Up Scaling the Forest Fire Monitoring and Early Warning System in Borjomi – Kharagauli National Park

1. Background and context

Borjomi-Kharagauli National Park (BKNP), located in central Georgia, represents one of the most significant protected areas in the Caucasus. As a biodiversity hotspot and a vital ecological corridor between Europe and Asia, the park plays a key role in regional and global environmental stability. The integration of innovative monitoring and early warning systems for forest fire detection strengthens the park's resilience against climate change and anthropogenic threats, aligning with international commitments to biodiversity conservation.

Ecological and Geographic Significance

BKNP spans diverse climatic zones and is home to numerous endemics, relict, and endangered species. Its old-growth forests act as natural carbon sinks and contribute to regulating regional microclimates. The park also functions as a critical part of the Caucasus ecological corridor, linking the Black Sea and Caspian Sea basins. This transboundary ecological connection supports genetic diversity, species migration, and ecosystem adaptability across Eurasia.

Pic.1 – Ecological corridor

CTCN AFRICA REGIONAL MANAGER
Digitally signed by Robinson Mugo
Date: 2025.06.16 11:47:19 +03'00'

Role in the Emerald Network and European Conservation

The park is included in the **Emerald Network**, a pan-European ecological initiative under the Bern Convention, reinforcing its continental importance. Its conservation contributes directly to the EU's **Natura 2000** objectives by preserving habitats of international value and species protected under European directives. As such, the BKNP is not only Georgia's natural treasure but a component of Europe's shared ecological heritage.

The Role of Borjomi-Kharagauli National Park in Eurasian Ecological Security and the Critical Importance of Fire Prevention

Eurasian Context — Strategic Ecological Position

Borjomi-Kharagauli National Park is located in the Greater Caucasus region—one of the most vital biogeographic zones recognized as a connecting link among global ecosystems. Its geographic position makes it a key ecological corridor linking the Black Sea and Caspian Sea basins, the ecosystems of Armenia, Azerbaijan, Russia, and Turkey, and it bridges the biodiversity between Europe and Asia.

Therefore, the park:

- Absorbs and stores atmospheric carbon dioxide (CO_2), contributing to global climate mitigation.
- Serves as an essential habitat for species migrating across Eurasia.
- Maintains air and water quality not only locally but across the South Caucasus.

International Obligations and Regulations

The park's protection and fire prevention efforts align with the following international frameworks:

- **Bern Convention** (1979)
  Requires the protection of natural habitats and migratory species.
- **Emerald Network Standards**
  Borjomi-Kharagauli is part of this network, granting it Pan-European conservation status.
- **Sendai Framework for Disaster Risk Reduction (2015–2030)**
  Emphasizes the role of early warning and disaster prevention systems.
- **EU Green Deal and Natura 2000 Goals**
  Support sustainable forest resource management in line with the project objectives.

2. Problem Statement

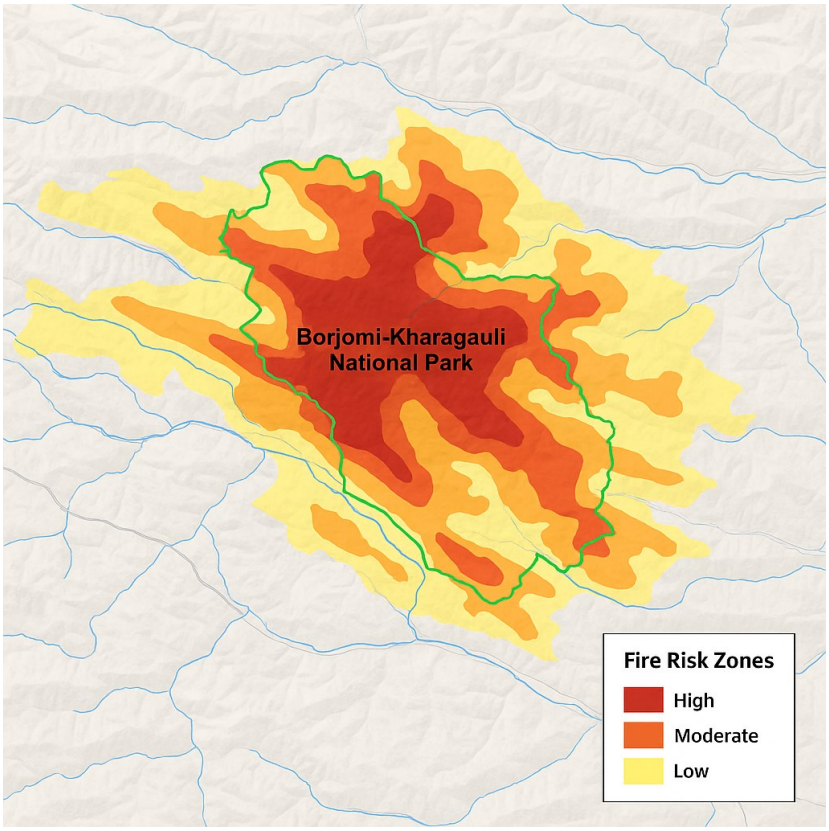
What Threats the Park Protects the Region From

Aggravation of Climate Disasters:
The park's forests act as a natural buffer that regulates the microclimate and mitigates droughts, storms, and erosion. Forest destruction increases environmental pressure.

Carbon Emissions Control:
Wildfires are a major uncontrolled source of CO_2 emissions. Borjomi's forests function as carbon sinks, reducing regional emissions.

Cross-border Biodiversity Conservation:
The park is a habitat for migratory species across Eurasia (e.g., birds and large mammals). For them, forested zones are irreplaceable.

Prevention of Soil Erosion and Water Pollution:
Damage to forests increases the instability of soil and risks riverbed degradation, affecting aquatic ecosystems including the Black Sea basin.



Pic.2 - Fire risk zones or carbon emission model

Ecological Risks from Wildfires in the Park

- **Catastrophic Loss of Biodiversity:**
  Fires destroy rare vegetation and threaten endemic and relict species (e.g., unique coniferous forests of Borjomi).
- **Ecosystem Degradation and Delayed Recovery:**
  Full forest regeneration takes decades. Recurrent fires hinder that process.
- **Negative Impact on Global Climate:**
  One large wildfire can release carbon stored over decades, intensifying global warming.
- **Transboundary Threats:**
  Smoke, toxic particles, and pollutants spread easily to neighboring countries, increasing regional environmental and political tensions.

Why Prevention is Critically Important

- **Time is Critical:**
  Wildfires spread rapidly. Delayed responses result in irreversible damage. Early warning systems safeguard ecosystem resilience.
- **Energy and Cost Efficiency:**
  Prevention is far less costly than managing the aftermath of wildfires (which requires technical, human, and restoration resources).
- **Compliance with International Environmental Obligations:**
  As part of the EU Neighborhood Policy and the Bern Convention, Georgia must take effective action, as supported by project RFP 3100005138.
- **Technological Sovereignty and Resilience:**
  A national monitoring system ensures independent and timely response, empowering local agencies in disaster risk management.

3. Opportunity

Through the **UNEP Project RFP 3100005138** several technical solutions for detection and early warning of forest fires were benchmarked and following consultations with main stake holders, a system was developed and implemented as a pilot project.

The system is already operational in Abastumani, with two surveillance points established:

Zekari Pass:

- A 6-meter communication tower constructed
- Lightning rod installed
- Secure room built
- Solar power supply system installed

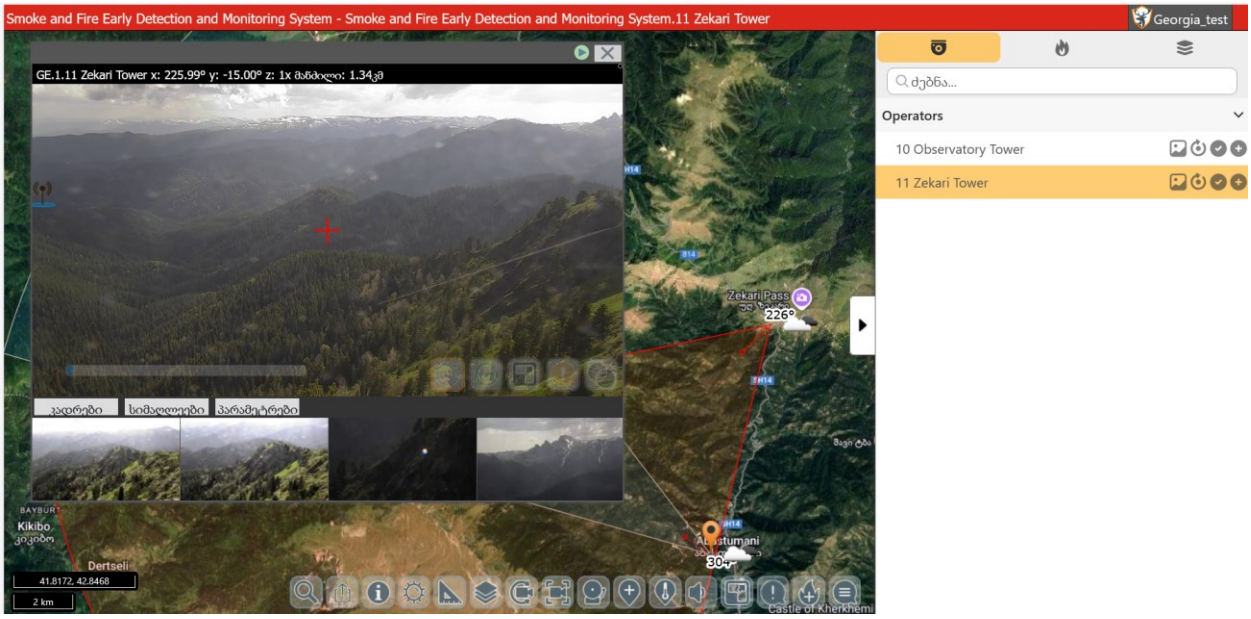
- Stable internet connection provided
- Forest monitoring video camera installed
- Security camera installed for perimeter surveillance

Abastumani Observatory:

- A forest monitoring video camera installed at a height of 22 meters on an existing tower

Both cameras are integrated into the central system Smoke and Fire Detection System (see Figure 1) and provide 24/7 forest area monitoring:

- Zekari camera: covers 7,700 hectares
- Observatory camera: covers 4,100 hectares



Pic. 3 – Position of existing cameras

The technical solution is suitable for the natural conditions as well as for the institutional capacity of the natural protected area administration, so it can be up scaled in order to cover the whole area of the National Park.

A major benefit is the fact that the software component of the system that was developed within the UNEP Project RFP 3100005138 can be used for the scale up solution without any additional costs. All forest monitoring video cameras installed in the Borjomi area will be integrated into the existing Smoke and Fire Monitoring System.

4. The Proposed Technical Solution

The early smoke and fire detection is carried out through selected video cameras that monitor the forest area with a 360-degree field of view and transmit real-time video footage to a centralized system. This central system uses artificial intelligence tools to analyze the video stream and automatically detect smoke and fire.

The core of the system is a data processing center – a complex of servers and software. The servers process, store, and analyze the data received from the cameras, calculate and map relevant information, manage routing and security, and respond to user requests.

Video cameras can be installed on towers or any suitable structures. The placement of cameras is determined using Geographic Information Systems (GIS), which identify optimal coverage zones based on visibility of high-risk areas. Key factors considered include tower coordinates and height, forest flammability, terrain, atmospheric transparency, and minimization of high-maintenance locations. All cameras are integrated into a unified system. Uninterrupted power supply and stable internet connectivity are essential for their operation.

To ensure full functionality of the system in protected areas, the following infrastructure is required:

- Mast for video camera installation
- Lightning protection system
- Solar power system
- Secure cabinet/room for active equipment
- Forest monitoring video camera
- Security video cameras for the tower's perimeter
- Communication equipment for internet connectivity
- The fencing of the constructed infrastructure area.

Selected Locations

To ensure monitoring of the designated area, project planning has been completed, and twelve locations have been identified. The twelve new video cameras will be integrated into the existing Smoke and Fire Detection System.

Pic. 4 - Map of selected mast locations

Table1. table of coordinates and height of selected masts

N	Mast Name	Mast height, M	Mast new or existing	Lattitude DMS	Longitude DMS
1	Mast N1	30	New	41°50'28.59"N	43°16'24.09"E
2	Mast N2	10	New	41°46'4.37"N	43° 1'13.29"E
3	Mast N3	10	New	41°49'25.96"N	43°13'13.87"E
4	Mast N4	40	New	41°51'55.05"N	43°21'7.54"E
5	Mast N5-Amarati	10	New	41°48'56.82"N	43° 7'31.99"E
6	Mast N6	10	New	41°49'22.23"N	43°34'6.09"E
7	Mast N7-Gvirini	10	New	41°52'14.53"N	43°28'58.56"E

8	Mast N8-Kokhta	10	**Existing**	41°44'8.99"N	43°33'12.74"E
9	Mast N9-Oshora	10	New	41°41'2.41"N	43°15'1.02"E
10	Mast N10-Tsikhisdziri	10	New	41°49'32.68"N	42°58'17.87"E
11	Mast N11-Lomisi	10	New	41°52'2.72"N	43°14'37.62"E
12	Mast N12	10	**Existing**	41°49'26.12"N	43°22'58.90"E

Each of the designated masts will be equipped with the following:

A forest monitoring video camera with a mounting bracket (total weight: 7 kg)

A communication antenna from the internet provider (1 meter in diameter)

A security camera for monitoring the surrounding area (local surveillance), total weight 2 kg

A 6-meter-high tower has been installed at the Zekari Pass (see Pic. N3) with the following key specifications:

Due to the challenging geographical location, the tower is divided into 5 sections and assembled on-site.

Main structure: Metal angle profile 50/3 mm; square tube 30/20/3 mm; fully metal construction using electric welding technique.

The tower is coated with anti-corrosion paint.

A foundation has been constructed for the tower: the rocky soil was drilled, and 18 mm diameter metal anchors were installed using a special chemical solution, followed by concrete casting.

The tower is further reinforced with additional anchors using 10 mm diameter galvanized cables.

An independent grounding circuit has been installed for the tower.

A mounting bracket has been installed for the video camera.

Pic. 5 - Zekari pass mast

Communication masts of appropriate heights (see Table 1) are to be installed at the twelve selected locations based on the same construction principles described above.

It is mandatory to install a **lightning protection system** (higher than the mast itself), either on the tower or in the immediate vicinity, with the following specifications:

- **Active Lightning Rod:** Forend Petex L E.S.E Air Terminal, ΔT = 60 µs, compliant with NF C 17-102:2011
- **Support Pole:** 9-meter galvanized steel pipe, diameter 63 mm
- **Foundation Construction** for the lightning rod support structure
- **Reinforcement:** Galvanized guy wires, diameter 8–10 mm
- **Conductor:** Specialized insulated copper conductor LICON FRND 35 - HVI conductor
- **Wall Mounts** for the HVI conductor
- **Electrode:** Copper-plated, diameter 20 mm, length 1.5 m
- **Clamp:** For connecting the electrode to the grounding strip
- **Drilling of rocky soil** for the electrode and filling with special compound
- **Grounding Strip:** Galvanized strip 4x40 mm^2
- **Insulation Tape:** Special-purpose
- **Grounding Terminal Connector**
- **Grounding Inspection Well**
- **Lightning Counter**

The grounding circuit for the lightning protection system **must not intersect** with the grounding systems of the tower or the protected cabinet/room

Grounding resistance measurement must be conducted in accordance with **ISO 17025 standard**

A **compliance report must be issued by an accredited laboratory**

After the installation of the **solar power system** and the **secured cabinet/room** near the tower, the entire constructed infrastructure must be **fenced off**.

Requirements for the Power System:

Required power capacity per mast:

Mast name	**Magti Comsuption per Site, W**	**Other Equipment**	**SUM**
Mast N1	75	130	**205**
Mast N2	75	130	**205**
Mast N3	75	130	**205**
Mast N4	75	130	**205**
Mast N5-Amarati	75	130	**205**
Mast N6	75	130	**205**
Mast N7-Gvirini	75	130	**205**
Mast N8-Kokhta	has an electric power supply system.		
Mast N9-Oshora	75	130	**205**
Mast N10-Tsikhisdziri	75	130	**205**
Mast N11-Lomisi	75	130	**205**
Mast N12	75	130	**205**

Required voltage: 20–60 VDC or 220 VAC

The number of panels must ensure system charging even during short daylight hours

The system must provide uninterrupted power supply for up to 7 days during poor weather conditions (e.g., cloud cover, limited sunlight)

Battery protection and charge balancing must be ensured

System monitoring must be available via the internet, including:

Input charging power from panels

Load consumption

Discharge levels

Remaining battery capacity (with the ability to forecast how long the system will remain operational during poor weather when full charging is not possible)

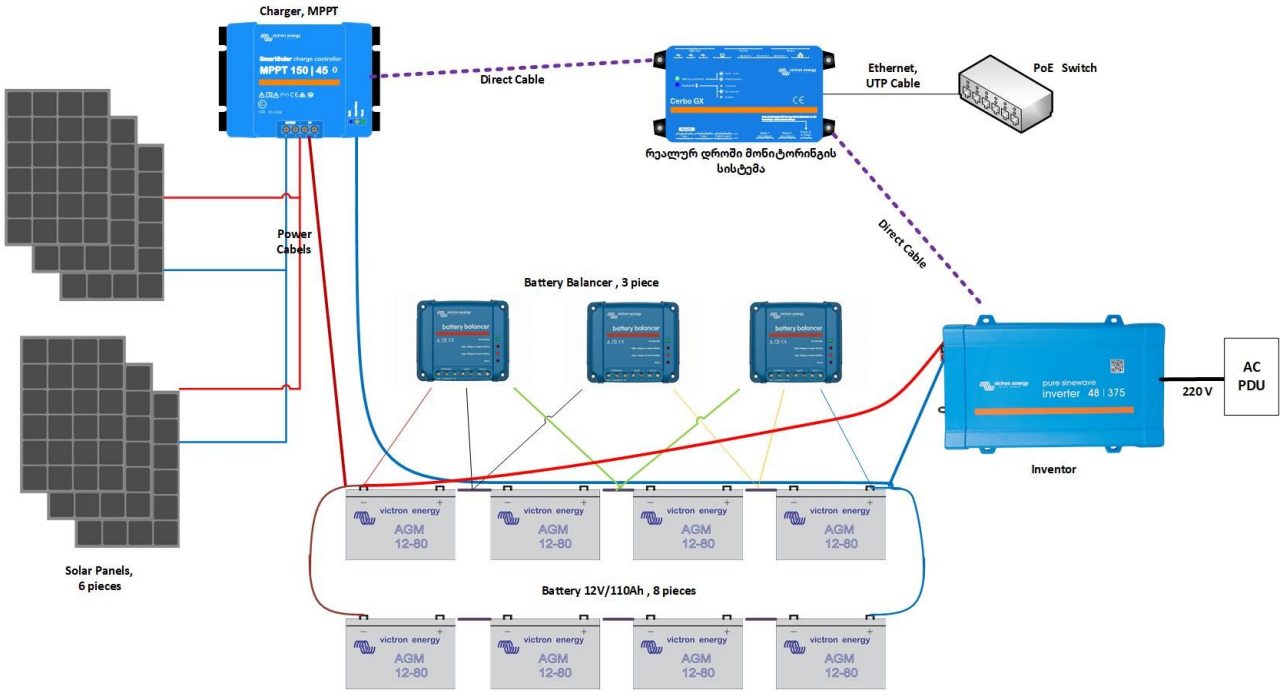
Panels must be installed in the vicinity of the tower

A complete power distribution setup must be built: including a PDU, inverter, and internal power network (AC or DC)

The electrical power system must be fully tested and ensure reliable operation of the entire system

All system components must have a minimum 1-year warranty

Upon completion of installation, technical drawings and documentation must be provided



Pic. 6 – Solar panels system diagram

Secure room/equipment cabinet

A secured room or cabinet will be installed near the tower with the following specifications:

Minimum dimensions: 150 x 150 x 200 cm

The following equipment will be housed inside:

a. Batteries
b. Solar panel equipment – panel and battery management system
c. Electrical distribution board with circuit breakers/switches
d. Networking equipment – internet/VPN router, switch, Silknet/Magti router
e. Power supply unit for the forest monitoring video camera – AXIS camera PoE device
f. Power supply for the security cameras
g. Indoor security camera for monitoring the interior space

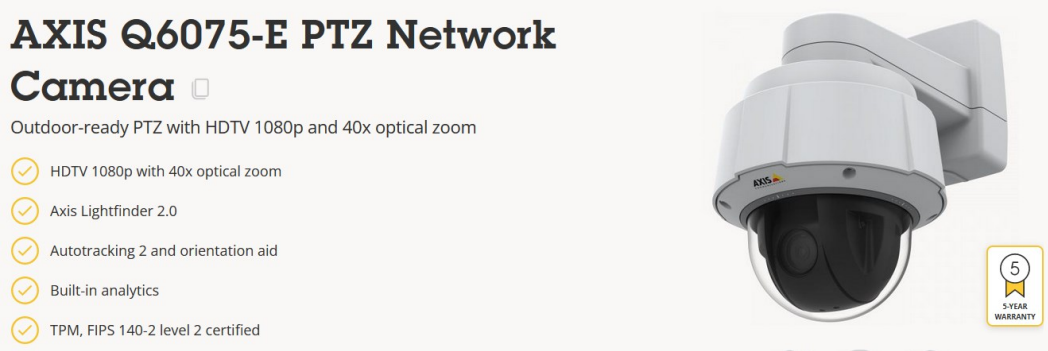
Interior shelving will be installed to accommodate the batteries and equipment.

Pic.7 – Secure room/equipment cabinet

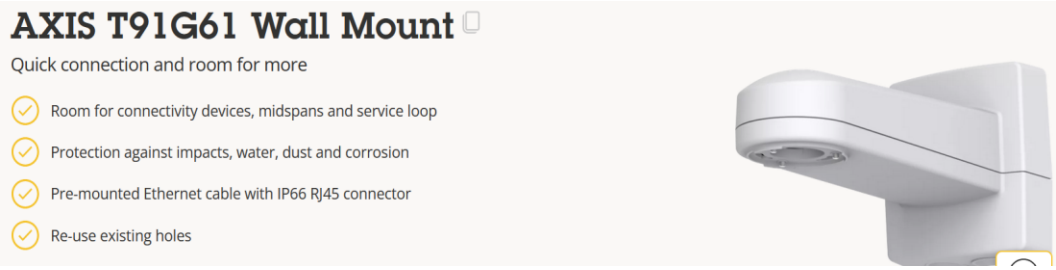
Video Cameras

Video Cameras for the Fire and Smoke Detection System will be installed on the selected Towers:

AXIS Q6075-E PTZ Network Camera , https://www.axis.com/products/axis-q6075-e#technical-specifications



Wall Mount - AXIS T91G61 Wall Mount, https://www.axis.com/products/axis-t91g61-wall-mount



All three video cameras will be integrated into the existing Fire and Smoke Detection System, providing access to designated Kolkheti Park personnel. Staff members will receive training on system operation and will be provided with user instructions.

Security Cameras for the Tower Area

To ensure security in the vicinity of the tower, an outdoor security camera will be installed on the tower. For monitoring the interior of a secured room or cabinet, an indoor-use camera will be installed. All security cameras will be connected to a video surveillance system, which will be located at the Borjomi Protected Area administration building. Authorized staff members will have appropriate access to this system.

Communication Equipment and Internet Connection

Each selected location/tower must be provided with an uninterrupted internet connection, with a minimum bandwidth of 15 Mbps. A local area network (LAN) must be established, and the following devices must be connected to the internal network:

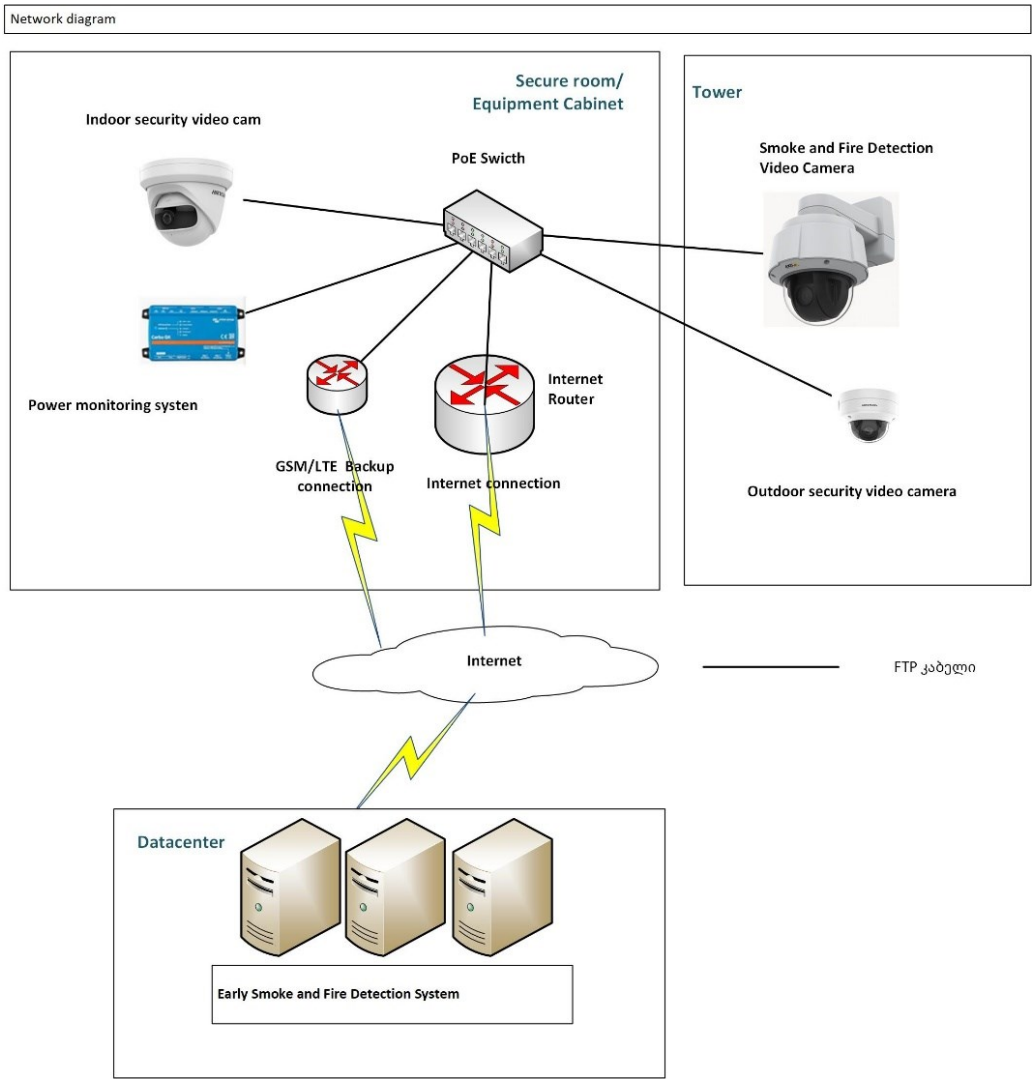
Forest monitoring video camera;

Local/perimeter security video cameras;

Solar panel management and monitoring system.

Through the internet connection, the forest monitoring camera must be integrated into the existing Fire and Smoke Detection System (Central Server).

See Pic.8 for a typical diagram of the internet-computer network of a tower located in the wild area.



5. Cost Estimate of Infrastrcture

Mast, lightning protection system and fence, 10 locations:

N	Mast Name	Mast height, M	Mast new or existing	Mast, lightning protection system and fence (USD)
1	Mast N1	30	New	65,000.00
2	Mast N2	10	New	30,000.00
3	Mast N3	10	New	30,000.00
4	Mast N4	40	New	75,000.00
5	Mast N5-Amarati	10	New	30,000.00
6	Mast N6	10	New	30,000.00
7	Mast N7-Gvirini	10	New	30,000.00
8	Mast N8-Kokhta	10	**Existing**	-
9	Mast N9-Oshora	10	New	30,000.00
10	Mast N10-Tsikhisdziri	10	New	30,000.00
11	Mast N11-Lomisi	10	New	30,000.00
12	Mast N12	10	**Existing**	-
SUM				380,000.00

Solar Panels System and Secure Room/Equipment Cabinet, 11 locations:

N	Description	Qtty	Unit price (USD)	Sum (USD)
1	Solar panels LONGI Solar 610 Wp	6	132.62	795.70
2	MUST PV18-5248 pro (5.2KW), Battery Mgm Syst, Newmax, 8 battery sets	1	2,757.40	2,757.40
3	AC DC cables, cable channels and other equipment	1	281.67	281.67
4	Secure room, equipment cabinet	1	2,796.61	2,796.61
5	Remote monitoring tools	1	1,200.00	1,200.00
6	Environment monitoring equipment	1	1,100.00	1,100.00
7	Installation, configuration cost	1	7,584.75	7,584.75
Sum, without VAT				16,516.13
VAT			**18%**	2,972.90

One Tower, Solar Panel System and SecureRoom/Equipment Cabinet	19,489.03

	Total, 11* masts , Solar Panels System and Secure room/equipment cabinet	**11**		**214,379.33**

* Mast N8-Kokhta has an electric power supply system.

Smoke and Fire Detection Video Cameras and Central Management System

№	Description	Qtty	Unit price	Sum
1	AXIS Q6075-E PTZ Network Camera Video Camera	12	$ 15,859.20	$ 190,310.40
2	Wall mount- AXIS T91G61 Wall Mount			
3	Video camera installation, configuration, integration into the Central Management System, linking to the map, annual service*			
Sum, without VAT				$ 190,310.40
VAT			18%	$ 34,255.87
Total, Video Cameras for Fire and Smore Detection System				$ 224,566.27

* Please note that, starting one year after deployment in the production environment, an annual camera fee equivalent to 6,026 USD will apply. The amount will be calculated in GEL based on the exchange rate set by the National Bank of Georgia on the date of payment

Security Video Cameras

N	Description	Qtty	Unit Price (USD)	Sum (USD)
1	***OUTDoor Video Camera***			
	Video Camera IP Hikvision, DS-2CD2345G0P-I,1.68mm, 4mp, Turret, IR10m, microSD	12	450.00	5,400.00
	MICRO SD CARD HS-TF-P1/128G	12	157.00	1,884.00
	Wall Mount DS-1473ZJ-155	12	39.00	468.00
	SUM			**7,752.00**
2	***INDOOR Video Camera***			
	Video Camera IP Hikvision, DS-2CD2345G0P-I,1.68mm, 4mp, Turret, IR10m, microSD	12	240.00	2,880.00
	MICRO SD CARD HS-TF-P1/128G	12	157.00	1,884.00

	Wall Mount	12	17.00	204.00
	SUM			**4,968.00**
3	NVR, Hikvision, DS-7732NI-M4, 32ch	**1**	900.00	**900.00**
4	Video Cameras Installation, Configuration	12	1,500.00	**6,200.00**
SUM				**19,820.00**
		VAT	18%	**3,567.60**
Total, 12 Masts, Secure Video Cameras				**23,387.60**

Tower Network Equipment and Internet cost

N	Description	Qtty	Unit price, without VAT (USD)	Sum, without Vat (USD)
1	Router -Industrial router, LTE Cat 6 Router	2	620.00	1,240.00
2	Switch - industrial switch 5 10/100/1000 ports PoE+ Switch,	1	270.00	270.00
3	LAN, WAN, Internet connection installation and configuration	1	4,181.82	4,181.82
4	Internet service fee, 1 year	1	4,437.60	4,437.60
SUM, without VAT				10,129.41
VAT			18%	1,823.29
One tower network cost, with VAT				11,952.71
Total, 12 Masts network cost		**12**		143,432.51

Total Cost of Infrastructure

N	Description	Sum (USD)
1	Mast, lightning protection system and fence, 10 location	380,000.00
2	Solar Panels and Security Room/Equipment Cabinet	214,379.33
3	Fire and Smore Detection System, Video Cameras	224,566.27
4	Security Video Cameras	23,387.60

5	Mast's network and Internet connection	143,432.51
Total, 12 Masts cost		985,765.71

NB. The above estimate covers only the cost of infrastructure. Additional costs with soft components such as training sessions for the future users of the infrastructure and project management costs are not included.

6. Conclusion

The imperative of up scaling the existing project is determined by the fact that protecting the Borjomi-Kharagauli National Park is not only a national responsibility but a regional imperative. By integrating modern technology with ecological preservation, Georgia contributes to the broader goal of sustainable environmental governance in Europe and Eurasia. The park's strategic role in climate resilience, biodiversity protection, and transboundary connectivity makes it a cornerstone of long-term regional ecological stability.