ENHANCING FINANCIAL SUSTAINABILITY

OF THE PROTECTED AREAS SYSTEM IN GEORGIA

Climate Change Vulnerability Assessment and Preparation of Adaptation Plans for Pilot Target PAs in Georgia – Tusheti PAs, Kazbegi NP and Pshav-Khevsureti NP

CC Adaptation Plan for the Kazbegi NP

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Acronyms and abbreviations

AP – Adaptation Planning

APA – Agency of Protected Areas

CC – Climate Change

CCVA – Climate Change Vulnerability Assessment

CNF – Caucasus Nature Fund

CSCP – Climate-Smart Conservation Practice

GEF – Global Environment Facility

IAS – Invasive alien species

ICD – Individual capacity development

MP – Management Plan

NP – National Park

PA – Protected Area

PAAP – Protected Areas Adaptation Plan

PL – Protected Landscape

UNDP – United Nations Development Programme

UNFCCC – United Nations Framework Convention on Climate Change

VA – Vulnerability Assessment

Executive Summary

Kazbegi National Park, Pshav-Khevsureti Protected Areas and Tusheti Protected Areas (the target PAs) are important parts of Georgia's national PA system and crucially contribute to meeting national commitments under biodiversity-related multilateral environmental agreements. This requires effective management and protection against all anthropogenic threats.

According to Georgia's Fourth National Communication to UNFCCC, the country is increasingly, but not uniformly affected by climate change. Climate change also affects the ecosystems and other biodiversity of Georgia's PAs, as well as the people living around or visiting them. PA management will increasingly need to take into account their vulnerability to the changing climate and will need to adapt to it. So far, this need to adapt to climate change has not been systematically reflected in the management systems of any Georgian PAs. Therefore, the Caucasus Nature Fund has commissioned PA-specific climate change adaptation plans (PAAPs) for Kazbegi National Park, Pshav-Khevsureti Protected Areas and Tusheti Protected Areas (the target PAs), which build on a joint climate change vulnerability assessment (CCVA) for all three target PAs together.

This document represents (a) the Adaptation strategies for the three PA-specific PAAPs, (b) a PA-specific adaptation plan for Kazbegi NP and (c) detailed plans for high priority adaptation interventions for Kazbegi NP, which were tailored to the needs and situation of the PA after the Consultation Workshop and meeting with the PA administration.

Adaptation strategies for the three PA-specific PAAPs

The draft planning template considers 35 specific adaptation strategies for identified vulnerabilities of the main biodiversity values of the three target PAs, plus another six broader, institutional interventions to strengthen the overall adaptive management capacity of the target PAs in the face of climate change (Section 3). These were identified based on the CCVA results during a participatory adaptation planning workshop on 24 February 2022 and subsequent in-depth analysis of literature on climate change adaptation measures used in PAs elsewhere (Section 2). It also provides a justification why no adjustments to the major conservation values, long-term conservation goals or demarcation of the target PAs are considered necessary because of climate change at this stage.

The 35 specific draft adaptation strategies were checked systematically based on the criteria of practical focus, feasibility, likely effectiveness, scenario robustness, and urgency (Appendix 1). As a result, up to 13 of them were identified as for immediate full-scale implementation, whereas another 13 will require further initial exploration, feasibility testing and piloting before they can be implemented at full scale. Two draft strategies were deemed not feasible/sensible, and another seven were deemed not appropriate at this stage but should be reconsidered again in about a decade (Section 3.2).

Most of the specific adaptation strategies address vulnerabilities of (sub-)alpine grasslands and mountain forest, with additional strategies focusing on the (sub-)nival zone, high mountain peatlands, rivers and streams, as well as specific flora and fauna.

In terms of their intervention logic, they either address interactive non-climate threats or non-climate threats likely to become aggravated by climate change, aim at improved viability of conservation values, interfere with the bio-physical factors functionally linking climate change to the viability of conservation values, or address potential, and potentially damaging, maladaptation by humans. Most of the strategies

proposed to support adaptation of biodiversity values have tangible collateral benefits to human resource users, local communities and visitors (Section 3.3).

The planning template also includes a specific proposal how to integrate those adaptation strategies that are finally agreed into the existing management systems of the target PAs (Section 3.5).

CC Adaptation Plan for Kazbegi NP

The CC Adaptation Action Plan for Kazbegi NP (Section 4) provides adaptation strategies relevant to Kazbegi NP, which were defined based on the proposed 35 strategies during the consultation meeting with Kazbegi NP PAs Administration. The Action Plan indicates specific activities under each strategy, interdependence on other strategies/activities, responsible institutions and the proposed period of implementation.

Detailed plans for high priority adaptation interventions for Kazbegi NP

Detailed plans are provided for three priority strategies (Section 5) selected by the PA Administration during a consultations meeting in July 2022. The plan provides a description of the strategy, a theory of change with indicators and activities, objectives, detailed activities and the needed budget.

1 Introduction

1.1 Background and justification

Climate change and human-induced biodiversity loss threaten to jointly degrade the ecological fabric of the planet (Korn et al. 2014). Because of the multiple interdependencies between climate change and biodiversity loss, there is a strong agreement that both threats need to be tackled jointly, and in a coordinated manner. See Pörtner et al. (2021) for a summary of the current state of this discussion. This agreement is starting to be translated into specific practical steps to meet the full potential of biodiversity and ecosystems for climate change mitigation and adaptation, and to fully take into account climate change impacts in biodiversity conservation practice (e. g. Arneth et al. 2020).

Georgia is of global importance for biodiversity conservation and increasingly affected by climate change. Climate change impacts on its biodiversity and protected areas have been discussed in the past, but – in spite of the realization that climate change cannot be ignored any longer – no systematic attempts to make the management systems of Georgia's protected areas climate-sensitive have been made.

The GEF/UNDP project "Enhancing financial sustainability of the Protected Areas (PA) system in Georgia" is a five-year "technical assistance" project financed by the GEF through the United Nations Development Programme (UNDP) in Georgia, with resources allocated from the GEF Operational Program for Biodiversity. The project objective is "To secure long-term financial sustainability and effective management to conserve globally significant biodiversity of target protected areas in Georgia". The ability of Georgian PAs to respond to climate change impacts on their biodiversity, but also ecosystem service provision and human wellbeing, falls squarely within the "effective management" dimension of this objective.

1.2 Goals and objectives

The ultimate goal to which the assignment aims to contribute is that the mitigation and adaptation capacity of the ecosystems in Georgian PAs, as well as the resilience of communities and society directly and indirectly benefiting from ecosystem services provided by natural ecosystems in PAs, are increased.

To contribute to this goal, we were tasked to develop and pilot – for the first time in Georgia – a participatory, science-based methodology for a PA climate change vulnerability assessment (CCVA) and PA-specific climate change adaptation planning (PAAPs) for three continuous PAs in the Central Greater Caucasus – Kazbegi National Park, Pshav-Khevsureti Protected Areas and Tusheti Protected Areas.

This output is the climate change adaptation plan for Kazbegi National Park, which was compiled based on the CCVA and generic adaptation plan, and detailed plans for high priority adaptation interventions, elaborated after the meeting with Kazbegi NP Administration in July 2022.

1.3 Adaptation to vulnerabilities, strategic adjustments and adaptation capacity

There are three levels on which PA management can be adapted to climate change. All have been considered during the PAAP process:

1. We can identify, design and plan specific measures to respond to identified direct and indirect climate change vulnerabilities (see Section 2.1).
2. We can adapt the long-term conservation goals and programme objectives of management plans so that they remain attainable even under the conditions of observed or projected climate change.
3. PA administrations can be supported in strengthening their adaptive management capacity so that they become capable of not only dealing with the climate change vulnerabilities that have already been identified (e. g. in the CCVA of this assignment), but also of identifying and responding to additional vulnerabilities that may arise in the future.

The third option is particularly important if there is little certainty about the course of future climate and its impacts on conservation values. This option usually comprises strengthened and more climate-focused monitoring (i. e. integration of indicators for possible but unconfirmed climate change vulnerabilities into PA monitoring programmes), more conscious and institutionalized learning and reflection based on management experience and monitoring results, and regular, formalized, informed revisions of existing management systems to adapt to changed conditions or improved understanding. This approach usually goes hand in hand with organizational adjustments to better integrate management, learning and decision making, e. g. through decentralization and rigorous application of the subsidiarity principle.

1.4 The CCVA for the three target PAs as a basis of the PAAP

For the identification of the adaptation strategies of all three types above an understanding of climate vulnerabilities including the uncertainty involved is crucial. The identification of specific climate change impacts and vulnerability aspects – exposure, sensitivity, and adaptive capacity - provides the basis for identifying adaptation strategies and actions (Stein et al 2014). A participatory, science-based methodology was used to assess the climate change vulnerability of the conservation values of the target PAs. This vulnerability assessment was carried out jointly for Kazbegi National Park, Pshav-Khevsureti Protected Areas and Tusheti Protected Areas and has been submitted as a separate output of the assignment.

2 Methodology

Our PA adaptation planning methodology broadly follows the CSCP approach (Garstecki et al. 2020a). It combines a review and refinement of the value specific situation models from the CCVA of the target PAs, an in-depth literature review to identify possible adaptation options used elsewhere, a participatory brainstorming of possible interventions for some vulnerabilities during the PA AP workshop on 24 February 2022[1], the rigorous testing of draft adaptation measures identified in this way based on criteria and a test of their underlying theory of change, and basic implementation planning for high-priority measures.

2.1 Review and adjustment of the value-specific CCVAs for the target PAs

We used the CCVA is the basis of PA adaptation planning because it identifies the climate change vulnerabilities of the biodiversity values of the PA, and the factors that can be used as intervention points for CC adaptation measures (Figures 2-8).

To prepare for the actual adaptation planning process, we first reviewed, reconsidered and in some cases slightly adjusted the situation models on the specific vulnerabilities of the main conservation values of the target PAs, as documented in the Appendix of the CCVA.

2.2 Re-consideration of conservation values and goals of PA

Before considering specific adaptation actions, we first asked whether the stated conservation values of the PA are likely to be viable at all over a timespan relevant to strategic PA planning, and if the conservation goals that are stated in the management plans of the PAs are still realistic in the light of observed or projected climate change.

This enquiry was based on the principle that no biodiversity value should be "given up" at this stage, and no conservation goal downgraded, unless it is beyond reasonable doubt that this value/goal will be unviable/unattainable because of climate change within two management plan lifespans, i. e. within 18-20 years.

Checking the need for strategic adjustments – not just adaptation measures – of PA management plans should be repeated whenever PA management plans are renewed, e. g. every 9-10 years.

2.3 Types of adaptation interventions considered

While large scale climate changes driving specific impacts on local ecosystems cannot be changed – at least not through PA management interventions – we used several other factors from the value-specific climate situation analyses (CCVA, Appendix) as intervention points for four different types of interventions to adapt PA management to identified climate change vulnerabilities (Figure 1):

[1] Not all biodiversity values with their vulnerabilities could be covered during the PAAP workshop on 24 February, because of lack of time. The workshop participants therefore agreed to task the Consultant team to brainstorm additional draft adaptation interventions using the same approach, and to consult them further as part of the draft PAAPs.

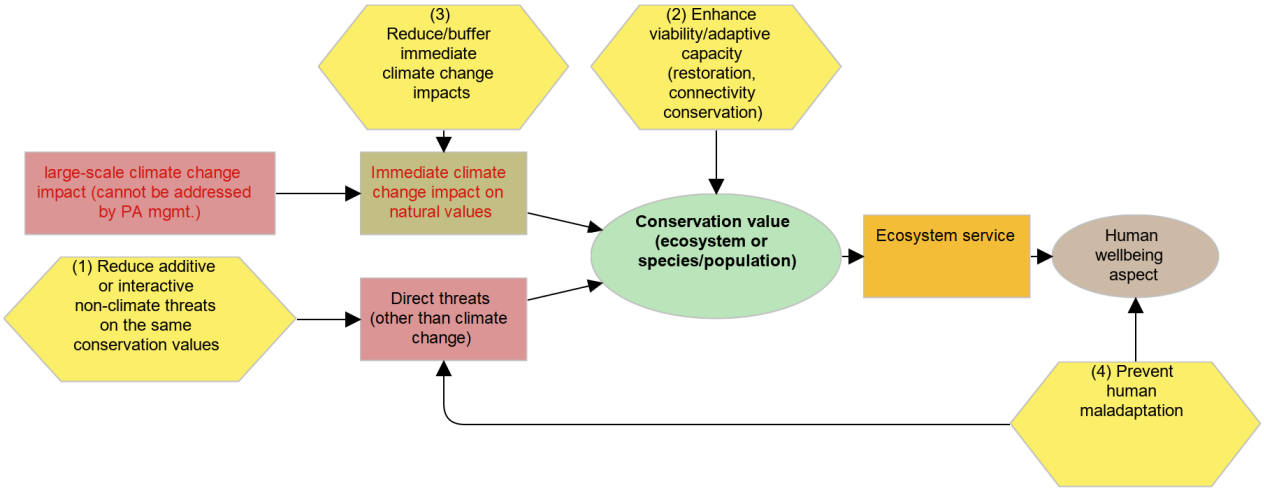

Figure 1. The four main types of climate change adaptation measures for known or inferred climate change vulnerabilities that were identified during PA adaptation planning, with their generic intervention points in the situation analysis (CCVA).

1. **Reduce interactive/additive non-climate threats:** Where climate vulnerabilities and non-climate threats interact, the vulnerability of conservation values to their combined impact can be reduced by controlling/reducing the respective non-climate threats. For example, if a warmer and wetter climate improves conditions for invasive alien species (IAS) in a forest, colonization by them can be controlled by avoiding disturbance of the existing vegetation and creation of pioneer habitats, which otherwise would allow these AIS to take hold.
2. **Enhance adaptive capacity and/or reduce sensitivity of biodiversity values:** The adaptive capacity of biota can be strengthened e. g. by restoration of ecosystems or by protecting ecological corridors which would allow adaptive migrations, gene flow and range shifts of biodiversity.
3. **Reduce or buffer immediate climate change impacts:** PA management cannot affect large-scale changes in temperature and precipitation, but it sometimes can break the chain of bio-physical triggers that functionally link these changes to the viability of conservation values. For example, if the increased frequency of extreme rainfall events and resulting floods threatens to wash away high-biodiversity value wetlands along a mountain river, upstream floodplain forests can be conserved/restored to act as a buffer against flood pulses and thereby reduce exposure of these wetlands.
4. **Support people to avoid maladaptation:** Since poorly planned adaptation efforts by humans around target PAs can further threaten biodiversity, beyond its direct vulnerability to climate change, this indirect vulnerability can be addressed by supporting these humans to avoid this maladaptation. For example, shrinking or degraded (sub-)alpine grasslands in the Traditional Use Zone of target PAs because of climate change could lead livestock farmers to intensify grazing in the remaining areas, thereby further enhancing degradation, food competition with wild ungulates and the mutual transmission of diseases. This can be counteracted through better value generation from livestock, promotion of alternative or complementary economic activity, and sustainable, climate sensitive pasture management.

In addition to these adaptation actions for identified vulnerabilities, we also considered broader interventions to strengthen adaptive capacity of the target PAs (cf. Section 1.3 above).

2.4 Desktop research on possible adaptation interventions

We reviewed and analysed national documentations, scientific literature, CC Adaptation Manuals, websites, specific examples from ongoing/implemented projects on adaptation strategies/measure of relevant ecosystem types and species mainly from comparable high-mountain regions. This we then used as a basis for further indentifying potentially suitable adaptation strategies for the target PA.

2.5 Participatory brainstorming of potential adaptation interventions

Potential adaptation strategies for the most important conservation values were brainstormed by the participants of the Adaptation Planning Workshop on 24 February 2022. Strategies for additional conservation values were brainstormed and drafted by the consultant team.

The participants jointly looked at the value-specific climate situation models (on a virtual whiteboard), first discussed their factual correctness, and then thought how the various factors in these models could be changed through interventions of the four broad types discussed. The compilation of possible adaptation strategies from the literature was used to inform the development of adaptation options.

Identified draft adaptation strategies were documented on the whiteboard (with their intervention points), described as concisely as possible, and subjected to further testing as per Section 2.6.

2.6 Evaluation of potential adaptation interventions based on criteria

In order to select the most effective and feasible adaptation strategies from the options identified during the participatory brainstorming, we first rated them based on the criteria of focus (i. e., whether they set out a concrete course of action), potential impact, and technical, social as well as financial feasibility, following Garstecki et al. (2020a/b) and generic Conservation Standards procedures (CMP 2021).

We also considered the validity of the underlying theories of change of those adaptation strategies that passed the criteria check – i.e., whether they are really likely to contribute to conservation of the main biodiversity and human wellbeing values under observed and projected climate change. This led to a list of prioritized adaptation strategies for the PA, the core part of their draft PA-APs.

2.7 Implementation planning for adaptation interventions

Once the draft adaptation interventions have been discussed during the Consultation workshop and with the PA administrations, we will also draft simple implementation plans for high-priority adaptation strategies, for further discussion with CNF, APA and the relevant PA administration. These will provide detail on specific actions, responsibilities, as well as funding, human resources input and other requirements.

2.8 Strengthening the adaptive management capacity of the target PA

In addition to adaptation measures to already identified climate change vulnerabilities, we also identified interventions on the institutional adaptation of the administration of the target PA. These set out a way in

which the management of the target PA can be made more strategic and adaptive, so that the administration will be in a better position to respond to any future vulnerabilities – be they known already or not.

2.9 Inclusion of adaptation into the existing management system

Climate change adaptation planning will have the greatest impact on the overall management of the target PA if it is closely integrated into its existing management system. Based on an analysis of the existing management plan, we devised a detailed proposal how this can be achieved.

3 Adaptation strategies for the three PA-specific PAAPs

Section 3 is the core section of the PAAP. Section 3.1 reports why no changes to the overall strategic framework for PA management in the target areas (i. e., main conservation values, long-term conservation goals, high-level programme objectives, and PA demarcation as defined by the management plan of the target PA) are proposed.

Sections 3.2 – list those PA adaptation strategies that were considered suitable for immediate implementation or further feasibility testing after a criteria-based rating (Appendix 1), for ecosystems, fauna and flora, respectively. The section lists additionally potential adaptation strategies that were brainstormed during the PA adaptation planning workshop or subsequent literature analysis but did not pass the criteria-based rating test for immediate implementation or testing, are listed in.

Section 3.3 briefly discusses the relevance of these adaptation strategies to human use of natural resources. This section focuses on those aspects of the necessary climate change adaptation of local communities around the target PA that are directly connected to the use of the PA (usually in the traditional use zone and visitor zone). Devising a full ecosystem-based adaptation plan for these communities would go beyond the scope of this assignment.

Besides specific adaptation measures to already identified climate change vulnerabilities, there are also more general interventions in which the management of the target PA can be made more strategic and adaptive, so that the administration will be in a better position to respond to any future vulnerabilities – be there known already or not. These interventions are presented in Section 3.4.

Section 3.5 proposes a way to integrate the climate change adaptation strategies identified into the existing management system of the target PA.

3.1 Adjustment of scope and goals of the target PA

After careful consideration of the VA and in view of the recent management planning process, the stakeholders at the PA Adaptation Planning Workshop in February 2022 decided ***not*** to propose any changes to the overall strategic framework for PA management in the target areas (i. e., main conservation values, long-term conservation goals, objectives and PA demarcation as defined by the management plan of the target PA), because of the following reasons:

- The VA does not identify any critical short-term vulnerabilities of any conservation values of the target PA, which would make it clear beyond reasonable doubt that any of the values are irreversibly lost or goals unattainable.
- Many of the vulnerabilities identified in the VA for the next decade(s) are highly scenario specific. It would not make sense to abandon any values or goals at this stage, without knowing for sure what the real future will look like in comparison to the scenarios.
- The VA and PA APs that have been compiled in the course of this assignment will sensitize PA managers and the wider PA community to climate change impacts on all three target PAs, and will contribute to better monitoring and additional long-term scientific studies. An informed decision about adjustments of the high-level strategic framework (values, goals, objectives) of the management plan for the target PA will be much easier once this has happened.

- The high-level management strategies of this target PA and the other target PAs have been developed and consulted only very recently. Proposing major changes now might confuse managers and stakeholders, and lead to disengagement and loss of ownership of the recently agreed management frameworks.

At the same time, there is agreement that changes in the strategic framework (values, goals, objectives) of the target PAs should not be excluded for the medium-term future, e. g. for the next major revision of the management plan in about a decade.

3.2 Climate change adaptation strategies for ecosystems, flora and fauna

Of the 35 climate change adaptation strategies initially identified during the PA adaptation workshop and subsequent literature analysis, (up to) 13 are proposed for immediate full implementation following a systematic criteria based rating, and subject to further consultation. Another 13 strategies should be further explored, feasibility tested and piloted, for subsequent decision making on application at scale. The Other nine strategies were deemed unfeasible or not relevant at this stage, but they are reported here, as they might be deemed relevant for possible implementation upon re-inspection in the future..

The criteria for the above classification of draft strategies and their implementation are documented in Appendix 1.

The below sections 3.2.1 and 3.2.2 describe the strategies belonging to the first two types. Their intervention points in the situation models for the main conservation values are also illustrated. The strategies identified as unfeasible or not relevant at this are given in section 3.2.3 and 3.2.4.

The numbering of this list does not start at "Number 1" because some draft strategies with low numbers did not pass the criteria (section 3.2.3 and 3.2.4).

3.2.1 Strategies suitable for immediate full implementation

Applicable to (sub-)alpine grasslands and their biota (Figure 2)

- **Strategy No. 5 - Prohibit grazing on eroded slopes, regulate access, grazing and burning, and allow for pasture regeneration phases:** Eroded areas can be seen in all target PAs. Some of the patterns represent natural erosion processes, but some are caused by former or current intensive pasture use, especially in areas previously used as cultivated lands and transformed for pastures. Sometimes it is difficult to distinguish between them (Gebhard 2019, NACRES 2017). The changing climate will enhance erosion through more surface run-off (Neale et al. 2014), particular under the Sirimiri and Tropicana scenarios. Infrastructure development, unsustainable grazing and burning practices as well as an increased number of visitors accelerate the erosion and could lead to more erosion processes. Therefore, the listed measures addressing all threats shall be taken.
- **Strategy No. 7 - Map (sub-)alpine grasslands regularly used by wild ungulate and manage grazing so that contact between livestock and wild ungulates is minimized:** (Sub-)alpine grasslands are used by the wild ungulates, in some places along with the domestic animals. With the warming climate (particularly under the Tropicana and Furnace scenarios) loss of (sub-)alpine grasslands is expected. Changes in species composition towards more thermophilic (Steinbauer et al. 2018) and less cold-

adapted species (Rumpf 2018) are also expected, along with the contraction from the below because of the upward moving forest belt (Cazolla Gatti et al. 2019). In order to minimize the competition for forage and possible transmission of diseases, it is advisable to minimize the contact between them by restricting livestock grazing in the areas used by the ungulates. This may require excluding these areas from the Traditional Use Zone of the target PA, and potentially additional temporal measures. First of all, possible areas of contact between domestic livestock and wild ungulates need to be mapped.

- **Strategy No. 9 – Introduce and promote the use of electric fencing to manage grazing:** One of the options to manage the grazing is introduction/promotion of the use of electric fencing. Such practice already exists in Tusheti PL and adjacent area of Pshav-Khevsureti. Besides protection the heard/flock from predators, electric fencing gives the possibility to introduce rotational grazing, implement other grazing-related strategies (e.g. No. 5-8) and thus ensure conservation of (sub-)alpine grasslands and sustainability of the production system.

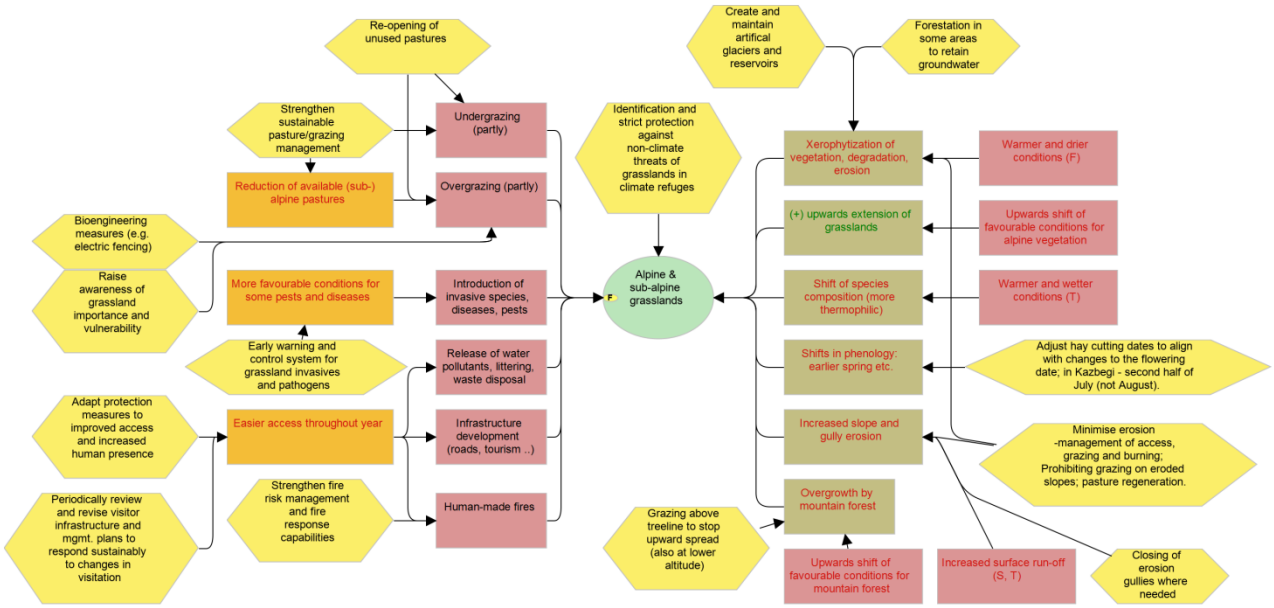

Figure 2. Adaptation strategies applicable to (sub-)alpine grasslands and their intervention points in the situation model.

- **Strategy No. 14 - Raise awareness of the importance and vulnerability of (sub-)alpine grasslands:** (Sub-)alpine grasslands are sensitive to climate change. A shift in species composition towards more thermophilic (Steinbauer et al. 2018) and less cold-adapted species (Rumpf 2018) is expected, while at the same time contraction from the below because of the upward moving forest belt (Cazolla Gatti et al. 2019). Ecosystem services provided by the grasslands are important, including supporting cattle and sheep breeding and hence the production of the dairy products in all in all PAs. All this needs to be shared with the public to raise the awareness and promote reduction of non-climate related threats, which otherwise might further aggravate climate change impacts.

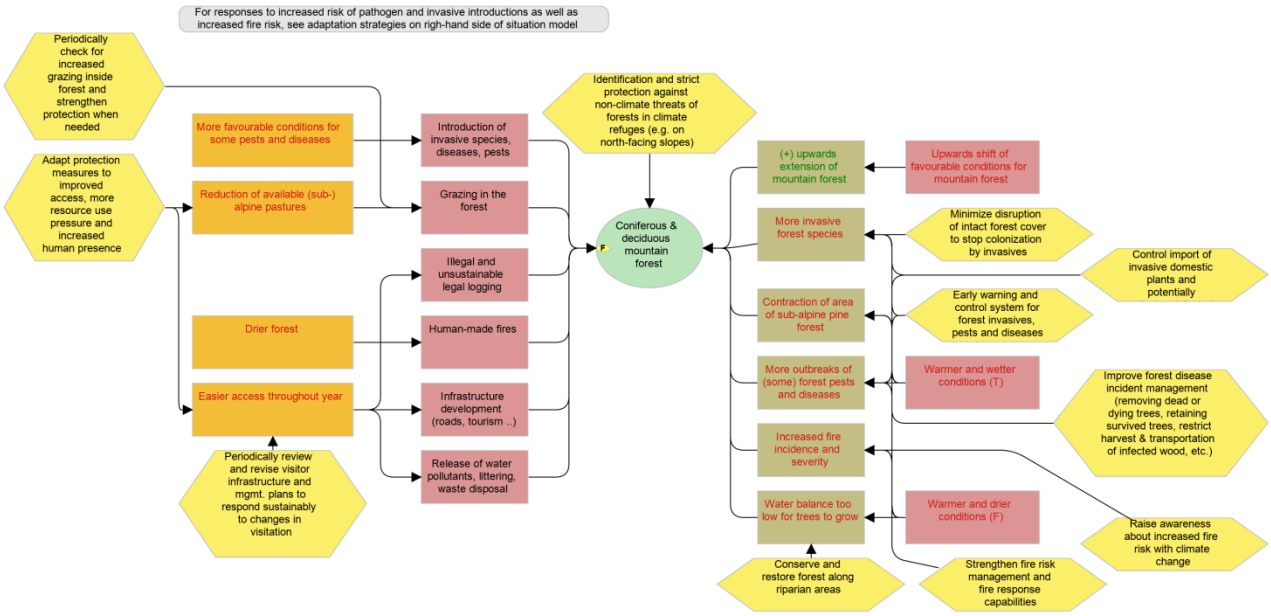

Figure 3. Adaptation strategies applicable to forest and their intervention points in the situation model.

Applicable to forest (and partly grasslands, peatlands) with their biota (Figure 3)

- **Strategy No. 15 - Establish an early warning system and capacity to control newly arising forest plant pathogens and pests:** Forest pest and pathogens are existing threat to the forest of target PAs, especially for coniferous forest. Climate change impacts on the incidence and severity of insect pests and forest diseases strongly depend on the lifecycle traits of the specific pests or pathogens. CC might create favourable conditions for outbreaks of existing pests and diseases; additionally stress to the forest tree species will increased its impact (Pureswaran et al. 2018, Sturrock et al. 2011). Along with existing pest and pathogens emergence of new ones might be also possible (UNDP 2021). Furthermore, the area impacted by the pest and diseases makes forests more vulnerable to fires. So, it is important to establishment early warning and control system for pests and diseases, including studies of existing pests and pathogens, monitoring, etc.
- **Strategy No. 16 – Improve forest disease incident management (removing dead or dying trees, retaining surving trees, restrict harvest and transportation of infected wood, etc.):** In order to avoid the spread of pest and pathogens several measures shall be implemented: Removing dead or dying trees in infected areas to minimize exposure of surrounding forest; during the sanitation operations, it is important to retain survivor trees of pest/disease outbreaks. Furthermore, restriction of harvesting and transportation of logs near the infected stands also will minimize spread of pests and diseases (NIACS 2022).
- **Strategy No. 17 - Minimize – through strict regulation – disruption of intact forest cover to stop colonization by invasives:** Maintaining a closed-canopy conditions to reduce the ability of light-loving invasive species to enter the understory is an important element in the fight against invasives which may otherwise encounter better conditions because of climate change. This needs to be enshrined in policies on infrastructure development and visitor management (NIACS 2022).
- **Strategy No. 18 - Strengthen fire risk management and fire response capabilities:** Fire as a significant threat to grassland, peatland and forest ecosystems and for the species of these habitats will become

more important particularly under the Furnace scenario. Fires in the target PA are usually man-made either by accident or because of the existing practices of burning pastures in adjacent areas. Direct (increasing temperature) and indirect (e.g. drying of vegetation, weakening of the plants) impact of climate change will contribute to the vulnerability and higher frequency of fires (UNPD 2021). Therefore it is important to enhance fire management. This will be achieved by elaborating fire risk management plans, establishment of voluntary groups, and conducting trainings (Neale 2014).

- **Strategy No. 19 - Raise awareness about increased fire risk with climate change:** As the most of the fire occurring in the target areas are man-made, either by incidents or because of the existing practices of burning pastures in adjacent areas, it is highly important to increase awareness (e. g. by installation of information boards, thematic meetings) on fires and climate change among different target groups (farmers, shepherds and visitors) visiting or leaving in and adjacent to protected areas.

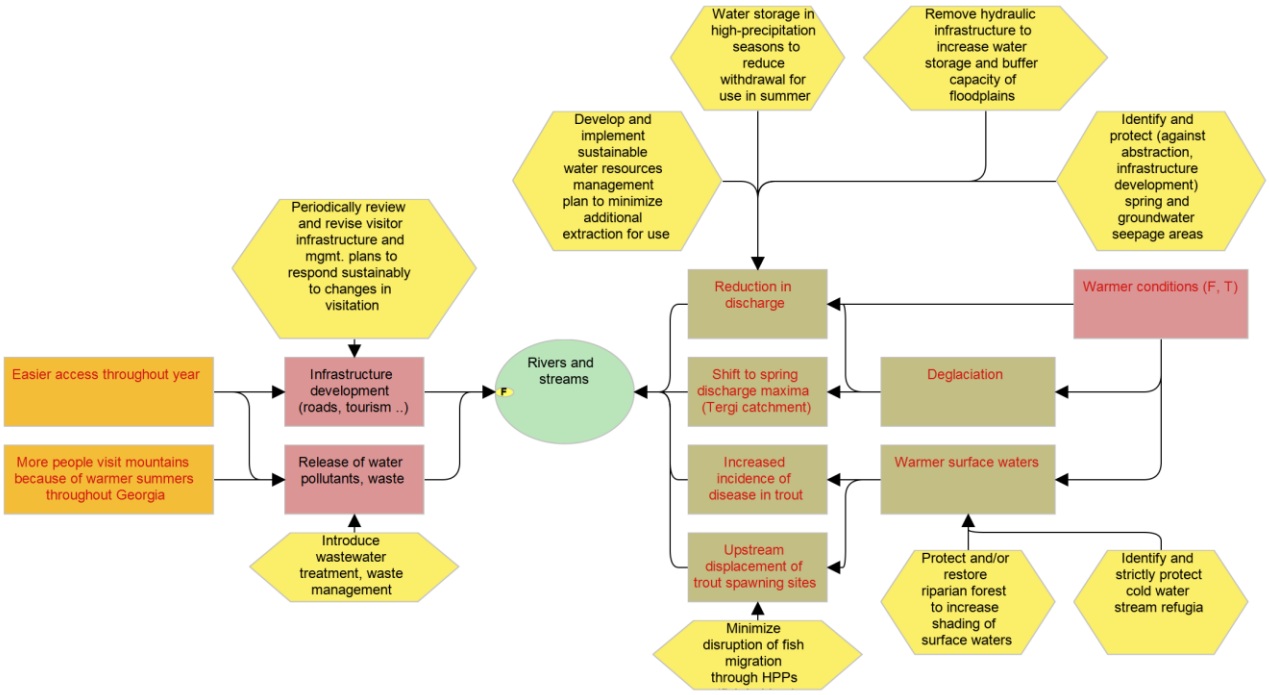

Figure 4. Adaptation strategies applicable to rivers and streams and their intervention points in the situation model.

Applicable to rivers, streams and their biota

- **Strategy No. 25 - Develop and implement a sustainable water resources management plan to minimize extraction of scarcer water for use:** Increased water scarcity is already being observed by locals in the target PA. The reduced glacial runoff and increased evapotranspiration due to higher temperature – particularly under the Furnace scenario – might exacerbate the already perceived water shortages. Therefore, the effective water management system is needed to make the most of the diminished water supply without compromising the integrity of the biodiversity values of the target PA.
- **Strategy No. 26 - Ensure that in the upper reaches of mountain streams and rivers inside PAs no damaging hydraulic infrastructure is established:** Unimpeded streams and rivers support adequate streamflows for ecosystems, buffer extreme discharge events and allow the vertical migration of

stream/river biota. The reduced glacial runoff and increased evapotranspiration due to higher temperature might exacerbate the already perceived water shortages in parts of the target area. Therefore, protection of the upper reaches of streams and rivers against damaging infrastructure is essential.

- **Strategy No. 27 - Engage downstream partners of PAs to ensure existing HPPs and other hydraulic infrastructure does not compromise migration of freshwater fauna:** Ensuring natural river processes is important for river ecosystems. Therefore any developments might constraining these processes and affect river biota. Cooperation with all relevant stakeholders should be ensured to avoid damage to the rivers, including access for the fish to the seasonal habitats.

Applicable to all ecosystems

- **Strategy No. 31 - Establish an early warning system and capacity to control invasive species:** Alien invasive species are a threat to all ecosystems which will be aggravated by a milder climate in the target PA. The risk of the colonization increases if there is also habitat and/or soil disturbance (e. g. infrastructure development, overgazing), that creates opportunities for new pioneering alien species. (Slodowicz et al. 2018). The early warning system shall consist of training of rangers to identify potential invasives using visual guides, inclusion of dedicated invasive patrols into the schedule of them, and cooperation with specialists to detect possible invasives in a timely manner. Depending on the species involved, these specialists shall also advise on appropriate pre-emptive and reactive measures against identified specific threats to the target PA.

3.2.2 Strategies suitable for immediate further exploration, feasibility testing and piloting

Applicable to (sub-)alpine grasslands (Figure 2)

- **Strategy No. 3 - Create artificial glaciers and reservoirs:** Where glaciers disappear, their modulating function on seasonal runoff from accumulated snow precipitation is lost. Downhill/downstream habitats that rely on glacial run-off for their water supply across the warmer seasons are vulnerable to this. Therefore, artificial glaciers (also called ice stupas in some areas) and reservoirs have been used to replace these disappearing glaciers, e. g. in the Himalayas (The Ice Stupa Project 2022). Seasonal reservoirs are an additional alternative. As ice stupas and reservoirs can be located at lower attitude than glacier covers and snow fences and relatively simple and robust, they are not as prohibitive in technical and financial term, but limited scalability probably constrains their use to small high-value habitats or as EbA solutions for water provision to local inhabitants, rather than as a full-scale climate-smart conservation strategy.
- **Strategy No. 6 - Use selective grazing along the advancing treeline to control the upward spread of mountain forest:** Currently, because of the reduced grazing on relatively remote areas, the forests have already started to cover areas of former grasslands (Gebhardt 2019). With the changing climate (particularly under the Tropicana and possibly under the Furnace scenario) the treeline shift will affect (sub-)alpine grasslands and may also lead to overgrowth of peatlands (Cazolla Gatti et al. 2019, Parish et al. 2008). To control the upward spread of the mountain forest and keep the grasslands open, it is necessary to concentrate grazing in such areas, possibly also using electric fencing.

- **Strategy No. 8 - Re-open and ensure access (and water availability where necessary) to currently un-used pastures:** The livestock number in the target PA has decreased in recent decades. The traditional way of land use based on vertical zoning has been abandoned in many places. The pastures that are easily accessible from the roads (often also on previously cultivated lands) are in intensive and often excessive use, whereas many remote pastures are partly of completely abandoned. There are erosion processes on some pasture that need to be addressed. The use of the unused pastures will prevent/decrease erosion processes near settlements, increase the sustainable resource based for grazing and support sustainable pasture management (Gebhardt 2019, CNF 2021). This shall be achieved through opening access and water infrastructure (where necessary), and incentives to pastoralists for use of relatively remote pastures. Pastures frequently used by wild ungulates shall be excluded from this strategy.
- **Strategy No. 10 - Adjust hay cutting dates to align with changes to the flowering date:** Warmer springs will cause many biological events (e. g. flowering of grasses) occurring earlier in the year, particular under the Tropicana and Furnace scenarios. This may require changes in order to reflect the earlier growth and flowering of plants. This might include changing the timing of the hay cutting, or changing timing, duration and extent of aftermath (vegetation that re-grows following cutting) grazing (Neale et al. 2014). Optimal period for hay cutting in Kazbegi is suggested by the Climate Change National Adaptation Plan for Georgia's Agriculture Sector (MEPA 2017): cutting must start in second half of July (instead of second half of August as previously practiced), during ripening of grain seeds, during the fruit bearing period of legumes and wild grasses.
- **Strategy No. 12 - Increase sustainable value generation from livestock economy:** As available (sub-)alpine grasslands are likely to progressively decrease and degrade, particularly under the Furnace and Crisp scenarios, there will be a reduced resource base to support both livestock and wild ungulate conservation in the target PA. One way of allowing local pastoralists to maintain their income even with reduced livestock numbers, and thereby indirectly allow ungulate conservation, is to increase value generation from raw products at the local level. For this, various value chain approaches, regional labels for produce, collaboration agreements with high-value tourism establishments around the target areas shall be instituted, along with capacity building among local pastoralists to implement these approaches in a sustainable way. This strategy will require piloting based on a nationally or donor-funded project.
- **Strategy No. 13 - Promote livestock-independent livelihoods:** The rationale for this strategy is similar to that of Strategy No. 12 – supporting the local economy to reduce its dependency from grazing on (sub-)alpine grasslands of the target PA. In this case, non-livestock dependent livelihoods shall be promoted through piloting, individual capacity building and other suitable elements like small grants schemes. Apart from obvious sectors related to PA-based tourism and visitation (gastronomy, accommodation, handicrafts), other possible directions to explore include horticulture (also in the light of the milder climate), public services (particularly with improved access to Stepantsminda area), and even – provided there is sufficient internet access – teleworking. As the previous one, this strategy will require piloting based on a nationally or donor-funded project.

Applicable to forests and their biota (Figure 3)

- **Strategy No. 20 - Protect and/or restore riparian forest to increase shading of surface waters, flood control, and the functionality of riparian connectivity corridors in Khevsureti:** Riparian forests can be found within the Aragvi Watershed area of Pshav-Khevsureti Protected Areas. Protecting/restoring

forest cover along rivers and streams as these natural linear features connect larger forests and increase habitat connectivity, thus providing corridors for species movement. Protected forests in headwater streams support adequate streamflows for fish populations and ensure protection of cold water refugia (Peterson 2011). The strong and healthy forest ensures providing regulating ecosystem services important for the downstream areas (as potable, irrigation water or energy generation).

Applicable to high-mountain peatlands and their biota (Figure 5)

- **Strategy No. 21 - Collect water and artificially re-wet high-mountain peatlands:** With their high dependency on precipitation and moisture conditions, the alpine peatlands of the target area are likely to suffer desiccation and degradation due to reduced water input in the Furnace scenario and potentially in others. Their characteristic vegetation may get replaced by more generalist vascular plant species. Artificially re-wetting peatlands shall be tested to prevent their degradation.

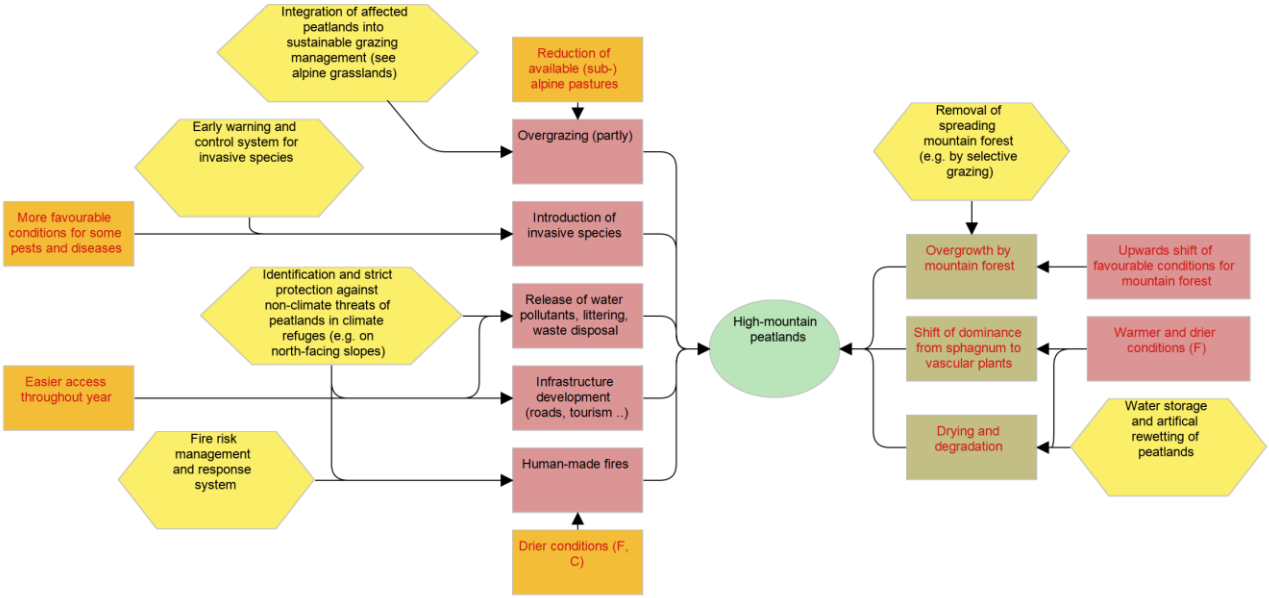

Figure 5. Adaptation strategies applicable to high-mountain peatlands and their intervention points in the situation model.

Applicable to streams and rivers (Figure 4)

- **Strategy No. 22 - Store water during spring to reduce withdrawal from rivers/streams for human use in summer:** Similar to Strategy 12, a reduced overall resource base – in this case regarding water and particularly under the Furnace and Crisp scenarios – requires interventions to improve supply for human activities around the PAs so that enough is left for maintaining the integrity of stream and river ecosystems and adjacent riparian areas. Storing water during discharge maxima in spring for human use in summer may contribute to maintaining the functionality of rivers and streams throughout the year. The best ways to realize this strategy (geographical areas, technical solutions, types of use supported) will need to be tested at small scale first.
- **Strategy No. 23 - Identify and protect spring and groundwater seepage areas:** Water is important for all ecosystems, and springs/seepage areas will become even more important as discharge of rivers and streams declines. Disturbance of these area by any development activities (e. g. extraction, roads,

infrastructure) might impact the availability of water quantity. Therefore, it is important to identify and strictly protect spring and groundwater seepage areas.

Applicable to all ecosystems with their biota

- **Strategy No. 28 - Identify local climate refugia and strictly protect against non-climate threats:** This strategy is applicable to (sub-)nival, (sub-)alpine, forest, peatland and river ecosystems with the species to which they provide habitat and may be particularly relevant to habitats of mountain galliforms. Identification and protection of the areas which are in cooler and wetter locations, where direct impact of climate change may be less than in surrounding areas and which have been generally undisturbed by humans, are expected to be less vulnerable also to future climate change. Such climate refugia are generally thought to help preserve habitats and ensure species viability (NIACS 2022). Potential refugia could be on the north facing or more sheltered slopes and areas with more secure water supply, e. g. near springs (Neale et al. 2014), but also in several other mountain settings (cf. Garstecki et al. 2020a, see p. 70). They shall first be mapped in more detail.

Applicable specifically to fauna (Figure 6-8)

The above adaptation strategies for ecosystems will also contribute to the adaptation of the biota for which these ecosystems provide habitats. They are therefore considered more broadly effective than purely species-orientated adaptation measures, and always need to be kept in mind as part of the PA's approach to species conservation. In addition to them, a few more specific adaptation measures for specific biota have been identified.

- **Strategy No. 34 - Assess potential competition effects of the colonizing Golden Jackal with autochthonous predators and predation effects and develop response options:** Golden Jackal is a generalist predator which has been extending its distribution range in Georgia and Europe during the last decades. It has also been observed in the target PA. A further, climate change enhanced spread is likely. This raises the question which impacts this spread may have on other biota, particularly through food competition and predation, and which measures may need to be taken to minimize impacts on the main conservation values of the target PA. This shall be answered through a literature study, as well as field studies to the extent necessary.
- **Strategy No. 35 - Identify and protect migration corridors linking target populations to neighbouring areas (along main Caucasus ridge, to North):** One natural adaptation mechanism of ecosystems and species populations to climate change is adaptive range shifts and migration. This needs to be supported through protection of ecological corridors and stepping stones. While it is unlikely that corridors can enable adaptive shifts/migration of those biota that are already concentrated in the (sub-)nival and high alpine areas, they may well ensure connectivity of potential local climate refugia – including in neighbouring PAs of the Russian Federation such as Erzi Strict Nature Reserve and Ingushsky Managed Reserve. Connectivity may also be highly relevant to range shifts and migration in an east-westerly direction, given the pronounced precipitation gradients between the (much wetter) west and the (much drier) east of the wider target area, which may become more pronounced particularly under the Furnace and Crisp scenarios. Based on more large-scale suggestions as those of the Ecoregional Conservation Plan for the Caucasus, more detailed options for corridor and stepping stone conservation shall be explored and implemented in the medium term.

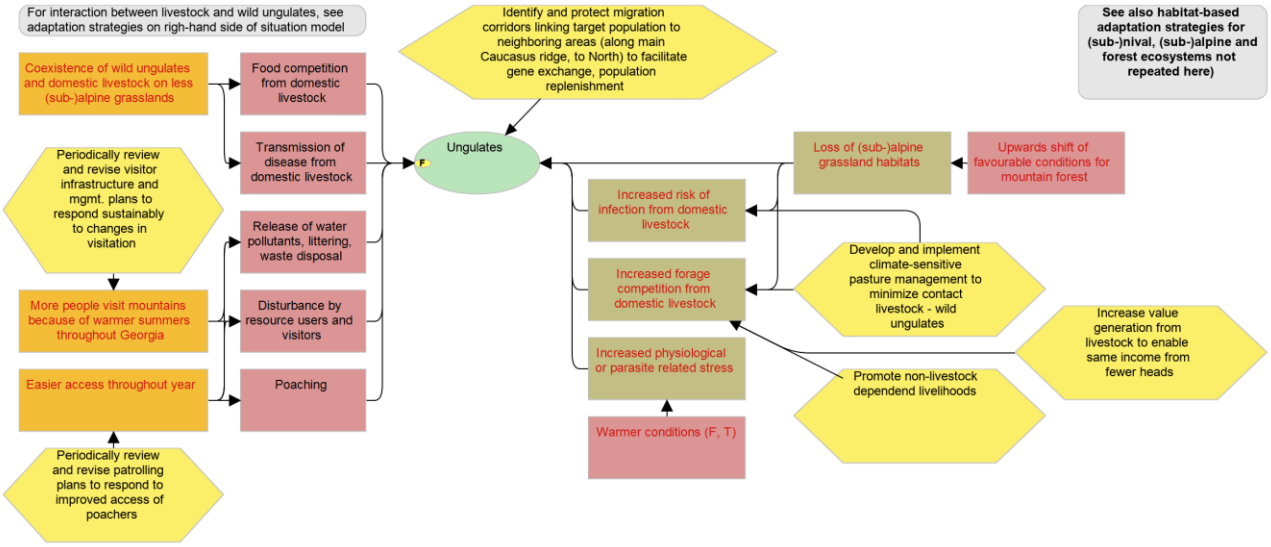

Figure 6. Adaptation strategies applicable to mountain ungulates and their intervention points in the situation model.

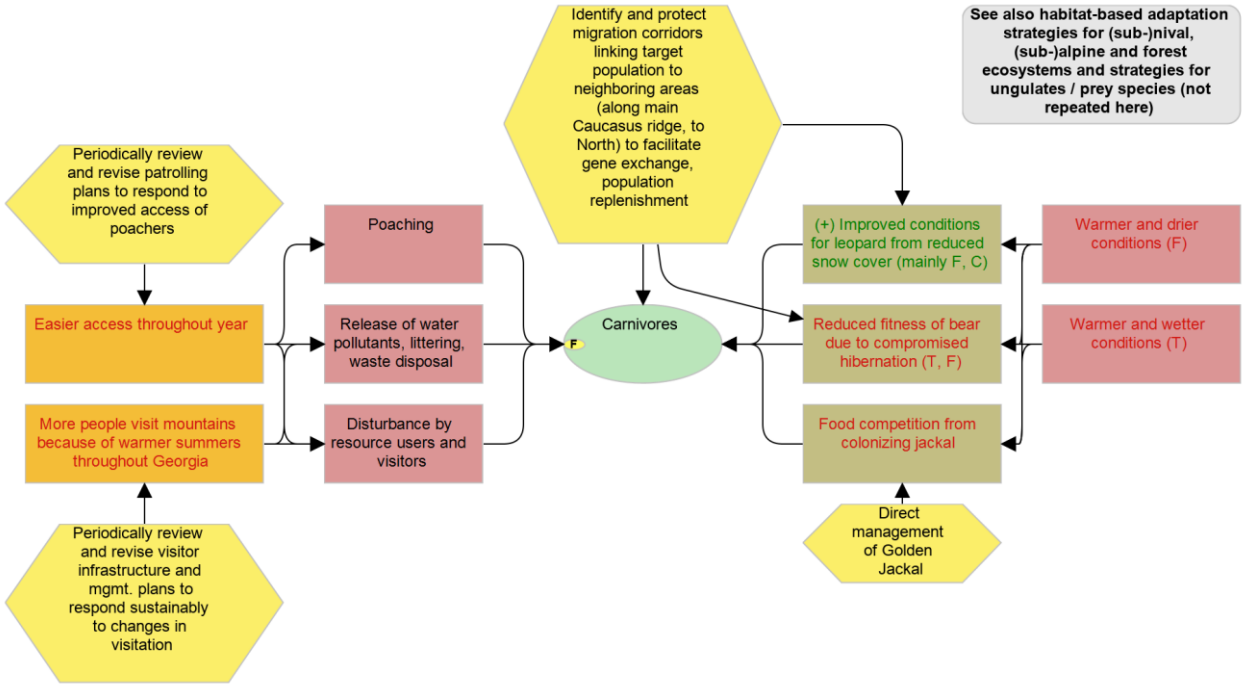

Figure 7. Adaptation strategies applicable to predatory mammals and their intervention points in the situation model.

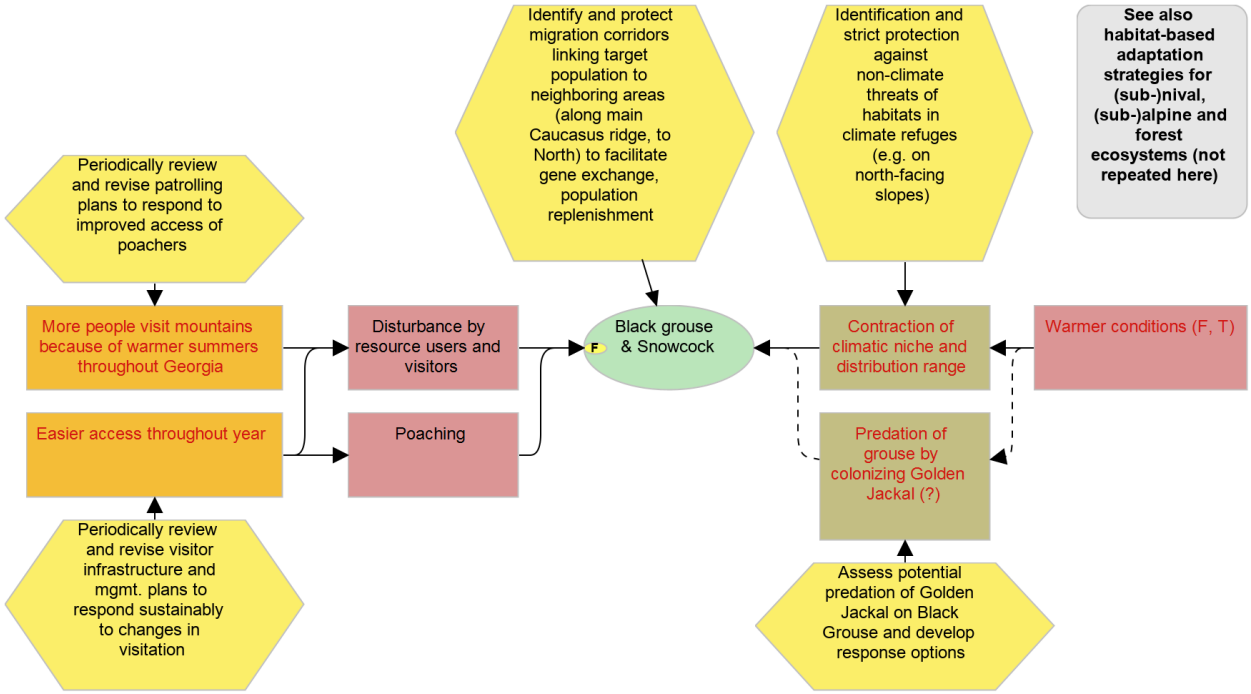

Figure 8. Adaptation strategies applicable to Caucasian Black Grouse and Caucasian Snowcock and their intervention points in the situation model.

3.2.3 Strategies considered not feasible

Climate change adaptation of ecosystems (and the habitats they provide)

Applicable to (sub-)nival ecosystems

- **Strategy No. 1 - Cover glaciers to protect against insolation:** Reflective fleece blankets have been used to shield glaciers in the Alps against insolation and to thereby reduce melting (e .g. World Economic Forum 2021). While this is locally effective, it is resource and labour intensive and cannot be applied at a larger scale, particularly in inaccessible terrain away from transport infrastructure such as lifts and prepared ski runs.
- **Strategy No. 2 - Install snow fences to support accumulation of snow:** Using snow fences to manage snow accumulation and snow cover in various environments including glaciers and snowfields has been discussed for a long time (e. g. Martinelli 1973). This may be a suitable small-scale strategy to manage snow cover and help protect high-value periglacial habitats. However, similar to the previous strategy, an application at larger scale would require prohibitive resources and in any case only function under high-precipitation scenarios (Sirimiri and Tropicana).

Applicable to (sub-)alpine ecosystems (and in some specific areas also in sub-nival and mountain peatland habitats)

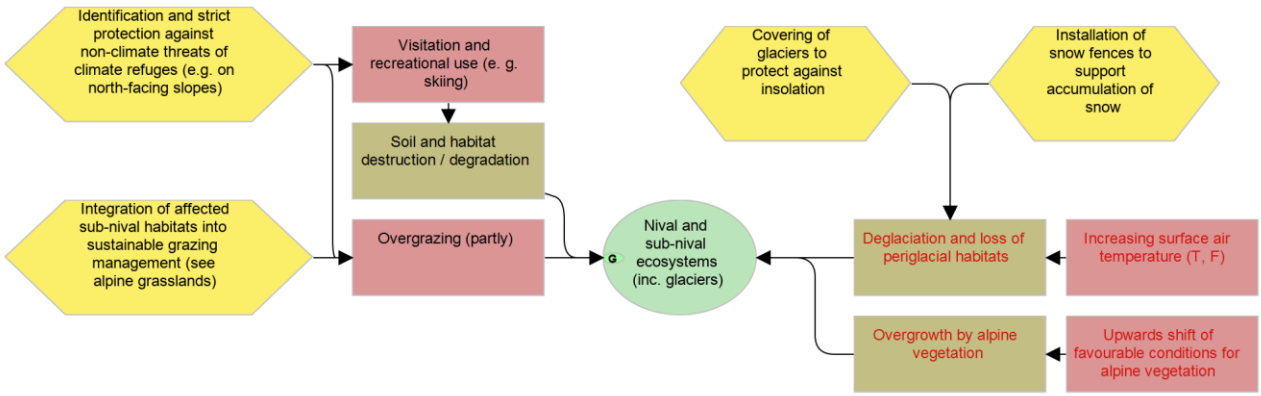

Figure 9. Adaptation strategies applicable to (sub-)nival areas and their intervention points in the situation model.

3.2.4 Strategies considered not relevant at this stage, but potentially in 10 years

Applicable to (sub-)alpine grasslands

- **Strategy No. 4 - Address reduced area and viability of (sub-)alpine pastures in existing sustainable pasture/grazing management systems:** Sustainable grazing/pasture management combines animal, plant, soil and other environmental components and the grazing methods by which the system is managed to achieve specific goals, such as improved pasture condition, higher forage yields and animal production with ecological concern (Sevov et al. 2018). This is usually achieved through managing standing stock, the livestock breeds used and recovery times for grass regrowth after grazing. This technical management is usually supported through participatory processes and governance arrangements, so as to keep the results equitable. This approach, which has already been introduced in Georgia, can also be used to adapt grazing regimes on (sub-)alpine grasslands of traditional use zones of the target PAs to reduced grassland extent and/or quality.
- **Strategy No. 11 - Close erosion gullies where necessary because of increased gully erosion:** Increased gully erosion particularly under the Sirimiri and Tropicana scenarios may damage (sub-)alpine grasslands and compromise grazing. Where this is the case, engineering measures to close erosion gullies shall be conducted. As a basis for this, erosion gullies shall be monitored in the near future and areas for closing them shall be identified.

Applicable to rivers and streams

- **Strategy No. 24 - Introduce/strengthen wastewater treatment if visitation at high altitude increases**: If higher summer temperates throughout Georgia lead to increased visitatzion and consequently to the development of more visitor infrastructure at high altitude within the target PAs, it will be crucial to protect high biodiversity value and at the same time already climate stressed rivers and streams (particularly headwaters) against water pollution originating there. This shall be achieved through requiring and installing appropriate wastewater treatment facilities in all existing or newly developed visitor infrastructure, particularly if it is established at above 1,000 m altitude.

Applicable to all ecosystems with their biota

- **Strategy No. 29 - Periodically revise and – if necessary – adapt protection measures (patrolling) to improved access, increased resource use pressure and increased human presence:** In all target protected areas there are still cases of violation of existing regulations (e.g. illegal logging, illegal grazing on grasslands and/or in the forest, poaching, assess of restricted areas, etc.). Such may be aggravated by climate change through easier access across seasons and a higher visitor load. Therefore, in line with the public awareness the periodic revision/update of existing patrolling systems is necessary.
- **Strategy No. 30 - Periodically review and – if necessary – adapt visitor infrastructure and visitor management systems to respond sustainably to changes in visitation:** Not only the conservation values of the protected PAs, but also the way people use them for recreation will be affected by climate change, in ways that are not always easy to predict. The relation between visitation and temperature is strong - visitation generally increases with increasing average monthly temperature. Climate change might cause shifts in visitation to high-elevation PAs like the target PA, including annual increased visitation as well as changes in visitation timing (Fisichelli 2015, Scott 2007). There could also be a demand for more visitor infrastructure. As a result, the already existing negative impact from visitors (e. g. noise, littering, water pollution, etc.) might increase, and particularly important local climate refugia might come under increased visitor pressure. This may be further aggravated by direct negative climate change impacts on the intactness of visitor infrastructure and feasibility of visitor management, e.g. through effects of extreme events. Therefore, an adjustment of visitor management/strategies to changes in visitation and climate change impacts on visitor infrastructure and management will be needed.

Applicable to flora

- **Strategy No. 32 - Ensure ex-situ conservation of endemic and/or critically threatened species of flora:** Some cold-adapted (sub-)nival and also (sub-)alpine flora depend closely on periglacial and other cold habitats and are likely to suffer considerably if glacial loss continues as observed so far and projected. These species – among them some threatened and endemic ones – might go extinct in the wild, which means that their genes should be conserved through ex-situ conservation as long as this is still possible. While ex-situ conservation falls beyond the mandate of the target PAs, relevant institutions (Institute of Botany of the NAS, Tbilisi Botanical Garden) shall be engaged to develop a contingency plan for ex-situ conservation of high-mountain flora, for implementation in the medium term.

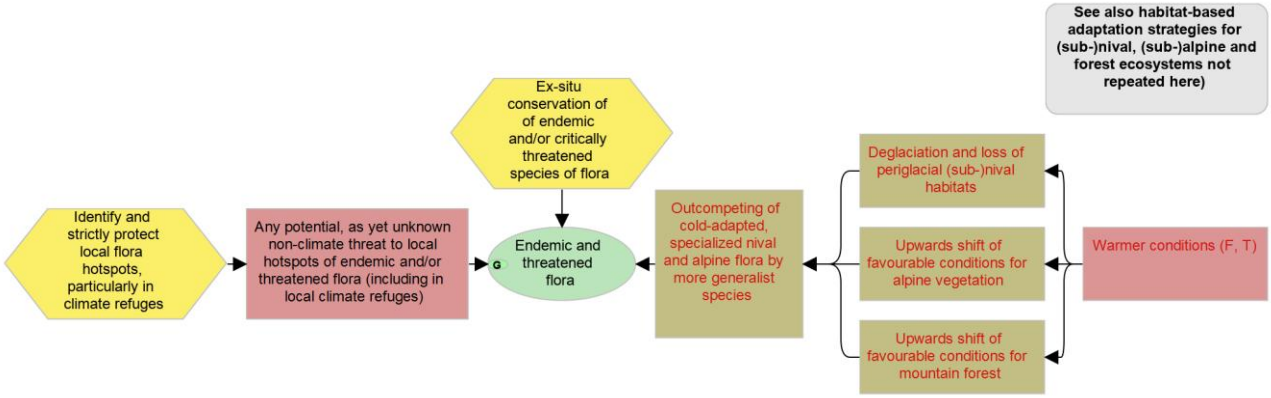

Figure 10. Adaptation strategies applicable to flora and their intervention points in the situation model.

Applicable to fauna

- **Strategy No. 33 - Periodically review and revise patrolling plans to respond to improved access of poachers:** In all target PAs poaching is still a threat for mountain ungulates, some carnivores and galliforms. It is mainly driven by interest in recreational hunting, demand for meat, hunting tradition, human-wildlife conflict, lack of awareness, etc. Improved access as a consequence of a milder climate, also across seasons, may facilitate poaching in the future. Therefore, it is possible that along with public awareness raising, stronger low enforcement will be necessary.

3.3 Relevance to adaptation of humans

While devising a full ecosystem-based adaptation plan for the communities surrounding the target PA would go beyond the scope of this assignment, most of the strategies developed for ecosystems, flora and fauna do also support the adaptation of human resource users. These are the following:

- **Strategy No. 3 - Create artificial glaciers and reservoirs:** Provision of water for livestock, other uses.
- **Strategy No. 5 - Prohibit grazing on eroded slopes, regulate access, grazing and burning, and allow for pasture regeneration phases:** Increased pasture quality and livestock yields.
- **Strategy No. 7 - Map (sub-)alpine grasslands regularly used by wild ungulate and manage grazing so that contact between livestock and wild ungulates is minimized:** No transmission (including spillback transmission) of diseases from wild ungulates to domestic livestock.
- **Strategy No. 8 - Re-open and ensure access (and water availability where necessary) to currently un-used pastures:** Broader resource base for grazing, less erosion near settlements.
- **Strategy No. 9 – Introduce and promote the use of electric fencing and other bio-engineering means to manage grazing:** Reduced human-wildlife conflict (see also Strategy 7 above).
- **Strategy No. 10 - Adjust hay cutting dates to flowering dates:** Better pasture productivity, less erosion.
- **Strategy No. 12 - Increase sustainable value generation from livestock economy:** Socio—economic benefits to local pastoralists are an integral part of this strategy.
- **Strategy No. 13 - Promote livestock-independent livelihoods:** Better livelihoods through diversified income opportunities.
- **Strategy No. 14 – Raise awareness of the importance and vulnerability of (sub-)alpine grasslands:** Better consensus on pasture management, greater equity, more effectiveness of technical measures.
- **Strategy No. 15 - Establish an early warning system and capacity to control newly arising forest plant pathogens and pests:** Reduced risk of loss of forest ecosystem services (fuelwood, avalanche control, flood control, tourism, etc.).
- **Strategy No. 16 – Improve forest disease incident management (removing dead or dying trees, retaining survived trees, restrict harvest & transportation of infected wood, etc.):** As above.
- **Strategy No. 18 - Strengthen fire risk management and fire response capabilities:** As above.
- **Strategy No. 19 - Raise awareness about increased fire risk with climate change:** As above.
- **Strategy No. 22 - Store water during spring to reduce withdrawal from rivers/streams for human use in summer:** Better water availability for human use in summer.

- **Strategy No. 25 - Develop and implement a sustainable water resources management plan to minimize extraction of scarcer water for use:** As above. Also more equitable water access.
- **Strategy No. 31 - Establish an early warning system and capacity to control invasive species:** Reduced risk of loss of ecosystem services because of invasives.

In addition to this, the integrity of the natural values as a result of climate change adaptation will also ensure that the tourism economy around the target area continues to function.

3.4 Strengthening the adaptive management capacity of the target PA

Section 3.2 deals with specific adaptation measures to likely future climate change vulnerabilities of the conservation values of the target PA and the human wellbeing of its neighbors. However, it is likely that additional vulnerabilities will arise in the future, e. g. because mechanisms that are currently not yet understood will trigger new climate change impacts on biodiversity, or because new interactions with non-climate threats will arise. In addition, some of the future vulnerabilities identified in the VA are scenario-specific, i. e., they will only become a reality under some of our four scenarios. This means that decisions on whether there is a need to adapt to these vulnerabilities will have to be taken, re-considered, and possibly revoked in the future.

Consequently – and specific climate change adaptation measures aside – the target PAs need to strengthen their strategic, adaptive management capacity to be able to take informed decisions on management interventions in a changing future environment, to constantly and critically check if these interventions have the intended results, to learn from their mistakes and to periodically adapt their management systems to new insights or changing conditions. The following institutional adaptation strategies are intended to contribute to this strengthening of adaptive management capacity. Some of them can only be implemented jointly by the administration of the target PA and APA, as they require adjustments of APA level procedures.

- **Institutional strategy No. 1 – Build understanding of PA managers of adaptive PA management:** To empower PA managers to take ownership of their PAs and exercise adaptive PA management in the face of climate change, they need to improve their understanding of the adaptative management cycle and their individual capacity to implement each of its steps in a conscious and reflected manner. This shall be supported through targeted individual capacity development (ICD) of PA directors, relevant medium-level staff (e. g. natural resources specialists, visitors' specialists, heads of protection service) and relevant APA staff. ICD shall include custom-designed training courses, mentoring, and practical "change practice and reflect" tasks on the job.
- **Institutional strategy No. 2 – Strengthen monitoring including the monitoring of climate impacts:** PA managers need to know their management outcomes in terms of threat reduction and improved biodiversity status. Progress towards long-term conservation goals and more specific threat reduction objectives needs to be monitored using dedicated indicators. This shall include indicators on known climate change vulnerabilities, including the following:
    - Local long-term meteorological trends (based on data from local NEA weather stations to the extent possible).
    - Trends in coverage of glaciers and snowfields in the target PA (based on remote imagery and long-term monitoring plots).

- Vertical position of the tree-line (based on remote imagery and long-term monitoring plots).
- Species composition of (sub-)alpine grasslands and forest, including status of endemic and threatened species (based on long-term monitoring plots).
- Trends in pasture extent and quality (based on repeated measurements of pasture degradation indices, such as (Etzold & Neudert 2013).
- Incidence of invasives, pathogens and pests particularly in forest.
- Frequency and severity of fire events.

- **Institutional strategy No. 3 – Institutionalize reflection and learning:** In many PAs, the weakest links of the adaptive management cycle are between practice, monitoring and learning. To strengthen these links, facilitated annual "pause and reflect" workshops at the individual administration of the target PA with participation of APA and local stakeholders shall be established. These shall be dedicated to answering the questions "Are we doing the right things to adapt to climate change?" and "Are we doing them right?", based on a systematic analysis of monitoring data and practitioner experience. Lessons learned shall be considered during annual action planning, the setting up of three-year operational plans and the revision of PA management plans. They shall also be shared between individual PAs.
- **Institutional strategy No. 4 – Integrate planning, management, monitoring, learning and adaptation through decentralization of decision making and communication across institutional levels:** Adaptive PA management requires a close integration of management planning and practice, the monitoring of biodiversity and threats, as well as learning and the adaptation of plans. This cycle often gets broken if different actors in different places are responsible for the various steps. To overcome this, as much responsibility and decision making on the above steps as possible shall be concentrated as close as possible to the PA itself, i. e., at the level of the individual administration of the target PA. This will need to be complemented by ICD (Institutional Strategy No. 1) and institutional capacity development, as well as the further strengthening of communication between the administration of the target PA and APA HQ.
- **Institutional strategy No. 5 – Institutionalize partnership with academic institutions:** Some of the functional links between climate change and the viability and status of conservation values of the target PAs are too complex to be analyzed even using an advanced PA monitoring system. At the same time, such linkages often make interesting research questions for academic institutions. Joint identification of practically relevant and at the same time academically interesting questions as well as cooperation between the target PA, APA and relevant scientific institutions in programmes to answer them shall be institutionalized by establishing a scientific advisory board on "climate change, biodiversity and PAs" (or activation and strengthening of the corresponding function of the existing scientific advisory board), which shall meet annually at the target PA or neighboring PAs, convened by APA.
- **Institutional strategy No. 6 – adapt PA infrastructure to climate change:** An increased frequency and severity of extreme events (rain, flooding, landslides and mudflows, etc.) threatens to disrupt infrastructure such as access roads to the target PAs as well as within them, shelters and communications equipment. This may compromise the capacity of the PA administrations for climate change adaptation interventions and general PA management, as well as visitor access. To

respond to this, APA and the administrations of the target PAs shall study the vulnerability of their infrastructure to climate change and ensure that all its infrastructure is designed, constructed and maintained in such a way that vulnerabilities to extreme events are minimized. In those cases where operation of infrastructure depends on infrastructure outside its mandate, APA and the individual administrations shall engage the mandated institutions (e.g. Road Department, municipalities) to support them to do the same.

3.5 Integration of adaptation into the existing management system

The draft adaptation strategies, elaborated based on the VA, were reviewed in order to identify and propose their possible integration into the existing management plans and/or other documentations. As climate change is a cross-cutting issue that affects the key values of protected areas, the majority of identified adaptation strategies can be considered as additional activities under the management programmes already defined in the MP.

At the same time, again because of their cross-cutting nature, some activities already proposed by the management programmes of the MP address the threats posed by the climate change. So, this then highlights the importance of identified actions in terms of the climate change.

The proposed adaptation strategies, based on the issues, can additionally proposed to be included/considered in other PA supporting documentation, e.g. pasture management, forest management, tourism strategy, etc.

The detailed possible integration of the adaptation strategies in the PA MPs and supporting documents are given in the Appendix 2.

4 Climate Change Adaptation Plan for Kazbegi NP

This section provides Adaptation Plan for Kazbegi NP. The adaptation plan includes adaptation strategies relevant to Kazbegi NP, which were selected based on the proposed 35 strategies during the consultation meeting with Kazbegi NP Administration on 11th July 2022. The selected strategies are those considered suitable for immediate implementation or further feasibility testing.

The numbering of the strategies in the plan does not start at "Number 1"; each strategy has the number assigned initially (Section 3.2).

In the Adaptation Plan specific activities are proposed under each strategy, as well a period of implementation of strategies. For each activity responsible institutions/organizations and, were needed, link/dependency of a specific activities with other strategies/activities are presented.

Each strategy was assigned a priority number (1-high priority, 2-medium priority, 3-low priority, Table 1.) ranked additionally based on Annex 1. During the meeting with the administration priorities were reviewed, which is reflected in the column of 'Period of Implementation'.

Table 1. Climate Change Adaptation Plan for Kazbegi NP.

#	Adaptation Strategy and Activity	Dependence on other Strategies/Activities	Responsible institution	Comments	Period of Implementation
3	**Create artificial glaciers and reservoirs** (Priority: 3)				To be reviewed in 10 years.
	3.1. Feasibility study to identify the proper approach (artificial glaciers and/or reservoirs) and location.		PA, APA, MEPA, with ext. expert	Administrations did not consider the strategy to tests at this stage.	
	3.2. Test establishment of artificial glaciers and/or reservoirs.	After implementation of 3.1.	PA, APA, MEPA, with ext. expert		
5	**Prohibit grazing on eroded slopes, regulate access, grazing and burning, and allow for pasture regeneration phases** (Priority: 2)				2024
	5.1. Identify / regularly update and map eroded areas		PA, APA, MEPA, with ext. expert	Pasture management plan exists for Pshav-Khevsureti PAs (SPPA 2019).	
	5.2. Elaborate / regularly update pasture management plans	Consider 7.1., 8.1. and Strategy 9.	PA, APA, with ext. expert	Pasture management plan exists for Pshav-Khevsureti PAs (SPPA 2019).	
	5.4. Minimize of erosion through visitor management plan (regular review/update based on erosions).	Based on the regular update of 5.1, 5.2, and 5.3.	PA, APA, with ext. expert		
	5.5. Prohibition of all development activities in or close to eroded areas (using zoning?).		PA, APA		
	5.6. Decommission (re-rout) roads/trails/infrastructure at or near eroded areas		PA, APA, Municipality		

6	**Use selective grazing along the advancing treeline to control the upward spread of mountain forest** (Priority: 2)				2026 –
	6.1. Identify priority areas with high diversity of sub-alpine flora were treeline is (likely) advancing.	Consider 7.1.	PA, APA, with ext. expert		
	6.2. Introduce incentive / regulations to promote grazing on identified priority areas in along the advancing treeline to control the upward spread of mountain forest.	After implementation of 6.1.	PA, APA, MEPA, Municipalities		
7	**Map (sub-)alpine grasslands regularly used by wild ungulate and manage grazing so that contact between livestock and wild ungulates is minimized** (Priority: 1)				2023
	7.1. Identify / map grasslands use by wild ungulates for grazing		PA, APA, with ext. expert	Monitoring of ungulates is carried out by 'Nacres' under CNF project, as well as by administration.	
	7.2. Revise zoning if necessary	After implementation of 7.1.	PA, APA, with ext. expert	Draft Mp is prepared, in which zonnation should be reviewed.	
8	**Re-open and ensure access (and water availability where necessary) to currently un-used pastures** (Priority: 3)				2024
	8.1. Elaborate / regularly update pasture management plans considering currently unused pastures.	Consider 7.1. Consider 9.2.	PA, APA, with ext. expert	.	
	8.2. Introduce incentives to facilitate (re-)utilization of remote pasture areas. (Pastures frequently used by wild ungulates shall be excluded from this strategy!)		PA, APA, MEPA, Municipalities	Needs to be subsidized by Government	
	8.3. Ensure access and water availability (e.g. arrange water infrastructure, were necessary) for livestock on remote pasture areas.		PA, APA, Municipalities		
9	**Introduce and promote the use of electric fencing to manage grazing** (Priority: 2)				- Based on monitoring; - To be reviewed during revision of pasture management plan.
	9.1. Improve grazing by using electric fencing.	Recommended based on 5.2.	PA, APA, with ext. expert		
	9.2. Promotion/Training on arrangement and use of electric fences.		PA, Ext. expert		
10	**Adjust hay cutting dates to align with changes to the flowering dates** (Priority: 2)				2026

	10.1. Conduct study to identify optimal period for hay cutting or changing timing, duration and extent of aftermath grazing.		PA, APA, with ext. expert	Hey cutting period is defined by locals. For Kazbegi cutting is suggested to start in second half of July, instead of second half of August as previously practiced (CC National AP for Georgia's Agriculture Sector (MEPA 2017).	
	10.2. Communication with /awareness raising, training of stakeholders on the period of hay cutting and aftermath grazing.	After implementation of 10.1.	PA, APA, MEPA, with ext. expert		
12	**Increase sustainable value generation from livestock economy** (Priority: 2)				To be review in 2028.
	12.1. Conduct study to identify value chain approaches to increase value generation from livestock economy		PA, APA, Municipalities, with ext. expert	(can be in combination with 13.1)	
	12.2. Promote / support implementation of value chain approaches to increase value generation from livestock economy	After implementation of 12 .1.	PA, APA, Municipalities, with ext. expert		
13	**Promote livestock-independent livelihoods** (Priority: 1)				To be review in 2028.
	13.1. Conduct study to identify livestock independent livelihoods (can be in combination with 12.1)		PA, APA, Municipalities, with ext. expert	(can be in combination with 12.1)	
	13.2. Promote / support livestock independent economy	After implementation of 13 .1.	PA, APA, Municipalities, with ext. expert		
14	**Raise awareness of the importance and vulnerability of (sub-)alpine grasslands** (Priority: 2)				2023 -
	14.1. Elaborate/implement awareness raising program (including all components and addressing corresponding stakeholders)		PA, APA, with ext. expert		
15	**Establish an early warning system and capacity to control newly arising forest plant pathogens and pests** (Priority: 1)				Based on monitoring
	15.1. Conduct forest pests and pathogens studies (to have a baseline and to identify candidate IASs,		PA, APA, with corresponding experts/institutions (Institute of	Some data was gathered during the training	

	pathogens, pests to look out for)		pathology and biodiversity)	(2019). Monitoring data by Administration available.	
	15.2. Conduct trainings for PA staff how to identify, map and monitor pathogens, pests		PA, APA, with corresponding experts/institutions	Training for the Administration staff was done in 2019.	
	15.3. Establish/strengthen monitoring system at the institutional level (procedures, resources, responsibilities etc.)		PA, APA, in collaboration with corresponding experts/institutions	Monitoring is carried out on sample plots.	
16	**Improve forest disease incident management (removing dead or dying trees, retaining survived trees, restrict harvest & transportation of infected wood, etc.)** (Priority: 1)				Based on monitoring
	16.1. Elaborate/regularly update and conduct forest disease incident management actions (based on specifics of the pests/diseases).	Consider 15.1 and 15.3. Based on the monitoring and recommendations from experts	PA, APA, in coordination with corresponding experts/institutions (e.g. Institute of pathology and biodiversity)		
	16.2. Develop Standard for logging considering restriction of harvesting and transportation of logs near infected stands with known insects or pathogens	Consider 15.1 and 15.3. Based on the monitoring	PA, APA		
17	**Minimize – through strict regulation – disruption of intact forest cover to stop colonization by invasives** (Priority: 1)				-
	17.1. Restrict any activities (e.g. development projects for transport and visitor infrastructure, forest management, etc.) causing disruption of intact forest cover.		PA, APA, MEPA	No intact forests are in the NP.	
18	**Strengthen fire risk management and fire response capabilities** (Priority: 1)				2023-2024
	18.1. Identify/map areas at risk from fires.				
	18.2. Elaborate fire management plans (inc. pre-fire planning and post-fire vegetation management and prevent invasives).		PA, APA, with ext. expert		
	18.3. Conduct trainings for PA staff and locals/shephards (optional).		PA, APA, with ext. expert		
	18.4. Equip PA staff with		APA		

	corresponding equipment.				
19	**Raise awareness about increased fire risk with climate change (**Priority: 2)				2023 -
	19.1. Develop/implement awareness raising program on fire risk minimization for local communities and visitors.		PA, APA, with ext. expert		
21	**Collect water and artificially re-wet high-mountain peatlands** (Priority: 3)				To be reviewed in 2027
	21.1. Test artificially re-wetting peatlands.		PA, APA, with ext. expert	Before implementation of the strategy, monitoring of drying of the existing lakes and changes in the vegetation can be started.	
	21.2. Establish long-term monitor programme (to assess changes due to CC - e.g. species composition, alien species, other threats) and re–evaluate restoration needs.		PA, APA, with ext. expert		
22	**Store water during spring to reduce withdrawal from rivers/streams for human use in summer** (Priority: 3)				Revised based on needs
	22.1. Support to test on a small scale storing water during discharge maxima in spring for human use in summer.		PA, APA, Municipalities, with ext. expert	No problem exists at this stage (only in Shatili and its because of improper water system)	
23	**Identify and protect spring and groundwater seepage areas** (Priority: 2)				2024
	23.1. Identify / map all springs and groundwater seepage areas		PA, APA, MEPA		
	23.2. Prohibition of all development activities close to the spring/groundwater seepage areas.		PA, APA, MEPA		
	23.3. Remove or temporarily close access roads to reduce soil erosion and sedimentation		PA, APA, with ext. expert		
	23.4. Revision of zoning		PA, APA, with ext. expert		
25	**Develop and implement sustainable water resources management plan to minimize extraction of scarcer water for use (**Priority: 1)				Revised based on needs
	25.1. Conduct study on availability of water resources.		PA, APA, MEPA, with ext. expert		
	25.2. Introduce and establish effective water management system.		PA, APA, Municipalities,		

			with ext. expert		
26	**Ensure that in the upper reaches of mountain streams and river inside PAs no damaging hydraulic infrastructure is established (**Priority: 1)				2023
	26.1. Prohibition of all development activities in the upper reaches of mountain streams and river through zonning.		PA, APA, MEPA	Draft Mp is prepared, in which zonnation should be revised.	
	26.2. Revision of zoning		PA, APA		
27	**Engage downstream partners of PAs to ensure existing HPPs and other hydraulic infrastructure does not compromise migration of freshwater fauna** (Priority: 2)				2023 -
	27.1. Idnetify risks to the freshwater fauna from HPPs and their mitigation measures,		PA, APA, MEPA, ext. expert	Blue, Rivers Environmental Consulting (Ukraine) implemented project "Water Biodiversity Action Plan and Implementation " (2015).	
	27.2. Communicate/lobby with all relevant stakeholders to ensure migration of freshwater fauna.		PA, APA, MEPA		
28	**Identify local climate refugia and strictly protect against non-climate threats (**Priority: 2)				2023 - 2024
	28.1. Identify/map and protect local climate refugias (areas with cooler and wetter locations that are expected to be more resistant to changes in climate)		PA, APA, with ext. expert		
	28.2. Identify/map and protect areas with diverse biophysical settings and community types where species can shift locally as conditions change.		PA, APA, with ext. expert		
	28.3. Establish monitoring of refugia sites	After implementation of 28 .1. and 28.2.	PA, APA, with ext. expert		
	28.4. Prohibite all development activities close to refugia.	After implementation of 28 .1. and 28.2.	PA, APA, MEPA		
	28.5. Revision and adjustment of borders and zoning to afford strict protection to climate refugia.	After implementation of 28 .1. and 28.2.	PA, APA		
31	**Establish an early warning system and capacity to control invasive species (**Priority: 1)				2023 -
	13.1. Conduct studies on alien, invasive species (to have a baseline)		PA, APA, with ext. expert		
	15.2. Conduct trainings for PA staff (on identification and eradication of current and potential invasive species)		PA, APA, with ext. expert		

	15.3. Establish monitoring system for known and potential invasive species to ensure early detection, especially along trails, roads.		PA, APA, with ext. expert		
	15.4. Clean equipment prior to forest operations (site preparation, harvesting, other) in order to prevent the spread of invasive plants.				
34	**Assess potential competition effects of the colonizing Golden Jackal with autochthonous predators and predation effects and develop response options** (Priority: 1)				2024
	34.1. Monitoring of the Golden Jackal.		PA, APA, with ext. expert		
	34.2. Conduct field study on feeding ecology of Jackal.		PA, APA, with ext. expert		
35	**Identify and protect migration corridors linking target population to neighbouring areas (along main Caucasus ridge, to North)** (Priority: 1)				- Based to monitoring results; - To be reviewed in the process of MP update.
	35.1. Identify migration corridors of main biodiversity value species (Chamois (*Rupicapra rupicapra*), Bezoar goat (*Carpa aegagrus*), Red Deer (*Cervus elaphus*), Lynx - (*Lynx lynx*), Brown Bear (*Ursus arctos*))		PA, APA, with ext. expert		
	35.2. Restoration (if needed) migration corridors of value species	After implementation of 35.1.	PA, APA, with ext. expert		
	35.8. Revision and adjustment of borders and zoning of target PA based on the studies of migratory corridors	After completion of 35.1-7 activity.	PA, APA, with ext .expert		
	35.9. Collaboration with adjacent areas (PAs, Municipalities, National Forest Agency, etc.) to Identify and protect migration corridors.		PA, APA, Municipality, MEPA		

5 Detailed Plan for High Priority Adaptation Interventions for Kazbegi NP

This section provides detailed plans for three priority strategies selected during the consultation meetings with Kazbegi NP Administration on 11th July 2022.

5.1 Adaptation strategy No. 27: Engage HPP operators downstream of PAs to ensure HPPs do not compromise vertical migration of freshwater fauna

5.1.1 Basic information

- **Priority assigned to strategy:** 2 (to be implemented)
- **Other PAs that have expressed interest in this strategy:** -
- **Biodiversity values targeted by strategy**
    - **Primary:** Rivers and streams with their biota
    - **Secondary: -**
- **Human wellbeing values targeted by strategy:** Benefits from recreational and subsistence fishing, human wellbeing values related to visitation and recreation along rivers and streams.

5.1.2 Summary of strategy

Ensuring natural river processes including vertical adaptive migrations as well as range shifts of their biota is crucial for river and stream ecosystems and the safeguarding of the ecosystem services they provide. Hydropower plants (HPPs) and other hydraulic infrastructure that obstructs vertical migrations and shifts might constrain these processes. These currently exist along the river Tergi downstream of Kazbegi National Park.

At least for the Georgian operators whose HPPs are located closely downstream from KNP, everything technically and economically feasible needs to be done to minimize disruptions of the vertical connectivity of these rivers and streams. The administration of KNP and APA, with the support of central government agencies, local municipalities and other community representatives, shall engage these HPP operators to help them define and implement biodiversity-friendly ways of operating. This is the focus of this strategy.

5.1.3 Theory of change with indicators and activities

The theory of change of Strategy No. 27 is shown in Figure 12 (see Figure 11 for legend). Table 2 explains the objectives set for Strategy 27 and their indicators.

Figure 11 is a generic legend that explains the meaning of diagramme elements used for this and other two strategies for which detailed plans have been developed.

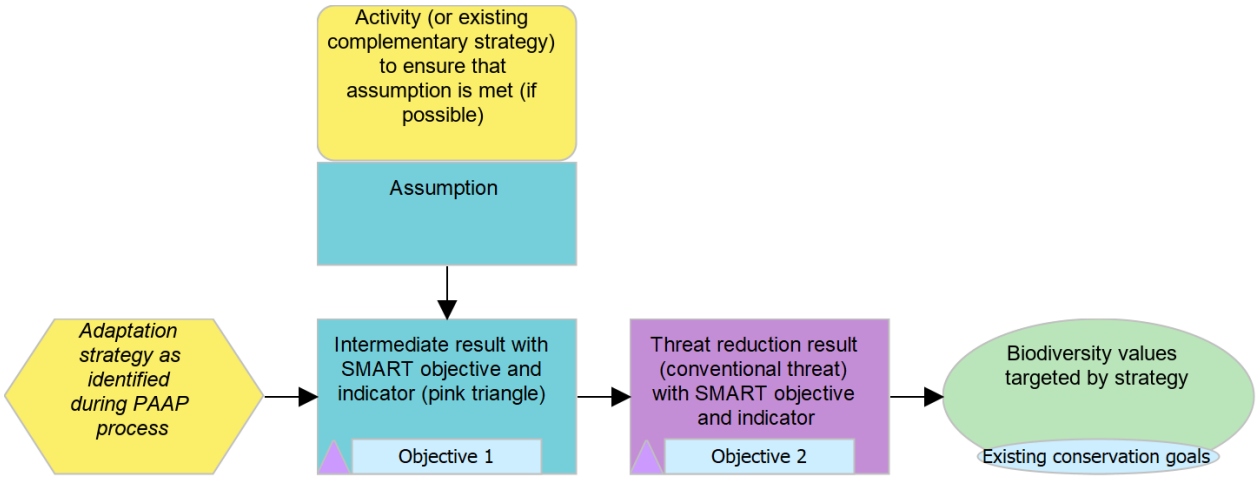

Figure 11. Generic legend of the diagramme elements used in the theories of change for high-priority strategies. Note that not all assumptions can be ensured through actions or complementary strategies. There can be more than o ne intermediate result and more than one assumption per result. There can also be more than one indicator per result. Only important intermediate results require objectives and indicators. Depending on the adaptation strategy, the description of goals can be specific or general.

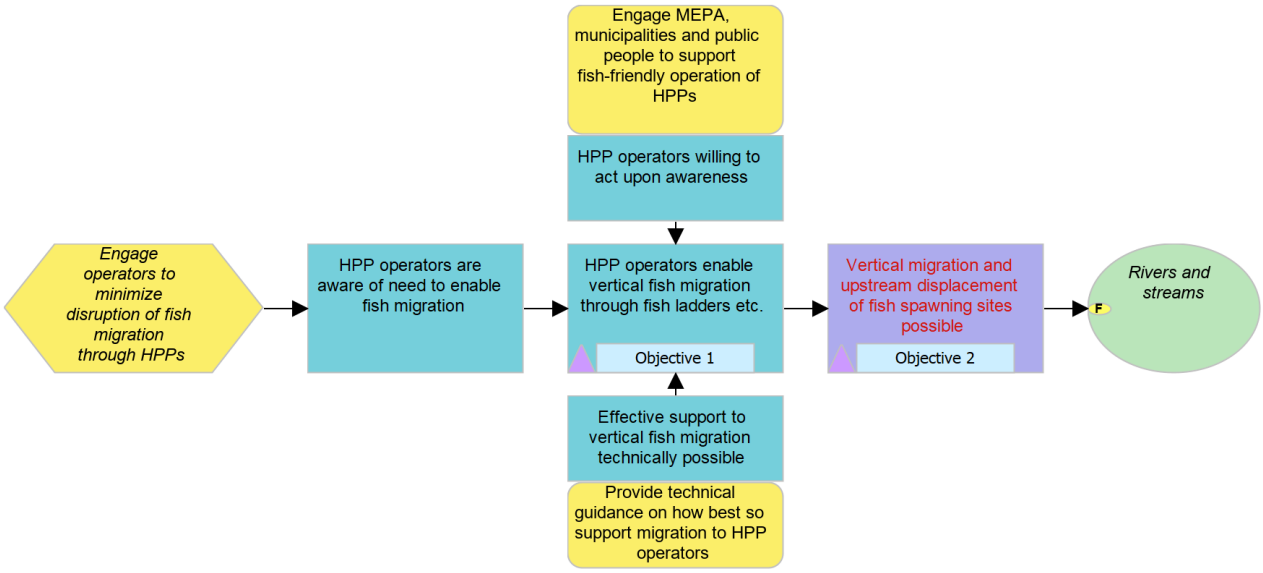

Figure 12. Theory of change for Strategy No. 27: Engage HPP operators downstream of PAs to ensure HPPs do not compromise vertical migration of freshwater fauna.

Table 2. Objectives and Indicators for Strategy No. 27.

No.	Objective	Indicator (data/information source)
1	All HPP operators along the riverTergi and Brolistskali downstream of KNP fully implement all technically and economically feasible measures to minimize disruption of vertical connectivity of the river.	% of recommended technical measures agreed and implemented by HPP operators (HPP records).
2	Existing HPP do not present a critical threat to vertical	% of known taxa for which existing HPPs continue to present

	connectivity of the Tergi and Brolistskali river and its tributary anymore.	an obstacle for vertical migration/spread (field survey).

5.1.4 Activities under the strategy with their resources/requirements and indicative budget

Table 3 lists the main activities under Strategy No. 27 with their necessary resources as well as requirements and an indicative budget.

Table 3. Main activities under Strategy No. 27 with their necessary resources/requirements and an indicative budget.

No.	Activity	Resources/ requirements	Budget ($)	Comments
1	Develop talking points and arguments with HPP operators to promote biodiversity-friendly operation	Small workshop with national experts and PA admin, with external facilitator (0.5 d)	1,000	Could also be facilitated internally if someone is available
2	Compile existing technical guidance on how best to operate HPPs to enable migration and range shifts	Specialist consultant desk study and consultation with national experts and PA admin (5 d)	2,000	
3	Engage national partners (e.g. MEPA), municipalities, NGOs and local community representatives to support promotion of biodiversity-friendly HPP operation.	Series of bilateral meetings of PA administration/APA with partners (2-3 d total)	-	As part of core activities of PA staff
4	Seek a series of meetings with HPP operators to present options and explain reasons for biodiversity-friendly HPP operation	Series of 2-5 meetings with HPP operators, including preparation, documentation (minutes) and follow-up (2-3 d, with paid time of specialist consultant)	1,500	Argue for a formal agreement / MoU with HPP operators for long-term biodiversity-friendly HPP operation
5	Ask mobilized partners as per (3) above to also lobby HPP operators if needed	Follow-up meetings to (3) as needed (2 d max)	-	In case operators initially do not agree to change practices, by PA staff
6	Support and check operators during implementation of agreement	Regular meetings (initially monthly, later quarterly) of PA director with operators	-	As part of core activities of PA staff
7	Monitor impacts of biodiversity-friendly HPP operation and use any observed benefits for further lobbying (optional)	Commission national specialist consultant to define indicators (presence/absence of key taxa upstream of HPPs, breeding success of trout, etc.) (5 d), develop capacity for their use (5 d), monitor, communicate results	7,500	Monitoring capacity could be developed at level of PAs or through collaboration with external contractors ("Development and Implementation of Aquatic Biodiversity Action Plan," was carried out in 2015 by Blue, Rivers Environmental Consulting, Ukraine); if funds are too limited, strategy could also initially be implemented without this activity
Budget total			$ 12,000	

5.1.5 Broader capacity needs for implementation of strategy

This strategy is essentially a campaigning, negotiation and lobbing strategy, and will require good capacity in the relevant APA and MEPA departments to support this type of activity.

5.2 Adaptation strategy No. 28: Identify local climate refugia and strictly protect against non-climate threats

5.2.1 Basic information

- **Priority assigned to strategy:** 2 (to be tested)
- **Other PAs that have expressed interest in this strategy:** Kazbegi NP, Tusheti PAs.
- **Biodiversity values targeted by strategy**
    - **Primary:** (sub-)nival ecosystems, (sub-)alpine grasslands, high-mountain peatlands, mountain forest (but location and extent of refugia will differ between values)
    - **Secondary:** Endemic and threatened flora, ungulates, carnivorous mammals, raptors (but location and extent of refugia will differ between values)
- **Human wellbeing values targeted by strategy:** all (but to varying and unpredictable degrees)

5.2.2 Summary of strategy

This strategy is applicable to (sub-)nival, (sub-)alpine, forest, peatland and river ecosystems with the species to which they provide habitat and may be particularly relevant to habitats of mountain galliforms. Identification and protection of the areas which are in cooler and wetter locations, where direct impact of climate change may be less than in surrounding areas and which have been generally undisturbed by humans, are expected to be less vulnerable also to future climate change. Such climate refugia are generally thought to help preserve habitats and ensure species viability (NIACS 2022). Potential refugia could be on the north facing or more sheltered slopes and areas with more secure water supply, e. g. near springs (Neale et al. 2014), but also in several other mountain settings (see Figure 13). They shall first be mapped based on remote imagery and subsequent ground truthing based on agreed criteria, then prioritized and proposed for inclusion into the strict protection zone of the PA – or theoretically in another zone that affords the necessary level of protection to exclude critical conventional (non-climate related) threats from the identified climate refugia. This shall then be turned into a formal proposal for re-zoning and submitted to MEPA for approval.

5.2.3 Theory of change with indicators and activities

The theory of change of Strategy No. 28 is shown in Figure 14 (see Figure 11 for legend). Table 4 explains the objectives set for Strategy 28 and their indicators.

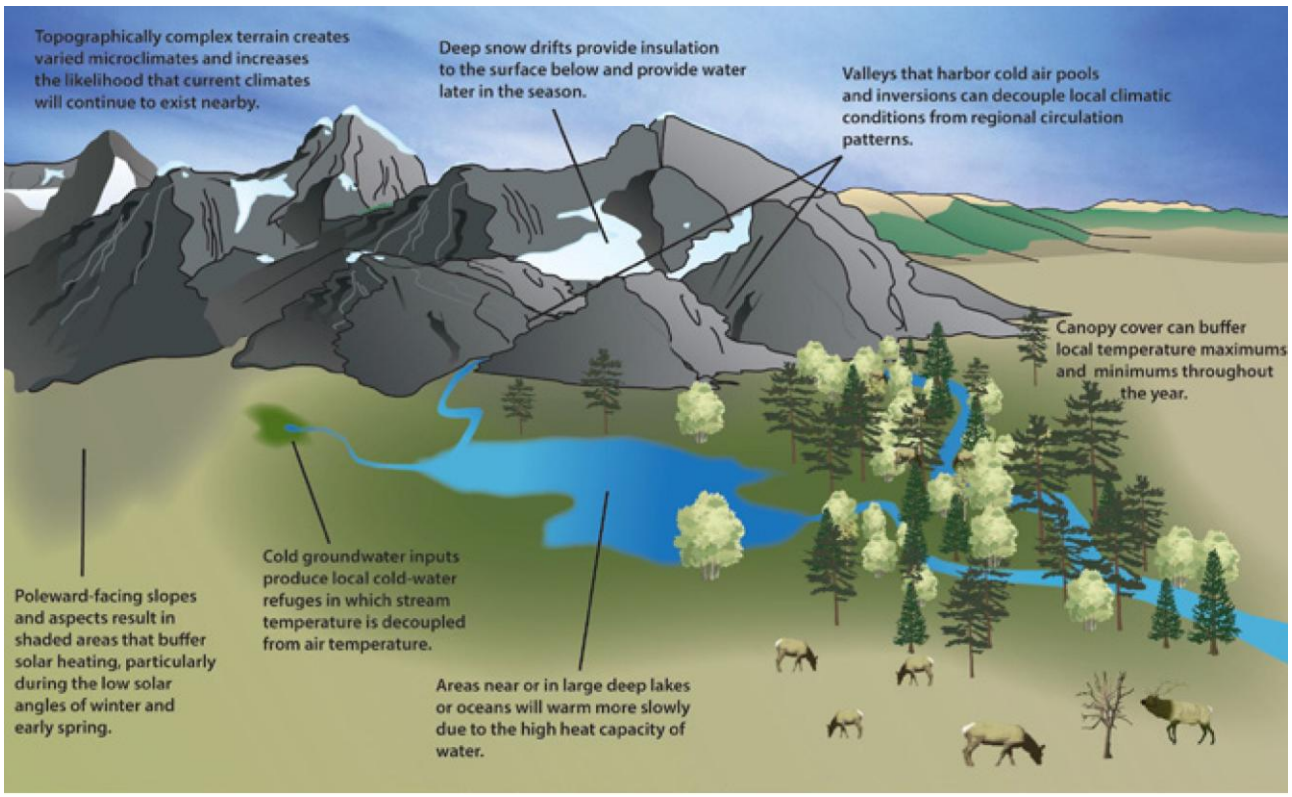

Figure 13. Examples of climate refugia. Source: Morelli et al. (2016).

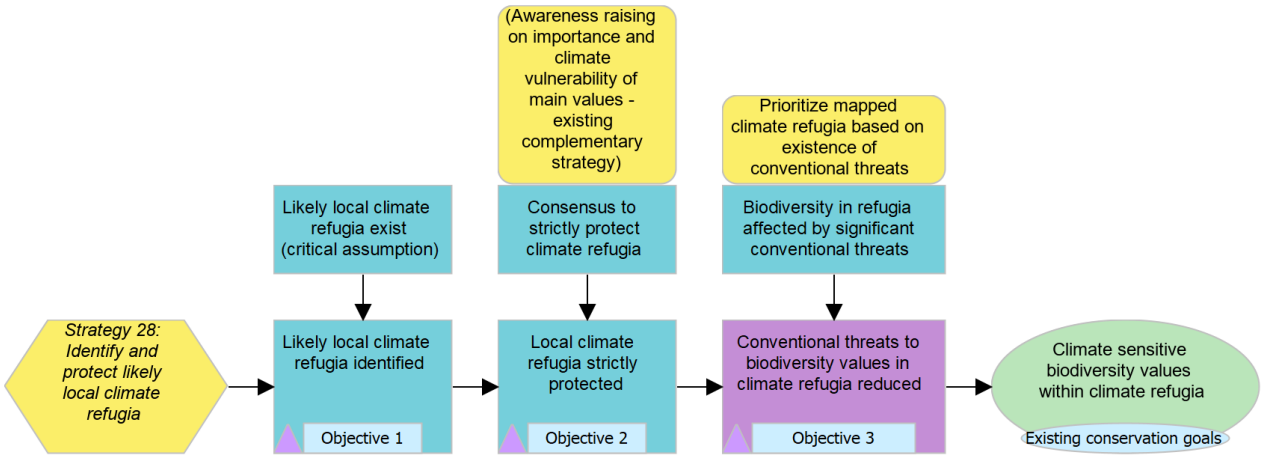

Figure 14. Theory of change for Strategy No. 28: Identify local climate refugia and strictly protect against non-climate threats.

Table 4. Objectives and Indicators for Strategy No. 28.

No.	Objective	Indicator (data/information source)
1	Entire area of PA screened for climate refugia	% of PA area screened for climate refugia (maps of screened areas)
2	At least 50% of the highest priority identified local climate refugia included in Strict Protection Zone (SPZ) of PA	% of maped climate refugia strictly protected (re-zoning decision)
3	Measurable reduction in conventional threats in climate refugia (degree of threat reduction depends on individual threats, needs to be specified by objective)	Depending on threats and main biodiversity values affected (various)

5.2.4 Activities under the strategy with their resources/requirements and indicative budget

Table 5 lists the main activities under Strategy No. 28 with their necessary resources as well as requirements and an indicative budget. Most of these activities shall be implemented by specialists on microclimate, commissioned by APA.

Table 5. Main activities under Strategy No. 28 with their necessary resources/requirements and an indicative budget.

No.	Activity	Resources/ requirements	Budget ($)	Comments
1	Define criteria and types of climate refugia (for broad functional groups and habitats, considering main values)	Desktop study by specialist consultant and online national expert consultation (total 5 d)	2,500	
2	Use freely available remote sensing data to identify potential climate refugia as per criteria	Analysis of GIS layers of PA by criteria as per (1) above (5 d)	2,500	
3	Field study to check potential climate refugia	Field survey (20 person days), plus optionally at least one year micro-climatological monitoring	10,000	Micro-climatological monitoring could be omitted, instead using a precautionary approach to protect all potential refuges that meet broad criteria.
4	Map confirmed climate refugia by main value	GIS mapping (5 d)	2,500	This is mainly processing information compiled through steps above.
5	Prioritize mapped climate refugia based on existence of conventional threats	Consultation with PA administration and national experts (2 d + 3 d preparation + WS costs)	3,500	
6	Elaborate proposal for inclusion of refugia into strict protection zone (SPZ) of PA	National PA legal expert (3 d)	1,500	Can be done based on existing templates
7	MEPA to approve re-zoning	-	-	Ultimately beyond control of APA but can be influenced by APA
8	Enforce and monitor re-zoned Strict Protection Zone (SPZ) to control conventional threats	Potentially increased patrolling effort needed, depending on change to SPZ	?	Can only be decided once results are available.
Budget total			$ 22,500 plus	Plus potentially micro-climatical study

5.2.5 Broader capacity needs for implementation of strategy

The main activities under the strategy shall be commissioned to external experts, as they require a highly specialized expertise. This cannot be reasonably expected to be present at an individual PA administration. Nevertheless, PA staff shall be familiarized with the general concept of climate refuges through the study.

Depending on how much the strict protection zone of the PA will finally be extended in order to protect identified climate refuges, a need to strengthen the capacity and staff of the protection service of the PA may arise.

Once likely climate refuges have been identified and are protected, it will be important to monitor if they really contribute to the better protection of their target biodiversity values. This will require a strengthening of the monitoring system – particularly for the state monitoring of the main biodiversity values of the PA – in the long term.

5.3 Adaptation strategy No. 31: Establish an early warning system and capacity to control invasive species

5.3.1 Basic information

- **Priority assigned to strategy:** 1 (to be implemented)
- **Other PAs that have expressed interest in this strategy:** -
- **Biodiversity values targeted by strategy**
    - **Primary:** All biodiversity values affected by invasive species of flora and fauna
    - **Secondary: -**
- **Human wellbeing values targeted by strategy:** All, but to different degrees and depending on which specific alien species / invasives are targeted using the strategy.

5.3.2 Summary of strategy

Alien species/invasive species are a threat to all ecosystems which will be aggravated by a milder climate in the target PA. The risk of the colonization increases if there is also habitat and/or soil disturbance (e. g. infrastructure development, overgazing), which creates opportunities for new pioneering invasives (Slodowicz et al. 2018). The early warning system shall consist of training of rangers to identify potential invasives using visual guides, inclusion of dedicated invasive patrols into their patrolling schedules, and cooperation with specialists to detect possible invasives in a timely manner.

Depending on the species involved, these specialists shall also advise on appropriate pre-emptive and reactive measures against identified specific threats to the target PA. The capacity of the PA administration to respond to detected alien species by suppressing them where feasible shall also be developed as part of this strategy.

5.3.3 Theory of change with indicators and activities

The theory of change of Strategy No. 31 is shown in Figure 15 (see Figure 11 for legend). Table 6 explains the objectives set for Strategy 31 and their indicators.

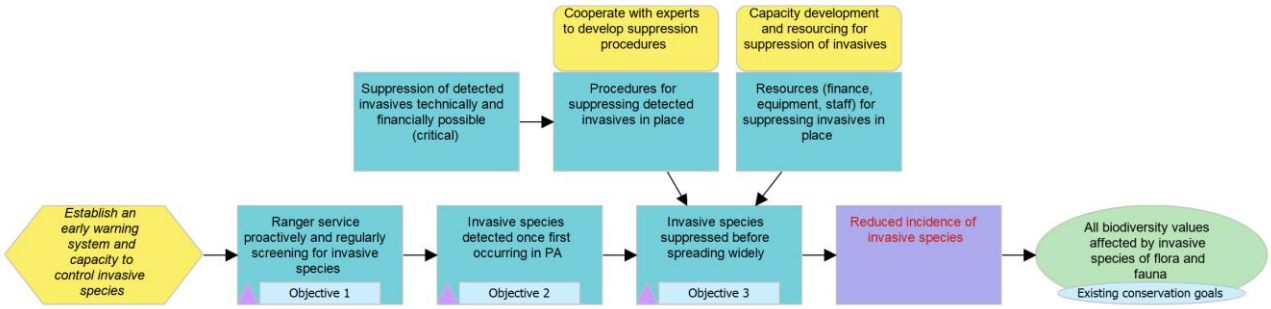

Figure 15. Theory of change for Strategy No. 31: Establish an early warning system and capacity to control invasive species.

Table 6. Objectives and Indicators for Strategy No. 31.

No.	Objective	Indicator (data/information source)
1	PA Rangers include screening for alien species / potential invasives along routes throughout the entire PA (but particularly lower altitudes) at least once per season into their standard patrolling routines	Field hours and/or patrolling distance for alien species / invasives screening per season (SMART records or manual patrolling logs)
2	Incidents of alien species / invasive species within the PA are detected when they are local (individual sites, limited spread) in extent	Extent, status and inferred age of colonization events at time of detection by rangers (evaluation of recorded incidents by rangers and/or national specialist expertise)
3	Detected incidents of alien species are suppressed before they expand to an uncontrollable scale if they are considered a specific threat to autochthonous biota, and if suppression is technically and economically feasible.	% of suppressible, threatening alien species incidents suppressed upon detection (PA incident statistics)

5.3.4 Activities under the strategy with their resources/requirements and indicative budget

Table 7 lists the main activities under Strategy No. 31 with their necessary resources as well as requirements and an indicative budget.

Table 7. Main activities under Strategy No. 31 with their necessary resources/requirements and an indicative budget.

No.	Activity	Resources/ requirements	Budget ($)	Comments
1	Commission a compilation of a list and identification guide of alien species / potential invasive species (flora and fauna) in the PA, as well as a guideline to screening for alien species / invasives	25 d of national experts time for field survey (e.g. 5 d 3x per season for botanists), plus preparation of guidelines (depending on number of species identified)	15,000 plus	Various national experts for relevant taxa to be involved; integration with existing patrolling support tools to be considered (e.g. guide on handheld SMART devices)
2	Train rangers, natural resources specialists, as well as potentially cooperating community members in screening for alien species / potential invasive species	2-d combined classroom and field training to be developed by national contractors (10), three runs, on-demand alien species / invasives surgery by national experts	10,000 plus	This would be highly compatible with the establishment of citizen science/monitoring activities within the PA
3	Integrate screening for alien species / invasives following the guideline and	Integration into patrolling plans by protection service as part of	-	Increased patrolling effort because of additional tasks

	using the list and identification guide into the routine patrolling plans of rangers	normal activity		may lead to a need for more rangers
4	Meetings and discussion with existing advisory board on invasives consisting of national experts on the matter	Initial meeting to define modus operandi, then annual standard meetings at APA plus incident dependent meetings	-	Existing board of experts at MEPA
5	Assess the risk and develop a catalogue of possible response protocols to the most likely alien species / invasive events, including estimates of necessary equipment, services and other resources	Desk study for risk assessment and short informal consultation with PA administration and advisory board as per (4) above, protocol design following agreed template (10 d per protocol)	20,000	National experts to advise on highest priorities. 5 protocols to be developed initially
6	Procure necessary equipment and other resources for high-priority response protocols, and engage potential service providers to be ready in case they are needed	As defined in output of (5) above. Equipment etc, could also be procured centrally by APA and kept at disposal for all relevant PAs	?	Procurement costs depend on specific protocols – impossible to estimate currently but likely to be thousands or tens of thousands of $$
7	Implement incident response protocols in those cases where alien species / invasives are initially observed during patrolling; this shall comprise checking of individual observations by specialists and implementation of response protocols	Part of routine tasks of protection service. National experts to be paid for site visits (fee and transport)	(500-750 per incident)	Costs for implementation of response protocols depend on specific protocols – impossible to estimate currently but likely to be thousands or tens of thousands of $$
8	Monitor success of incidence response measures, adapt protocols accordingly, and share among Georgian PAs and beyond	Part of routine monitoring tasks of PA, protocol adaptation to be discussed in advisory board if needed	-	
Budget total			$45,000 plus	

5.3.5 Broader capacity needs for implementation of strategy

The main capacity building activities needed for the implementation of this strategy are already listed in the main activities. It will be important for the PA administration to develop its networking capacity, so as to keep the invasives advisory board engaged in this strategy and ensure regular contact and exchange. As a complementary additional capacity which might support this strategy, the capacity to establish and run citizen science programmes would be useful.

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7 Appendices

7.1 Appendix 1: Rating of draft strategies according to criteria

Draft adaptation strategies obtained through participatory brainstorming at the PA adaptation planning workshop and/or literature analysis were preliminarily rated by the Consultant based on the following criteria, using a categorical appraisal:

- **Focus:** Does the strategy set out a specific course of action, or is merely a general objectives (e.g. "reduce poaching")? – Yes/?/No
- **Effectiveness** (Effect.): How many targets will be effected, and how likely is it that their high-priority climate change vulnerabilities can be reduced through by implementing the strategy? – Very effective (4) – effective (3) – partly (2) – mostly ineffective (1) – not effective at all (0).
- **Feasibility** (Feas.): To what extent is the strategy feasible technically, financially/resource-wise, capacity-wise, and in terms of the mandate of APA/PA administrations? – Very feasible (4) – feasible (3) – partly (2) – mostly unfeasible (1) – not feasible at all (0).
- **Scenario robustness** (Rbst.): How applicable is the strategy across scenarios, and how sure is it that there will be no maladaptive effects of the strategy in any of the scenarios? – Very robust (4) – robust (3) – partly (2) – mostly not robust (1) – not robust at all (0).
- **Urgency** (Urgnt.): How urgent is the strategy in the light of expected climate change vulnerabilities of biodiversity values? This is partly related to the above - some strategies only need to be operationalized once we know which climate scenario will be the case. It is important to document all draft strategies, but for now we only need to support CNF to support APA to operationalize the most urgent ones. Very urgent (4) – urgent (3) – partly (2) – not very urgent (1) – not urgent at all (0).

CCL.: Conclusion – do not pursue, wait 10 years and revisit decision whether to pursue, test as soon as possible, start implementing as soon as possible.

#	Short name	Focus	Effect.	Feas.	Rbst.	Urgnt.	CCL.	Comments
1	Cover glaciers	Y	2	1	3	4	No	Technical feasibility at scale unclear, no financial feasibility currently.
2	Snow fences	Y	2	1	1	4	No	Technical impact for significant scale unclear.
3	Artificial glaciers/reservoirs	Y	2	2	2	3	Test	Can be feasibility-tested as local small-medium scale solution.
4	CC smart grazing mgmt.	Y	3	3	3	2	Wait	Likely feasible and effective, if mgmt. provisions accepted by local SH. Need to first establish basic SGM.
5	Erosion control	Y	2	2	3	4	Do	Likely feasible and effective, if mgmt. provisions accepted by local SH.
6	Control treeline through grazing	Y	3	3	3	2	Test	Should first be piloted and tested, with long-term control plots.
7	Minimize contact livestock	Y	3	3	4	4	Do	Effective and feasible across scenarios

	– wild ungulates							and even independently of CC.
8	Reopen unused pastures	?	2	2	4	2	Test	"Unused" pastures might be used by wild ungulates. Specific pastures to be opened need to be identified.
9	Electric fencing	Y	3	3	4	2	Do	Feasible and likely effective in conjunction with strategies 4, 6, 7,8.
10	Adjust hay cutting dates	Y	2	3	3	3	Test	Can be piloted with control areas to optimize dates.
11	Close erosion gullies	Y	2	2	3	3	Wait	Particularly relevant to Sirimiri and Tropicana scenarios, but not maladaptive under others.
12	Improve livestock value generation	?	3	2	4	2	Test	More income per head does not automatically reduce number of heads. Study precedents from elsewhere in Caucasus and C Asia.
13	Livestock-independent livelihoods	?	4	2	4	3	Test	Alternative income sources do not automatically reduce grazing pressure. Study precedents from elsewhere in Caucasus and C Asia.
14	Awareness on grassland importance, vulnerability	Y	2	3	4	3	Do	(of local resource users and visitors)
15	Early warning & response (plant pathogens/pests)	Y	3	3	4	3	Do	Can be implemented relatively easy.
16	Forest disease incident mgmt.	Y	3	3	4	3	Do	Good practice in forest sector exists, can be applied.
17	Protect forest cover to keep out invasives	Y	3	3	4	3	Do	Needs to be considered in infrastructure decisions, in which there sometimes is considerable political interest.
18	Fires risk mgmt. & response	Y	4	3	3	3	Do	Good practice in forest sector and PAs exists, can be applied.
19	Awareness (fire risk increase)	Y	3	3	3	3	Do	(of local resource users and visitors)
20	Protect/restore riparian forest	Y	3	2	4	2	Test	Specific feasibility study needed, including on high-priority areas.
21	Rewet mountain peatlands	Y	2	2	2	2	Test	Specific feasibility study needed, including on high-priority areas.
22	Store water in spring for summer	Y	2	2	2	3	Test	Can be piloted at small scale first.
23	Protect springs and groundwater seepages	Y	2	3	4	2	Test	Need to be mapped
24	Wastewater treatment if visitation increases	Y	3	2	3	2	Wait	CC adaptive only once visitation increases, but likely useful anyway.
25	Sustainable water resources mgmt.	?	4	3	4	2	Do	Mainly under Furnace, also under Crisp scenario

26	Do not construct large hydraulic infrastructure	Y	3	4	4	4	Do	Little large-scale hydraulic infrastructure planned ***inside*** PAs anyway.
27	Engage downstream partners (HPPs)	Y	2	3	4	3	Do	Engaging HPP operators is one thing, achieving operation friendly to river biota another.
28	Identify, strictly protect local climate refugia	Y	3	3	3	3	Test	First need for systematic study to identify refugia. May require re-zoning.
29	Revise and adapt patrolling	Y	4	4	4	2	Wait	Can be integrated into standard adaptive mgmt. procedures.
30	Revise and adapt visitor mgmt., infrastructure	Y	4	4	4	2	Wait	Can be integrated into standard adaptive mgmt. procedures.
31	Early warning & control system (invasives)	Y	4	3	4	4	Do	Can be implemented relatively easy.
32	Ex-situ conservation of critically threatened flora	Y	2	3	2	2	Wait	Only as last resort, for critically endangered local populations, particularly of endemics. Requires external cooperation.
33	Adapt patrolling to improved poacher access	Y	3	4	3	2	Wait	Can be integrated into standard adaptive mgmt. procedures.
34	Understand and maybe manage Golden Jackal	Y	3	3	4	3	Test	Need for in-depth field and literature study.
35	Identify and protect local corridors, stepping stones	?	3	3	3	4	Test	Some mapping done. High mountains already act as corridors. May require re-zoning of PAs, medium-term.

7.2 Appendix 2: Integration of adaptation into the PA MP and other relevant documentation

#	Short name	Possible integration in the PA MPs and supporting documents
1	Cover glaciers to protect against insolation	- ?
2	Install snow fences to support accumulation of snow	- ?
3	Create artificial glaciers and reservoirs	- ?
4	Address reduced area and viability of (sub-)alpine pastures in existing sustainable pasture/grazing management systems	- Sustainable use of natural resources programme, PA MP - Public relations programme, PA MP - Pasture MP
5	Prohibit grazing on eroded slopes, regulate access, grazing and burning, and allow for pasture regeneration phases	- Patrolling and law enforcing programme, PA MP - Sustainable use of natural resources programme, PA MP - Public relations programme, PA MP - Zonation, PA MP - Eco-tourism and visitor management programme, PA MP - Pasture MP - Tourism Strategy - Tourism Carrying Capacity Study
6	Use selective grazing along the advancing treeline to control the upward spread of mountain forest	- Sustainable use of natural resources programme, PA MP - Public relations programme, PA MP - Zonation, PA MP - Pasture MP
7	Map (sub-)alpine grasslands regularly used by wild ungulate and manage grazing so that contact between livestock and wild ungulates is minimized	- Zonation, PA MP - Pasture MP
8	Re-open and ensure access (and water availability where necessary) to currently un-used pastures	- Sustainable use of natural resources programme, PA MP - Public relations programme, PA MP - Zonation, PA MP - Pasture MP
9	Introduce and promote the use of electric fencing and other bio-engineering means to manage grazing	- Sustainable use of natural resources programme, PA MP - Public relations programme, PA MP - Pasture MP
10	Adjust hay cutting dates to align with changes to the flowering dates	- Monitoring of key biodiversity values and threats programme, PA MP - Sustainable use of natural resources programme, PA MP
11	Close erosion gullies where necessary because of increased gully erosion	- Conservation and restoration programme, PA MP - Eco-tourism and visitor management programme, PA MP - Zonation, PA MP - Tourism Strategy - Tourism Carrying Capacity Study - Pasture MP
12	Increase sustainable value generation from livestock economy	- ?
13	Promote livestock-independent livelihoods	- ?

14	Raise awareness of the importance and vulnerability of (sub-)alpine grasslands	- Public relations programme, PA MP - Communication Strategy
15	Establish an early warning system and capacity to control newly arising forest plant pathogens and pests	- Fires, pests, fungi's and diseases management programme, PA MP - Strengthening administration capacity programme, PA MP
16	Improve forest disease incident management (removing dead or dying trees, retaining survived trees, restrict harvest & transportation of infected wood, etc.)	- Strengthening administration capacity programme, PA MP - Forest MP - ?
17	Minimize – through strict regulation – disruption of intact forest cover to stop colonization by invasives	- Patrolling and law enforcing programme, PA MP - Fires, pests, fungi's and diseases management programme, PA MP - Eco-tourism and visitor management programme, PA MP - Environmental education programme, PA MP - Public relations programme, PA MP - Strengthening administration capacity programme, PA MP - Zonation, PA MP
18	Strengthen fire risk management and fire response capabilities	- Patrolling and law enforcing programme, PA MP - Fires, pests, fungi's and diseases management programme, PA MP - Eco-tourism and visitor management programme, PA MP - Strengthening administration capacity programme, PA MP - Zonation, PA MP - Forest MP - Fire management plan
19	Raise awareness about increased fire risk with climate change	- Public relations programme, PA MP - Environmental education programme, PA MP
20	Protect and/or restore riparian forest to increase shading of surface waters, flood control, and the functionality of riparian connectivity corridors in Khevsureti	- Conservation and restoration programme, PA MP - Public relations programme, PA MP - Zonation, PA MP - Forest MP
21	Collect water and artificially re-wet high-mountain peatlands	- ?
22	Store water during spring to reduce withdrawal from rivers/streams for human use in summer	- ? - Monitoring of key biodiversity values and threats programme, PA MP - ?
23	Identify and protect spring and groundwater seepage areas	- Conservation and restoration programme, PA MP - Zonation, PA MP
24	Introduce/strengthen wastewater treatment if visitation at high altitude increases	- ?
25	Develop and implement sustainable water resources management plan to minimize extraction of scarcer water for use	- ?
26	Ensure that in the upper reaches of mountain streams and river inside PAs no damaging hydraulic infrastructure is established	- Zonation, PA MP - Public relations programme, PA MP

27	Engage downstream partners of PAs to ensure existing HPPs and other hydraulic infrastructure does not compromise migration of freshwater fauna	- Public relations programme, PA MP
28	Identify local climate refugia and strictly protect against non-climate threats	- Patrolling and law enforcing programme, PA MP - Conservation and restoration programme, PA MP - Zonation, PA MP -
29	Periodically revise and – if necessary – adapt protection measures (patrolling) to improved access, increased resource use pressure and increased human presence	- Patrolling and law enforcing programme, PA MP
30	Periodically review and – if necessary – adapt visitor infrastructure and visitor management systems to respond sustainably to changes in visitation	- Eco-tourism and visitor management programme, PA MP - Tourism Strategy - Tourism Carrying Capacity Study
31	Establish an early warning system and capacity to control invasive species	- Monitoring of key biodiversity values and threats programme, PA MP - Patrolling and law enforcing programme, PA MP - Strengthening administration capacity programme, PA MP
32	Ensure ex-situ conservation of endemic and/or critically threatened species of flora	- ?
33	Periodically review and revise patrolling plans to respond to improved access of poachers	- Patrolling and law enforcing programme, PA MP
34	Assess potential competition effects of the colonizing Golden Jackal with autochthonous predators and predation effects and develop response options	- Patrolling and law enforcing programme, PA MP
35	Identify and protect migration corridors linking target population to neighbouring areas (along main Caucasus ridge, to North)	- Monitoring of key biodiversity values and threats programme, PA MP - Zonation, PA MP - Corresponding Studies