specific detailed reports
- Statistical analysis of detection efficiency
- False positive analysis for system improvement
- Response time metrics for performance evaluation
- Seasonal risk pattern identification

6. Sequence of Events Upon Alert Activation

6.1. Fire Alarm Activation

6.1.1. Initial Detection and System Response

1. The system detects potential fire signatures through automated monitoring.
2. AI algorithms analyze detection against false positive patterns.
3. System assigns confidence level to the alert (high, medium, low)
4. System triggers visual and audible alerts at monitoring stations.
5. The system automatically redirects cameras to focus on the alert location.
6. System records event with timestamp in the database
7. The system displays an enlarged image of potential fire on the operator's monitor.
8. System marks fire location on the GIS map interface

6.1.2. Operator Verification Process

1. Operator acknowledges alert within 30 seconds.
2. Operator reviews video feed from primary detection camera

3. Operator utilizes camera controls to enhance view (zoom, pan, tilt)
4. Operator checks secondary cameras covering the same area if available.
5. The operator consults weather data for contextual information.
6. Operator references historical data for known false positive locations.
7. Operator makes initial determination of alert validity.
8. Operator documents initial assessment.

6.1.3. Alert Classification

1. Operator classifies alert as:
    - Confirmed Fire: Clear visual confirmation of fire.
    - Probable Fire: Strong indicators but not visually conclusive
    - Possible Fire: Some indicators but require field verification.
    - False Alarm: Clearly identifiable as non-fire phenomenon
2. For "Confirmed" or "Probable" classifications:
    - System upgrades alert status to "Active Fire Incident."
    - The system initiates full response protocol.
3. For "Possible" classification:
    - The system maintains alert status as "Under Investigation."
    - Field verification is requested.
4. For "False Alarm" classification:
    - System logs incident as false positive
    - The alert is closed with documentation of course.

6.1.4. Response Coordination

1. For confirmed or probable fire alerts:
    - Operator notifies on-duty Park Manager immediately.
    - Operator contacts nearest field staff for immediate response
    - Operator alerts appropriate firefighting resources based on location and severity.
    - Operator prepares initial incident brief using system data.
2. System automatically generates:
    - Incident ID number
    - GIS coordinates of fire location
    - Nearest access points and routes
    - Weather conditions and fire spread risk assessment.
3. Operator continues monitoring and documenting incident development.
4. Operator establishes ongoing communication with field responders.

6.1.5. Incident Documentation

1. The system starts continuous recording of all camera feeds covering the incident area.
2. Operator maintains chronological log of all actions and communications.
3. The system records all user actions related to the incident.
4. Operator documents:
    - Time of alert
    - Verification process
    - Classification decision
    - Notifications made.
    - Initial response deployed.
    - Fire characteristics (size, behavior, spread direction)

6.1.6. Ongoing Monitoring and Escalation

1. The operator continues monitoring the incident until field confirmation.
2. If fire size or intensity increases:
    - Alert status upgraded to higher priority.
    - Additional resources requested.
    - Evacuation considerations initiated.
3. Based on field reports, operator updates:
    - Fire location accuracy.
    - Spread direction and rate.
    - Resource requirements
    - Threat assessment to infrastructure or populated areas
4. System continuously updates fire spread prediction based on new data.
5. Operator maintains communication with field responders until incident command established.

6.2. Supervisory Signal Activation

6.2.1. Supervisory Alert Detection

1. System detects abnormal conditions not classified as immediate fire threat.
2. The system generates supervisory signal alerts on operator console.
3. System logs supervisory condition with timestamp and affected component.
4. System displays affected component status on system health dashboard.

6.2.2. Operator Response to Supervisory Signal

1. The operator acknowledges supervisory alert within 2 minutes.
2. Operator identifies specific supervisory condition type:

- Camera malfunction
- Network connectivity issues.
- Environmental interference
- Power supply irregularity
- Software anomaly
- Sensor drift

3. Operator verifies impact on system capability:
   - Isolated component issue
   - System zone impact
   - Potential system-wide implications
4. Operator documents initial assessment.

6.2.3. Technical Evaluation Process

1. Operator performs initial troubleshooting based on alert type:
   - Checks system diagnostics for affected component
   - Attempts remote reset if appropriate.
   - Verifies backup systems engagement.
   - Assesses weather conditions that might affect components.
2. Operator notifies System Administrator for conditions requiring technical intervention.
3. System continues monitoring affected component for changes in status.
4. Operator documents troubleshooting steps and outcomes.

6.2.4. Mitigation Actions

1. For camera-related supervisory signals:
   - Adjust patrol routes to compensate for coverage gaps.
   - Increase monitoring frequency in adjacent areas.
   - Schedule maintenance visit if remote resolution unsuccessful
2. For network-related supervisory signals:
   - Switch to backup communication channels if available
   - Implement reduced data transmission protocols if bandwidth limited.
   - Notify field staff of potential communication limitations.
3. For power-related supervisory signals:
   - Verify backup power systems activation.
   - Monitor power consumption and remaining backup capacity.
   - Implement power conservation measures if extended outage expected.
4. For software-related supervisory signals:
   - System Administrator implements appropriate patches or workarounds.
   - Document impact on detection capabilities.

- Consider manual monitoring enhancement if automated functions affected.

6.2.5. Documentation and Resolution

1. Operator maintains log of supervisory conditions.
2. System Administrator documents:
   - Technical cause of supervisory condition
   - Temporary mitigation measures implemented.
   - Permanent resolution plan
   - System performance impact assessment
3. Upon resolution:
   - System returns component to normal status.
   - Alert is cleared from active console.
   - Incident is archived with complete documentation.
   - The system generates performance reports for affected components.

6.3. Trouble Signal Activation

6.3.1. Trouble Signal Detection

1. System detects component failure or critical malfunction.
2. System generates trouble signals with high-priority alerts on operator console.
3. The system activates audible alarm in monitoring centers.
4. System logs trouble condition with critical status flag
5. System initiates automatic diagnostics to assess extent of failure.

6.3.2. Immediate Operator Response

1. The operator acknowledges trouble signal within 30 seconds.
2. Operator identifies affected system component and failure mode.
3. Operator assesses immediate impact on system functionality:
   - Detection capability compromise
   - Coverage area reduction
   - Data integrity issues
   - Communication failure
4. Operator implements immediate contingency measures:
   - Activate backup systems if available.
   - Redirects operational cameras to compensate for coverage loss.
   - Switches to alternative communication channels
   - Initiates manual monitoring procedures if automated systems compromised.

6.3.3. Technical Response Mobilization

1. The operator immediately notifies the System Administrator regardless of time.
2. System Administrator remotely accesses system for diagnosis if possible.
3. For critical failures affecting multiple components:
    - Technical response team is dispatched to facility.
    - Emergency maintenance procedures are initiated.
    - Vendor technical support is contacted if necessary.
4. System continuously tests affected component for recovery status.
5. Operator documents extent of system compromise

6.3.4. Operational Continuity Measures

1. Park Management is notified of system compromise:
    - Extent of affected coverage area
    - Estimated restoration time.
    - Interim risk mitigation recommendations
2. For extended system failures:
    - Manual fire watch procedures are implemented.
    - Additional field staff are deployed in high-risk areas.
    - Alternative detection methods are activated.
    - Partner agencies are notified of detection capability reduction.
3. Emergency services are informed of potential detection limitations.
4. System Administrator establishes recovery timeline and resource requirements.

6.3.5. Resolution and System Recovery

1. Technical team implements repairs or replacements as required.
2. System Administrator performs comprehensive system testing:
    - Component functionality verification
    - Integration testing with other system elements
    - Performance testing against baseline metrics
3. Once functionality restored:
    - System returns to normal operational status.
    - Trouble signal is cleared from active console.
    - Manual contingency measures are deactivated.
    - All stakeholders are notified of system restoration.
4. Post-incident technical review:
    - Root cause analysis documented.
    - Preventive measures identified.

- System improvements recommended.
- Spare parts inventory adjusted based on failure type.

Annex 2 – Annual Operation Plan for Forest Fire Monitoring

Approved
By Borjomi-Kharagauli
National Park

Annual Operation Plan for Forest Fire Monitoring and Extinguishing

(Name of the forest area)

for the duration of the fire season for the year 2025

I. General provisions

1. Description of the forest Unit/Protected Area

(Area, species distribution, Distribution of the forests by forest fire hazard classes,

description of the main conditions that determine forest flammability,

average statistical dates of the fire season according to the data

contained in the registry of the local forestry office)

2. Information about government bodies, their territorial divisions, implementing the organization of extinguishing forest fires, as well as about other government agencies and organizations participating in forest fire extinguishing measures

(Name of the Government Bodies, their contacts including names of the persons responsible and managers)

3. Information about people responsible for the organization of extinguishing forest fires measures

№	Name	Position	Contacts

II. Forest fire preventive infrastructure at the territory of target area

1. Forest roads intended for the protection of forests from fires.

№	Location (Forest unit, compartments)	Length and condition (km)	Person responsible	Note

2. Landing sites for helicopters used for aerial work on extinguishing forest fires.

№	Location, GIS coordinates, Nearest settlement	Area, M^2	Condition	Person responsible	Note

3. Clearings, fire breaks, fire mineralized strips

№	Name of the object	Location (Forest unit, compartments, litters)	Person responsible	Note

4. Fire observation posts (towers, masts, pavilions, and other observation posts), points for concentration of fire-fighting equipment.

№	Name of the object	Location, GIS coordinates, Nearest settlement, forest unit, compartment, litter	Description of the object	Person responsible	Note

5. Water reservoirs and approaches to water supply sources to be used to extinguish forest fires.

№	Name of the object	Location, GIS coordinates, Nearest settlement, forest unit, compartment, litter	Characteristics of the object (for water intake by ground means - volume in m3, for water intake by aviation means - depth in m, area for aircraft operation - dimensions in m^2)	Condition of the reservoir and access to the water supply source	Person responsible	Note

6. Reducing the natural fire hazard of forests by regulating the species composition of forest stands and implementing sanitary and health measures.

№	Type of measure	Location (forest unit, compartment, litter)	Unit of measurement	Volume of work	Date of implementation	Per respo

7. Conducting preventive controlled firefighting burning of brushwood, forest litter, dry grass, and other flammable forest materials

№	Type of measure	Location (forest unit, compartment, litter)	Unit of measurement	Volume of work	Date of implementation	Per respo

8. Other measures

№	Type of measure	Location (forest unit, compartment, litter)	Unit of measurement	Volume of work	Date of implementation	Per respo

9. Map-scheme of fire-prevention arrangement of forests on the territory of target forest as attachment one.

10. Control of the implementation of fire preventive/protective measures by people using forests or forest lands provided for permanent (unlimited) use, for lease, etc.

№	Type of activity	Date	Person respo

III. Organization of monitoring of fire danger in forests and forest fires

1. The Body/Structural Unit that monitors fire hazards in forests and forest fires.

№	Name of the Body/Structural Unit	Area identified for monitoring, forest unit, compartments	Person respo

2. List of measures for organizing monitoring and controlling fire hazards in forests

№	Type of measures	Date	Person respo

3. List of measures for organizing a system for detecting and recording forest fires, a system for monitoring their development

№	Type of measures	date	Person respo

4. Organization of forest patrols

№	Responsible Body that patrols forests	Type of patrolling (ground, aerial)	Area identified for patrolling, forest unit, compartments	Patrol period, frequency, and time of implementation	Perso respons

Summary of ground patrol of forests, summary of aerial patrol of forests, map-scheme of routes of ground patrol of forests, map-scheme of aerial patrol of forests are as attachment 2-4.

5. Receiving and recording reports of forest fires, as well as alerting the population and fire services about the fire hazard in forests:

1) receiving and recording reports of forest fires

№	Responsible Body for receiving and recording reports of forest fires	Methods of receiving mess and contact informatio

2) alerting the population and fire services about fire hazards in forests and forest fires

№	Responsible Body that notifies the population and fire services about fire hazards in forests and forest fires	Notification methods

6. Information about the specialized dispatch/communication service

№	Body, ensuring. the functioning of a specialized dispatch/communication service	Contacts of the Body	Surnames, first names, patronymics of those responsible for duty	Contact information of government bodies, local government bodies, organizations with which the specialized dispatch/communication service interacts (including address, telephone, etc.)	Person responsible fo the functioning of the specialized dispatch/communicati service

IV. The list and composition of forest fire formations, fire-fighting equipment and machinery, fire-fighting gear and inventory, other means of preventing and extinguishing forest fires in the relevant territory.

1. Information on the organization of forest fire formations required to extinguish forest fires depending on the level of fire danger in the territory of the target forest unit/protected area.

Fire hazard class	Number of required forest fire fighting units	Composition of forest fire fighting unit[4]	The number of employees required of forest firefighting units engaged in extinguishing forest fires	The amount of equipment and inventory required[5]	Number of required. firefighting equipment and equipment[6]		Note

2. Summary information on the availability of fire-fighting equipment and inventory, fire-fighting equipment, and machinery for extinguishing forest fires in the territory of the target forest area is provided as attachment five

3. Information on people admitted to the management of forest fire extinguishing (leaders of forest fire extinguishing)

№	Name	Experience (special training, number of cases managed/participated, etc.)	Contacts	Note

V. Activities to coordinate work related to extinguishing forest fires.

1. Information on the organization and functioning of the relevant commissions, headquarters, and groups for extinguishing forest fires (including their personnel, work schedule, etc.)

[4] One Unit consisting of 2-3 person using manual extinguishing means and 1-2 units of forest fire techniques
[5] Shovel (1-2), bucket (1-2), axe (1-2), chain saw (1) first aid kit (1), means of communication (2)
6Minimum 1 forest patrol car with water tank up 1 m^3, tractor with plow, motor pump

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1. List of government bodies, local government bodies, organizations aiding five in extinguishing forest fires

№	Name of the Organizations	Type of assistance, its volume	Contacts	Persons responsible

2. Scheme of movement of forest fire brigades, fire-fighting equipment, and machinery

3. Measures to prevent the spread of forest fires to the lands of populated areas and lands of other categories.

№	Type of measures	Date	List of Central and local government bodies, other organizations involved	Perso responsib over coordin

4. Measures to prevent the spread of fires that occur on lands of populated areas, agricultural lands, and lands of other categories into forests.

№	Type of measures	Date	List of Central and local government bodies, other organizations involved	Person responsible for overall coordination

Annex 3 - Forest fire situation assessment form

Forest fire situation assessment form

Date:	
Type of fire:	Manager for the Emergency Situation: **An intern**:
Fire location	**Area**: _____ Hectares **Owner**: ___BKNP __District name, others
Type of vegetation:	**The nature of fire:** ____Strangler ___Creeper ___Spotting ___ Torchlight ___Crown ___fast
Flame lengths (meter):	**Positioning on the slope:** ___law1/3 __medium one-ninth __part1/3 plain_____
Slope degree (%):	Exposition : _N _NE _NW _S _SE _SW _E _W
Height:	
Wind: Speed_____ Impulses_____ Direction	

Distribution potential: no law (0-2) medium (2-5) high (5-10) very high (10+)
Starting strategy: _____ direect ____nondirect ____combined
Values under risk: buildings infrastructural cultural/historical natural resources other
Risks: Deadwood electric lines stones roads flammable materials hazardous materials others
Cause: Lightning bonfire waste burning power line equipment deliberately ignited other
Additional needs: Fire trucks Bulldozers ATVs (Quadro cycles) Personnel
Factors affecting fire suppression (eg, weather, terrain):
Buildings under the threat: Living buildings ____ commercial buildings____ other.

Annex 4 - Case study – Forest fire management scenario

Case study – Forest fire management scenario

In August, an early warning system camera located in Abastumani forest unit, Zekari pass detected a sign of fire. Once the system administrator has validated the information, it is provided to BKNP. BKNP employees will arrive on the stage within 20-30 minutes. They fill **Forest fire situation assessment form** which states that a fire spread over an area of twenty hectares in the vicinity of the town, namely in the Abastumani forest around 14:00. The probable cause is the careless handling of a bonfire by a local resident. The fire has not spread to the population and does not pose a threat to the population at the first stage, however, after approximately 30 minutes, the approximate speed of fire spread is 4-5 hectares per hour. The rate of fire spread is determined by the topographic conditions, namely the slope degree exceeds 40%. Intense winds are observed by the administrator, in the indicated area, which became more intense after 14:00.

BKNP is informing local EMS and at 14:40, the fire and rescue service is mobilized on site and begins to localize the fire, by this time an emergency headquarters has already been created and assembled. The Emergency Management Service, in agreement with the employees of the BKNP, local National Forestry Agency and the police, establishes a fire zone and the police ensures that the roads leading to the zone are blocked for those entering, ensures the maintenance of public order, and manages the flow of passengers and vehicles.

The headquarters for inter-agency coordination is fully mobilized on site and the members of the headquarters are performing the duties assigned to them by tactical plan, elaborated by EMS based on **Forest Fire Situation assessment form and Annual Operational Plan provided by BKNP.**
The Emergency Management Service provides the headquarters with information that it will take approximately 24 hours to localize the fire.

At around 16:00, a thick plume of dark smoke is rising from the fire zone, indicating that the fire's intensity is increasing. The area is mostly covered by coniferous forest, with fire hazard calories I-II.
At around 17:00 The fire has grown into a crown type, which is becoming impossible to stop on the spot. Additional firefighting forces from various regions of Georgia need to be called in to contain the fire. The situation is complicated by the terrain. 2 Border Police helicopters have been involved in the operation, however, due to intense winds, they cannot actively participate in the work process. Additional aviation support from neighboring countries may be required.

At 19:00, 150 employees of the Special Tasks Department of the EMS joined the operation.

At 10:00 the next day, the fire front line moved up the slope and headed in the direction of Abastumani, there was a risk of it moving into the settlement. Evacuation of up to 150 people may be necessary. Heavy smoke is observed in the settlement. However, firefighters, foresters, and employees of the Special Tasks Department near the settlements were able to stop the fire.

Fire prevention measures are underway, localization is underway, and 4 days after the notification, the fire is fully localized, and extinguishing (liquidation) requires approximately 24 hours. After the expiration of this time, the fire hot spots are being monitored by the Emergency Management Service and BKNP for approximately 3 days.

After the fire danger is eliminated, the Emergency Management Service removes restrictions established for the emergency duration period.