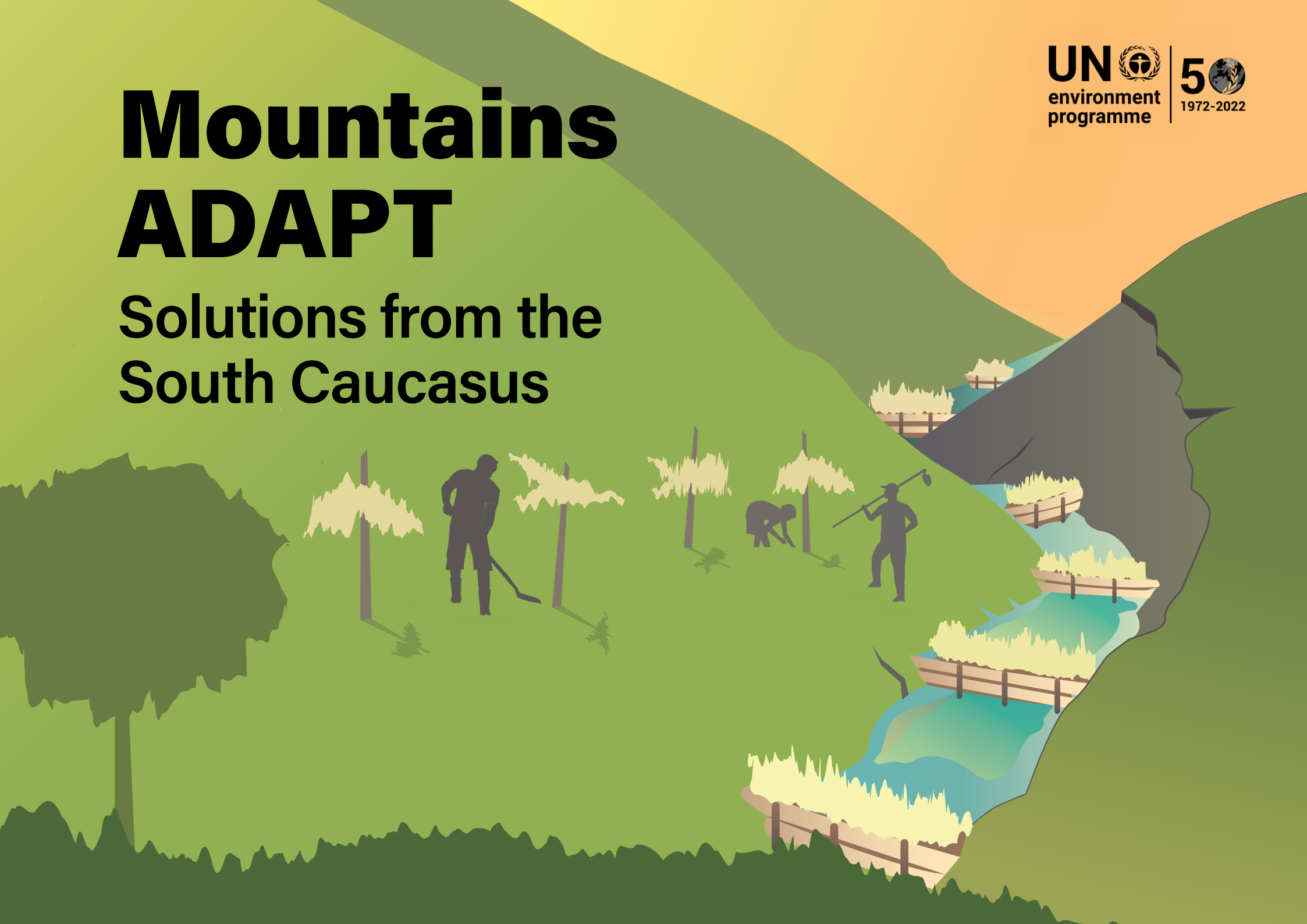
Mountains ADAPT

Solutions from the South Caucasus



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ADAPTATION AT ALTITUDE
Taking Action in the Mountains

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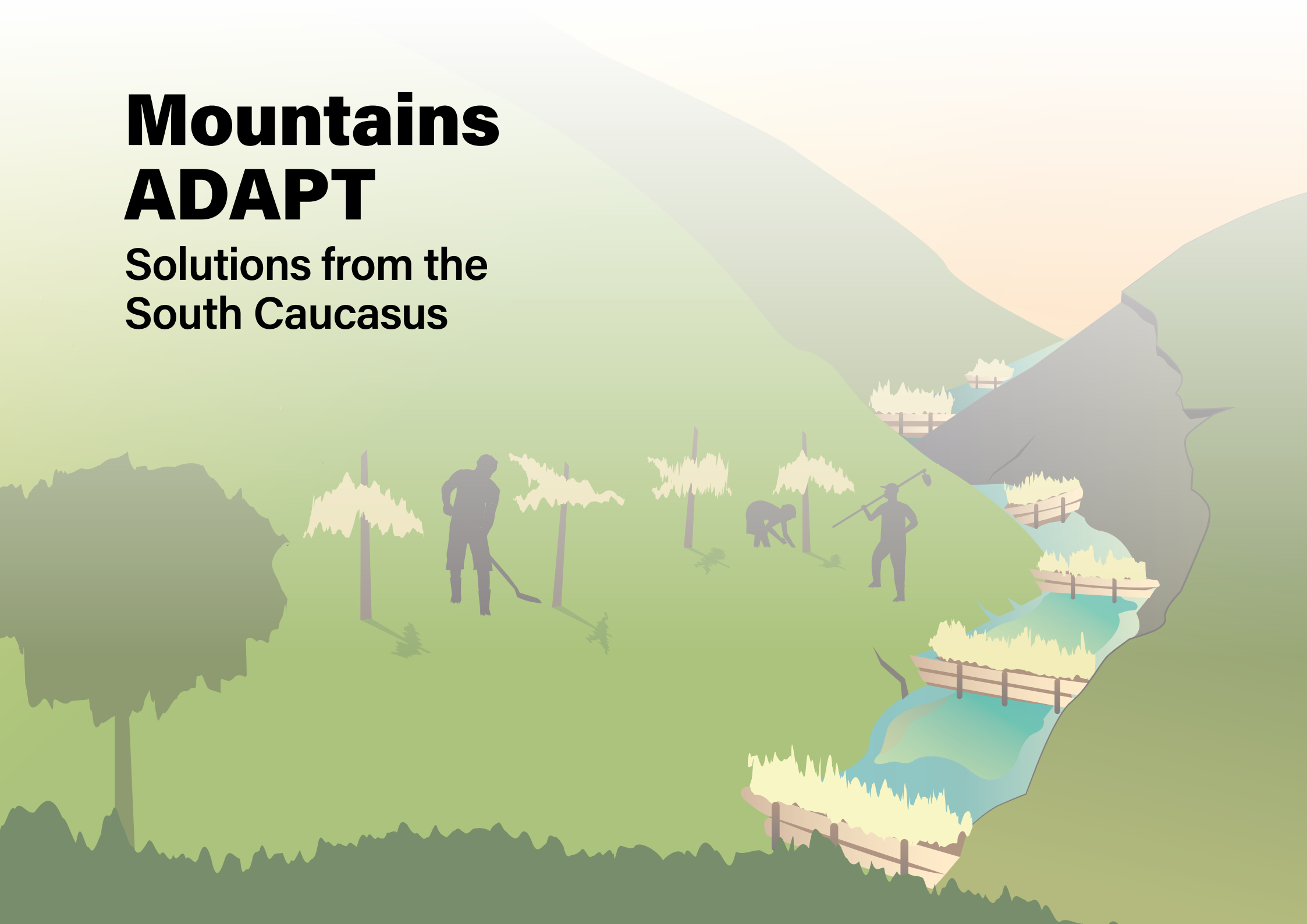

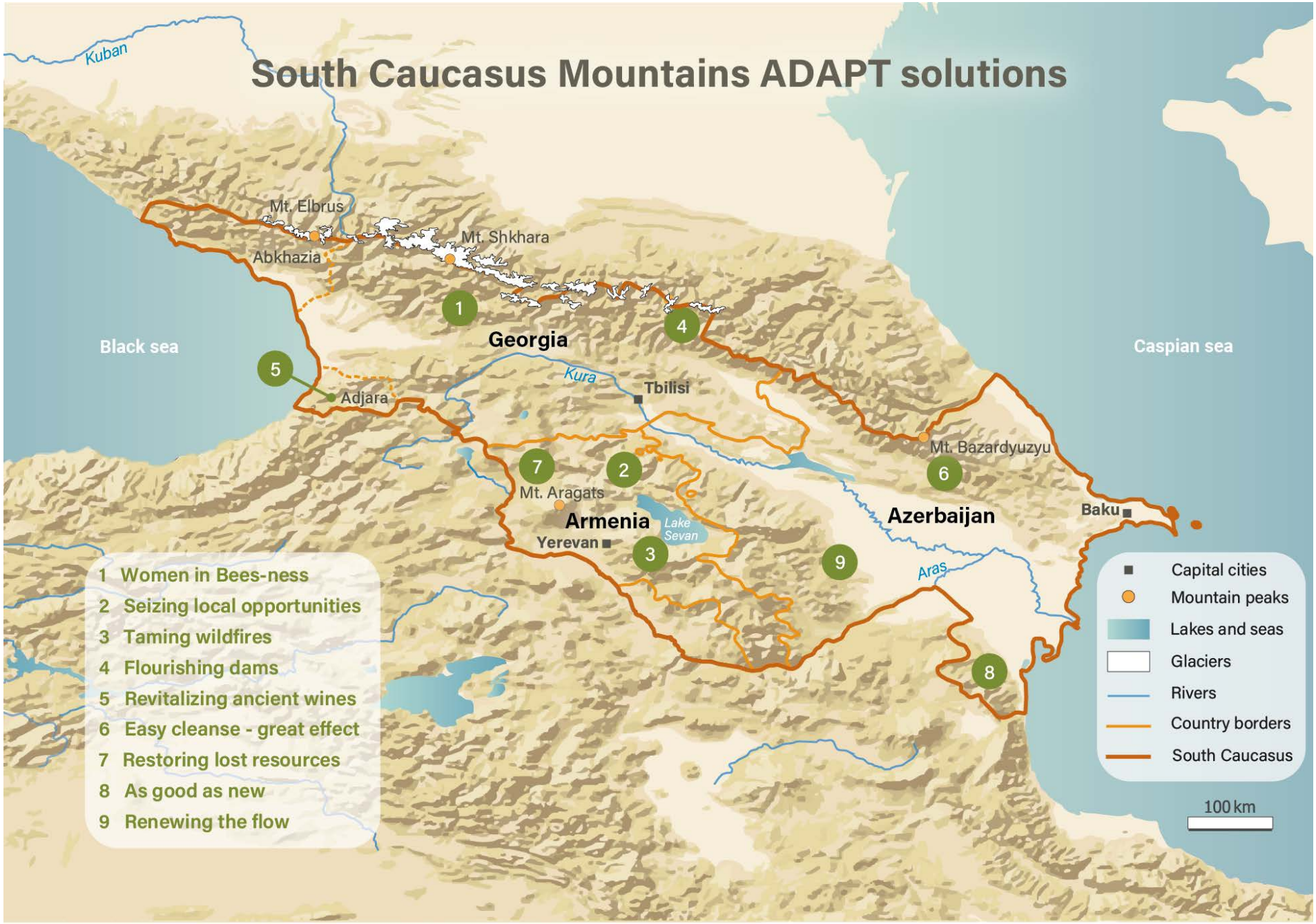

Source: Mountain delimitation modified from K3 definition in Kargulle et al. (2017).
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GRID-Arendal (2022)

Mountains ADAPT

Solutions from the South Caucasus

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Acronyms

CENN	Caucasus Environmental NGO Network
DRR	Disaster Risk Reduction
EbA	Ecosystem-based Adaptation
EU	European Union
EWS	Early warning system
EWMI	East West Management Institute
FAO	Food and Agriculture Organization of the United Nations
GAWB	Georgian Association "Women in Business"
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KOICA	Korean International Cooperation Agency
masl	meters above sea level
NbS	Nature-based Solutions
NGO	Non-governmental organization
RCP	Representative Concentration Pathway
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goal(s)
TFD	The Russian Federation-UNDP Trust Fund for Development
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VIIRS	Visible Infrared Imaging Radiometer Suite
WWF	World Wide Fund for Nature

Intro

A few words about ...

...the context

Climate change is disproportionately affecting mountain regions and their communities across the world with an amplified rate of warming compared to lower elevations and leading to rapidly changing conditions. Mountains provide a range of ecosystem services and goods that are an important source of future agrobiodiversity, water supply, and associated poverty alleviation and sustainable development at local, regional, and international levels. Observed changes in climate at high altitudes show a general decline in snow cover, glaciers, and permafrost. This decline has altered the frequency, magnitude, and location of most related natural hazards that expose mountain communities to higher risks (Hock et al. 2019a). Earlier onset of spring snowmelt and glacier retreat have already contributed to seasonal changes in streamflow in low-elevation mountain catchments. These trends are expected to continue and their impacts to intensify, posing increasing challenges for water supply, agriculture, biodiversity, disaster preparedness and tourism (Intergovernmental Panel on Climate Change [IPCC] 2021). It is therefore crucial to identify, develop, transfer, and implement practical mountain adaptation solutions.

In this context, the global programme Adaptation at Altitude: Taking Action in the Mountains,[1] funded by the Swiss Agency for Development and Cooperation (SDC), aims to increase and share knowledge on appropriate climate change adaptation solutions in mountains, and feed it into science-policy platforms for better informed decision-making. The Adaptation at Altitude programme improves the availability and use of mountain observation data and information, strengthens regional science-policy dialogue platforms, increases knowledge on mountain adaptation solutions, and influences global policy processes to mainstream climate change adaptation in mountainous regions. The target mountain ranges are found on four different continents, stretching from the Andes, over the East African mountains, the South Caucasus to the Hindu Kush Himalaya. The solutions showcased in this booklet form part of a wider collection of adaptation solutions from across the mountain world, which are presented in an online solutions portal on the programme website.

...the South Caucasus region

This booklet zooms in on concrete adaptation solutions in the mountains and communities of the South Caucasus region, located between the Caspian Sea and the Black Sea. It covers the three countries of Armenia, Azerbaijan, and Georgia. The region has a diverse climate, in large parts because of its altitudinal differences and complex terrain: the biomes found at altitudes include alpine meadows in the North and steppe landscapes in the drier mountain plateaus of the South (Muccione and Fiddes 2019; Zazanashvili et al. 2020). The mountainous parts of the three countries are inhabited by a rural population that is mainly working in the countries' agricultural sectors. In each country, the concentration of economic activity and development has been led by capital cities leading to patterns of spatial disparities between urban and rural areas. Access to income generating opportunities is generally low among the geographically more isolated, perpetuating the dependence on low-productivity agriculture (The World Bank Group 2019). The communities have less access to education and healthcare than in the cities and are closely interlinked with and depend on their surrounding natural environment. This makes the mountain inhabitants of the South Caucasus particularly vulnerable to the effects of climate change, which is already altering the fundaments of their livelihoods.

...climate change and socioeconomic challenges

The climate in the South Caucasus region is expected, with some local uncertainties, to become warmer and drier with less predictable rainfall patterns, along with an increase in extreme precipitation events. Warmer temperatures are likely to alter water cycles and reduce water availability in the mountains, as well as downstream (Shatberashvili et al. 2015; Muccione and Fiddes 2019). Mountain farmers and herders will therefore have to adapt to drier conditions, while forest management will need to be prepared for a heightened risk of fires or other forest disturbances, such as drought, disease outbreaks, decrease in reproducing potential and thus protective functions. Heavy rainfall events are forecasted to occur more frequently by 2050, which for mountain communities means a higher risk of landslides and increased erosion (Shatberashvili et al. 2015; Bayramov et al. 2019). A combination of poor management and inadequate land use practices are putting local environments under heavy pressure. Climate change and its effects are often an additional trigger exacerbating already existing challenges.

[1] www.adaptationataltitude.org

In the 20th century, Armenia, Azerbaijan, and Georgia formed part of the Soviet Union. Since its collapse, the countries have experienced multiple reforms in the context of complex social and political structures. The economy has improved since the crises in the 1990s, but cluttered agricultural reforms and changing water management institutions have limited the rural mountain communities' adaptive capacity (Shatberashvili et al. 2015; Worden and de Beurs 2020).

What to expect…

…in this booklet

This booklet showcases adaptation solutions proven to be successful in response to specific issues caused, or accelerated by, climate change that negatively affect mountain communities' livelihoods and ecosystems. These solutions were selected for their inclusive approaches, their potential to be transferred and upscaled, as well as their extended benefits to downstream communities across the region.

"People living in the South Caucasus mountains — from villages at the foot of the Great Caucasus range to further downhill — have always lived with extreme climatic conditions. Yet the climate crisis means we now need to find a new relationship with nature, and also tap into old wisdom to keep benefitting from nature's gifts, like freshwater and stable healthy soils.

We need solutions for climate change adaptation that seize on opportunities for livelihoods that are in harmony with the environment. And we need a regional approach. This collection can act as a guide on our path to help the people of the South Caucasus mountains adapt to new living conditions in the 21st century."

– **Bruno Pozzi**, Regional Director for Europe, United Nations Environment Programme

The booklet aims to highlight a variety of possible approaches in addressing climate change related vulnerabilities. The booklet focuses on actions and measures that already have been or are being implemented to allow for evaluation of their impacts. Enabling factors are also assessed to show the potential for replication in different sociocultural, ecological, political, or economic contexts, sectors, and geographies.

The objective of the publication is to share knowledge with local, regional, and national policymakers, practitioners, potential donors as well as local communities and the interested public about mountain adaptation solutions. The collection aims to inspire, facilitate, and promote the uptake, transferal, and upscaling of adaptation action in the mountains of the South Caucasus.

…from mountain adaptation solutions

We define adaptation solutions as planned and autonomous responses that address one or several mountain-specific challenge(s) and exploit opportunities to adapt to changing future environments. Thus, they represent mountain-specific interventions that build socio-ecological resilience, strengthen adaptive capacity, and contribute to climate-resilient development pathways. As such, the solutions benefit people's livelihoods and income opportunities, and further support healthy mountain ecosystems.

How we gathered solutions…

…along six key dimensions

Adaptation solutions were gathered and selected following a step-by-step process along six key dimensions to qualify for a mountain adaptation solution:

- relevance in addressing at least one mountain-specific climate change risk.
- practicality and feasibility of implementation in terms of human and financial resources available.
- direct benefits and co-benefits to the environment, the economy and society, especially with regards to gender equality and empowering women and girls.
- flexibility and robustness in terms of effectiveness under a range of different climatic and socioeconomic development scenarios.
- potential for adjustment, replication, or upscaling in other geographic, social, or sectoral contexts.
- political, cultural, and social acceptability and coherence with existing or planned policies at the local, regional, and national level.

…with our step-by-step approach

In a first step, an initial broad scoping on ongoing and recently finalized adaptation activities was completed by experts from each of the three countries. A total of 39 solutions could be identified, offering various sectors, differing levels of implementation and a range of executing entities and donors. Taking into consideration, among other aspects, the thematic balance, country coverage, inclusive approaches such as Ecosystem-based Adaptation (EbA[2]),

[2] Ecosystem-based adaptation (EbA) is "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change" (Convention on Biological Diversity [CBD] 2009)

types of solution-providers, and information available, nine solutions were selected to be further investigated for the purpose of being featured in this booklet.

What we learned ...

Although all solutions are context and site specific,

- they share certain enabling factors for successful implementation, i.e., local community support, economic and other co-benefits, as well as incorporating traditional knowledge and socio-economic practices.
- climate change is most often "only" an additional trigger for adaptation action.
- size and coverage of solutions implemented largely depend on availability of and access to financing mechanisms (with international donors providing the largest contributions).
- types of solutions not only refer to specific climate risks, but rather to the broader context (e.g., geopolitical, socio-economic) in which they are embedded.
- only a few solutions are linked to the direct implementation of national adaptation plans and strategies.

Whom to thank for ...

Most of the solutions showcased are associated with development projects, with a variety of solution-providers highlighted. Some can be considered bottom-up, whereby local actors-initiated action, while others stem from donor-driven projects initiated by national, regional, or international actors. Bottom-up solutions include business ventures taking advantage of local niches, or the revitalization of traditional knowledge that has been in the community for generations. Donor-driven projects are often bigger in scope and span, from projects implemented in a single community to large-scale projects covering several regions.

Some background on...

...how the solutions are described

The solutions featured in this booklet are structured along four overarching themes that outline the broader context:

- Diversified livelihoods with climate and biodiversity benefits
- Disaster risk reduction
- Erosion control
- Water harvesting and retention

The nine solutions presented in this booklet under these themes have been implemented or are being implemented at the time of writing in the three countries of the South Caucasus. These solutions are designed to bring multiple benefits, such as improved local resilience and biodiversity, and a better life with more income opportunities for the people in the communities in which they are implemented.

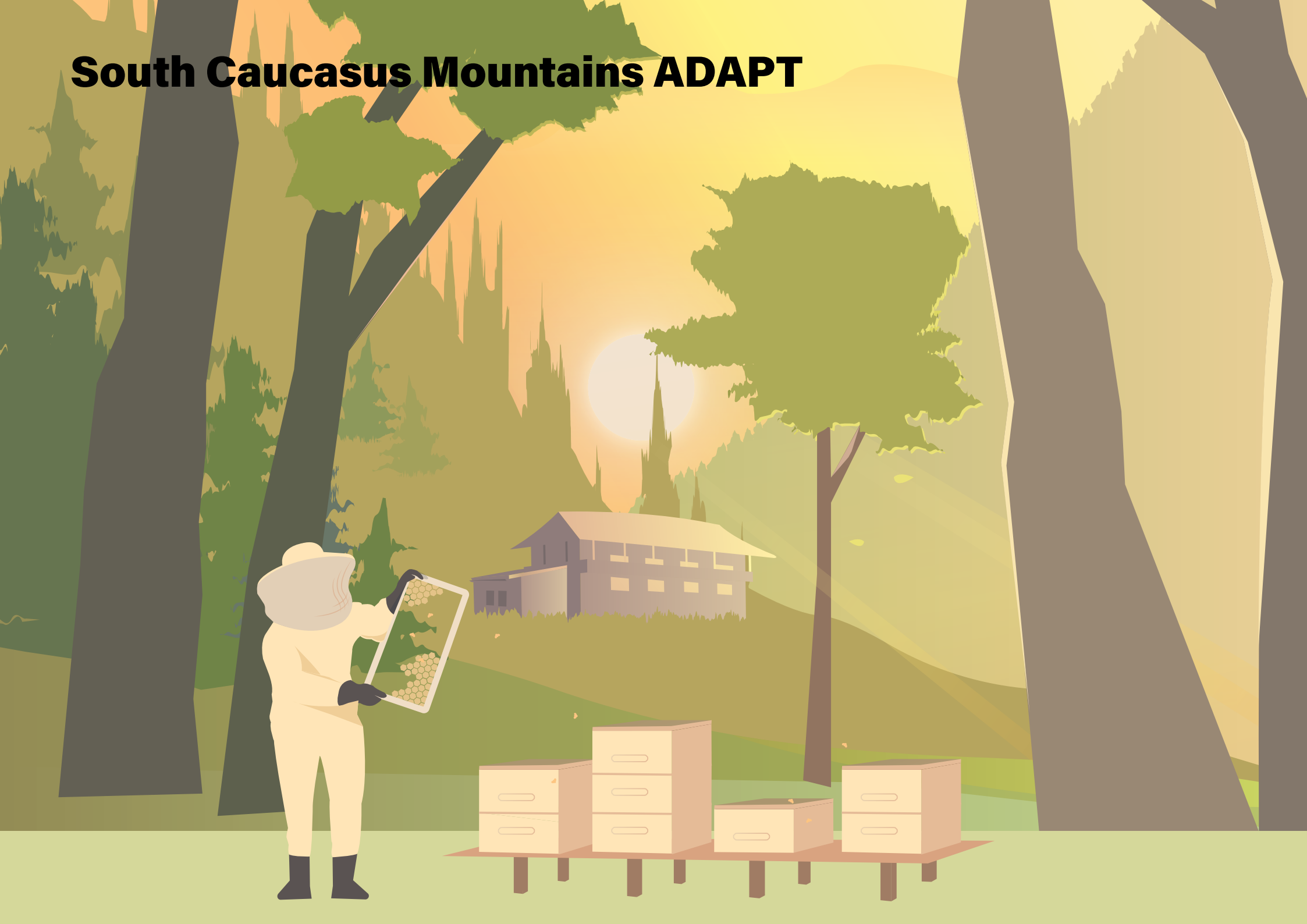
...what the solutions offer

The solutions focus on essential aspects of adaptation in mountain areas, and attention is paid to implementation strategies, financial schemes, local voices, gender equality and success factors such as ownership and co-creation of the local communities. Some of the solutions are Nature-based Solutions (NbS[3]) and EbA, using both traditional and new technologies. An important aspect is the restoration of mountain ecosystems, as land degradation is an increasing issue that directly affects communities in the South Caucasus mountains, where agriculture is the main source of income for households (The World Bank Group 2019). Several solutions include mountain restoration activities, relating well to the 2021-2030 United Nations Decade of Ecosystem Restoration[4] which aims to prevent, halt, and reverse the degradation of ecosystems on every continent and in every ocean.

[3] Nature-based Solutions are actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits (United Nations Environment Assembly 2022).

[4] https://www.decadeonrestoration.org/

South Caucasus Mountains ADAPT



SOLUTIONS

Diversified livelihoods with climate and biodiversity benefits

Diversifying the activities supporting every-day life through creating new income opportunities is not only improving the economic situation of local communities but also reducing risks associated with overdependence on natural resources. Often, this has several co-benefits such as reducing the pressure on the environment, mitigating the risk of natural disasters and improving gender equality. There are many elements that support sustainable livelihood choices such as appropriate policies, knowledge and education, alternative economic options, and access to markets. Providing guidance for and concrete examples of sustainable practices and financial support to the local populations help to increase their resilience for the future in a changing climate.

In the South Caucasus, mountain communities mostly rely on agriculture and livestock for their livelihoods. Agriculture is predominantly carried out by individual households and is often a mix of crop and fruit production and small-scale animal husbandry (Buchner et al. 2020). Along with socio-political factors and significant effects of climate change, poor pasture management and overgrazing has led to progressive land degradation, making the region and its residents less resilient (Shatberashvili et al. 2015; Neudert et al. 2019). Supporting ecosystem services such as bee pollination is a Nature-based Solution (NbS) that supports biodiversity in natural vegetation and agricultural produce. Honey is a by-product and provides an additional income source. Engagement of marginalized groups, such as women, is important for ensuring equal access to livelihood opportunities (Jashi 2017).

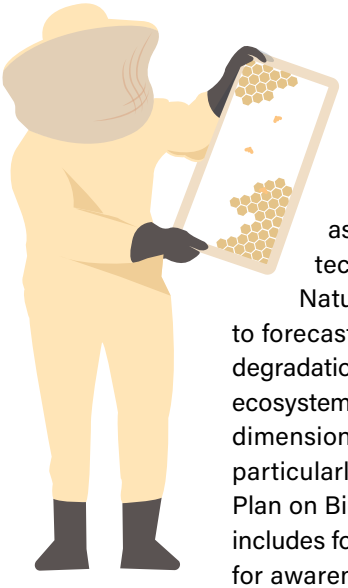
Educating the local communities, especially women and girls, about environmental change and biodiversity ensures greater ownership by the mountain inhabitants and supports building long-term resilience. The following solutions exemplify how seizing local opportunities and targeted training can create new livelihood opportunities that have multiple benefits for both communities and their environment.

Women creating a buzz

What is the issue ...

The Ambrolauri municipality in north-western Georgia is home to about 11,000 inhabitants who live within the vicinity of large deciduous forests and abundant water resources. With an average altitude of 500 masl, winters can be harsh, whereas summers are long and mild. Mining has been a driver of the local economy in Soviet times, but in recent years, activities have shifted towards forestry and agriculture.

The 57 villages of the Ambrolauri municipality belong to the 22 per cent of Georgia's surface area at high risk of landslide events. According to the Climate Change National Adaptation Plan for Georgia's Agriculture Sector (Georgia, Ministry of Environment and Nature Protection 2017), the frequency of natural hazards is expected to increase across Georgia due to warming temperatures. In the absence of adaptation measures, agricultural productivity in the Ambrolauri municipality will be reduced and interrupted by reoccurring landslides, flooding, and other climate risks even more so than today. Precipitation change is also expected to reduce access to irrigation and negatively affect agriculture. Moreover, the degradation of forests will limit their protective function, thus further contributing to a decrease of water availability (National Association of Local Authorities of Georgia 2016).



Beehives in the Ambrolauri municipality ©Sustainable Caucasus

Looking at Georgian society, women are considered more affected by climate change, mostly due to a higher vulnerability to natural disasters than men (National Association of Local Authorities of Georgia 2016), and various gender-specific cultural, social, and economic barriers lead to less food security. In Ambrolauri, there is also a high proportion of women living below the poverty line, further increasing their vulnerability to climate change (Shatberashvili et al. 2015).

How can it be solved ...

In the framework of the European Union (EU)-funded Climate Forum East II, the non-governmental organization (NGO) ECOVISION developed a Climate Change Adaptation Plan for Ambrolauri City and the Ambrolauri Municipality. The adaptation plan aims to strengthen local ecosystems and their services and create alternative income sources for the municipality's population. As a first step, a climate risk assessment was developed, and – with the technical support of the World Wide Fund for Nature (WWF)-Caucasus – modelling was used to forecast impacts of climate change induced land degradation and biodiversity loss in Ambrolauri forest ecosystems. The assessment also looked at the social dimension and found that women and youth were particularly vulnerable. A specific Local Adaptation Plan on Biodiversity Protection was developed that includes forest adaptation measures but also provisions for awareness-raising. This included tools to inform communities about alternatives to livelihoods based on forest resource use for which the local NGO "Georgian Association Women in Business" (GAWB) was tasked with implementation.

To strengthen women's involvement in businesses, diversify and improve their livelihoods, and support the local economy in the municipality of Ambrolauri, GAWB offered trainings on alternative income opportunities such as beekeeping and marketing of local products along with awareness-raising for biodiversity conservation. They provided both women already in the honey-making business and women new to beekeeping with several bee colonies as an incentive to start their own business and ensured that they received relevant theoretical and practical support for beekeeping, honey production, packaging and sales.

For women to generate revenue from their businesses, a small shop was opened near the main road in the Nikortsminda village, offering a permanent and free place for women to sell their products, including the local well-known 'Lobiani' bread with bean, and exchange within the community. The shop is

Beehives in the Ambrolauri municipality ©Sustainable Caucasus

Natia Geladze ©Sustainable Caucasus

> ***In 2015, within the project for women, our family got hives with bee [colonies] for free to start beekeeping. The expert who trained us also lives in our village, and when we have questions, he is always ready to give free consultations. Currently, we are selling honey to the domestic market. This business is profitable because the demand for honey is high, and the price has also increased in the last few years. Involvement in this project was a good decision.***
>
> – Natia Geladze, beneficiary from Ambrolauri

placed on a frequently visited tourist route to cultural heritage sites in Ambrolauri municipality and was therefore successfully embedded into the local tourist infrastructure, thus supporting direct supply chains from production to local sales. To foster sustainability, a social enterprise for the management of the beehives has been created, which is supposed to increase revenue and further enhance promotion of this alternative income opportunity.

The expansion of beekeeping practices is also beneficial for the environment as it is expected to increase pollination via the local Caucasian honeybee (*Apis mellifera caucasia*). These bees are known for being gentle and easy to handle, to produce large quantities of honey and are adapted to the climate of the Caucasus mountains (Khositashvili et al. 2019). Bees are a major pollinator of crops and wild plants and therefore play a crucial role in agricultural production. Moreover, increased pollination leads to more plant reproduction and transport of seeds. Hence, vegetation cover on mountain slopes improves, with the positive effect of reducing the exposure to erosion (Pacheco Gil and Montilla Pacheco 2020).

Who is benefitting ...

The solution was implemented within the Ambrolauri municipality and included two pilot villages with up to 300 beneficiaries. They have been chosen considering their capacity and opportunity to support livelihoods linked to tourism in the municipality and have already been negatively affected by natural disasters. Beneficiaries included local self-government, the municipal population in general and farmers in particular, but also local NGOs. Trainings have provided beginners but also experienced entrepreneurs with practical skills to start or boost their beekeeping business.

Through opening a local shop where also honey and other bee products can be sold through direct marketing along frequented tourist routes, income is expected to further increase.

... and how could it work elsewhere?

This type of solution can be implemented in different parts of the South Caucasus and other remote mountain regions and can have a particularly positive effect in communities where rural emigration rates are high and women's inclusion in local businesses is low. Through providing a lucrative option for income generation, especially for women, it contributes to poverty reduction by shifting dependence from forest resource use, thus increasing resilience of households to climate change induced impacts. Important enabling factors include the formulation of a local adaptation plan, peer-to-peer exchanges and learning, considering and linking to tourist infrastructure for marketing and sales, as well as raising awareness of the environmental co-benefits of beekeeping.

The number of pollinators is decreasing in many regions of the world, meaning that this solution combining community with environmental benefits fits in several mountain regions. In hilly areas where agriculture and increased erosion cause land degradation, promoting beekeeping can assist with restoration. It is important to note that the honeybee species selected needs to be adapted to the climate and environment in which it is being introduced.

Seizing local opportunities

What is the issue ...

In Armenia, due to its climate and pronounced location in the South Caucasus with a mountainous landscape and fragile ecosystems, the compounding effects of climate change and land degradation substantially affect local economies and communities` livelihoods. This is particularly the case for the communities living next to the Khosrov Forest State Reserve (Ararat Marz, south-western Armenia) and Dilijan National Park (Tavush Marz, north-eastern Armenia). Both protected areas are highly important for species conservation. Several plants and animals of the Red List of Threatened Species of Armenia can be found here, including migratory species.

Dilijan National Park border, where forest abruptly meets agricultural land in Fioletovo village, Armenia (1700 masl) @Sustainable Caucasus

The communities surrounding these protected areas depend on limited land and pasture resources that are increasingly impacted by climate change. They are facing high rates of poverty with limited capabilities to address land degradation and sustainably manage natural resources of the region. Community pastures are 3-9 km away from the villages, which are used by cattle breeders. Those pastures are severely degraded as continuous grazing from early spring to late autumn does not allow plants to undergo generative development and restore the area through seeds. There is a high risk that community pastures are transformed into unproductive landscapes thereby depriving rural mountain livelihoods. The lack of alternative income opportunities further weakens the adaptive capacity of their production systems (Adaptation Fund 2013).

Agriculture has traditionally been the backbone of Armenia's rural economy, but agricultural productivity has decreased in the past five years (Adaptation Fund 2013). Meanwhile, between 2013 and 2020, at the national level the share of the agricultural sector's gross domestic product has gradually decreased from 18.4 per cent to 11.7 per cent (World Bank 2021). The decrease in harvesting for the rural populations adjacent to Khosrov Forest State Reserve and Dilijan National Park is mainly due to the lack of irrigation water and efficiency of the deteriorated irrigation systems, where large water losses occur in irrigation channels. This is further aggravated by frequent hails, spring frosts, high summer temperatures and hot winds (Adaptation Fund 2013).

How can it be solved ...

An inclusive approach has been chosen to strengthen adaptation capacities for communities close to the protected areas of Khosrov Forest State reserve and Dilijan

National Park within an internationally funded project, targeting both livelihoods and adjacent ecosystems.

As lack of water has been a major concern in the areas close to the Khosrov Forest State Reserve and Dilijan National Park, water-use efficiency has been improved by renovating the main irrigation supply systems where large water losses occurred. The water saved can now be used to expand irrigated land, which increases crop yield and thus income for the rural population. In addition, drip irrigation has been established in the communities for planting orchards and preventing further soil degradation. Mulching and the adoption of more heat- and drought-resistant pasture crops were also promoted to cut down water use (Adaptation Fund 2013).

For reducing pressure on community pastures, climate smart livestock management has been introduced including rotational grazing and construction of livestock watering points as well as indigenous reseeding for restoring degraded land (Adaptation Fund 2013).

Livelihoods are also being strengthened by diversifying agriculture and decreasing energy needs and costs. New technologies that have been introduced include lightweight greenhouses and solar dryers. Non-heated greenhouses extend the growing season and reduce water demand, allowing villagers to grow non-traditional and non-native crops that are in high demand in the market. Solar dryers for fruits, berries, vegetables and herbs reduce raw material loss, and improve the quality of the final products. Overall, these new technologies improve farm productivity and increase income. To empower marginalized groups, women and youth have especially been supported with these technologies (Adaptation Fund 2013).

An old well used as a watering point will be renovated in the Aghavanavank village next to Dilijan National Park
©Sustainable Caucasus

Who is benefitting ...

In Ararat Marz, a total of 4,525 inhabitants have been targeted in about 1,000 households across three rural settlements. The communities' administrative area is about 9,400 hectares, which includes pastureland (82.2 per cent), arable land (8.1 per cent), remote pastures (5.9 per cent), land plots (1.7 per cent), perennial herbs (1.3 per cent) and gardens (0.4 per cent). The total number of cattle in 2017 was 7,149.

In Tavush Marz, the number of inhabitants targeted by the project was 11,643 in 2016, across about 3,700 households. The communities' administrative area includes pastureland (68.8 per cent), hay meadows (18.3 per cent), arable land (7.4 per cent) and land plots (5.5 per cent) (Adaptation Fund 2013). There were about 8,653 heads of livestock in 2016.

Through the holistic approach taken to support family farms and rural communities in the two areas, food and nutritional security could be improved along with increasing efficient management of water resources for the benefit of the community. The promotion of orchards, greenhouses, and solar dryers in combination with training on the marketing of products on local and national markets has further provided new income opportunities, particularly for women.

... and how could it work elsewhere?

This type of solution is relatively easy to scale up and implement in other communities in the vicinity of a protected area. The measures to diversify income sources benefit biodiversity conservation by reducing land use pressure on the protected areas (such as uncontrolled grazing and wood collection). The combined approach of developing climate smart pasture management, establishing agricultural value chains, introducing energy saving technologies and increasing water use efficiency will help to sustain rural livelihoods while restoring degraded land.

To gain the trust of community members, a key enabling factor to support the solution's success is an early-on dialogue with the villagers, explaining the approach and ensuring interventions are targeted to local circumstances and needs. Another important element to facilitate long-term change is the training of community champions, regular exchanges of best practices between communities, and more traditional lecturer–listener models of knowledge transfer (Adaptation Fund 2013).

In this solution, a formal agreement between the Ministry of Environment and each community was signed, declaring their commitment to implementation, as well as mutual liabilities and reporting requirements. The open-access agreement and protocols aim to ensure public accountability, transparency, and the sustainability of implemented changes.

Karlen and Anush Baghdasaryan from the Aghavnavanq village next to Dilijan National Park @Sustainable Caucasus

> *Metaphorically speaking, this project seemed to help the villagers get their hands back. It is a big privilege to work on one's own land and enjoy the results achieved. These canned vegetables are made of vegetable crops provided by the project. More such projects are needed to reach the state of self-confidence and self-sufficiency of villagers.*
>
> – Mr. Baghdasaryan

> *Our family is among those selected to receive a fruit solar dryer. We rely very much on this chance to start a small business and even to create a few job opportunities for others. As informed, the dryer is supposed be an 18 square metre dry fruit producing unit, which should be big enough to establish a family business with a few employees.*
>
> – Ms. Baghdasaryan

SOLUTIONS | Disaster risk reduction

The South Caucasus countries are particularly prone to natural hazards, including earthquakes, floods, and landslides. The region spans several fault lines, making it one of the most seismically active zones in the world, with frequent earthquakes (European Commission 2018), which are directly connected with stimulation of landslides and debris/mudflow phenomena (Tsereteli et al. 2021). At country level, 2/3 of landslides observed in Georgia took place in mountain zones, while debris/mudflows, snow avalanches, rockfalls and rock avalanches occurred almost exclusively in mountains (Tsereteli et al. 2021). Approximately one third of Armenia´s communities are exposed to mudflow and landslides, large areas face drought risk and around 40,000 people are affected by flooding each year (The World Bank Group and the Asian Development Bank 2021a). Azerbaijan faces significant disaster risk levels with high exposure to flooding and drought risk (The World Bank Group and the Asian Development Bank 2021b). With climate change, extreme events are on the rise and cause increasing damage due to converging driving forces that are (re)shaping hazards and threats (European Commission 2021). With almost two-thirds of the entire population of the South Caucasus region living in mountainous areas, climate-related hazards already pose a serious threat to communities and local economies. Climate change is however not the only driver behind the evolving disaster risk. Some of the additional factors are unsustainable agricultural practices and natural resource management on mountain slopes, including illegal logging, poorly planned infrastructure, and urbanization, as well as insufficient resources and capacities (Spanu, Gaprindashvili and McCall 2015). It is therefore crucial to have arrangements in place for effective prevention, mitigation, preparedness, response and recovery from disasters in the future.[5] Action can be taken at several levels, including national implementation of the Sendai Framework for Disaster Risk Reduction, and local activities to manage disaster risk. These actions can include developing preparedness measures such as early warning systems (EWS), local awareness-raising, effective emergency management, and longer-term measures such as developing sustainable land and ecosystem management techniques. It has also been shown that gender inequality creates adaptation barriers and makes women and girls disproportionately vulnerable to climate-related disasters and threats (UN Women n.d.). Empowering women and their participation in designing, resourcing and implementing gender-sensitive responses are critical to effectively manage evolving disaster risk (United Nations Office for Disaster Risk Reduction [UNDRR] 2015).

Recent years have seen devastating wildfires following heatwaves and droughts exacerbated by climate change. As the loss and damages from extreme wildfires increase, prevention and response management approaches are needed (UNEP 2022). The following solution highlights an innovative national approach to reduce the risk of forest fires in Armenia by improving policies to better detect and warn of potential forest fires. Importantly, other solutions in this booklet, especially under the theme of erosion control, also feature elements of disaster risk reduction, for instance reducing the risk of landslides through tree planting.

[5] "Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development" (UNDRR n.d.)

Taming wildfires

What is the issue ...

Armenia currently has a tree cover of about 10 per cent of its total surface (Global Forest Watch 2021). Most of its forests are located in the Tavush and Lori regions (72 per cent), but there are also forested areas in mountainous regions across the country. Forest degradation and reduced forest integrity result in biodiversity losses, damages of livelihoods and reduced resilience of forest ecosystems to the impacts of climate change.

With an average temperature increase of 1.03°C since records began at the turn of the twentieth century, and an overall average decline in precipitation of 9 per cent compared with the baseline period 1961-1990 (Armenia, Ministry of Environment 2020), Armenia has become more vulnerable to forest fires over the last few decades. Between January 2012 and October 2021, the country experienced a total of 2,464 Visible Infrared Imaging Radiometer Suite (VIIRS) events, in which thermal anomalies are detected by satellites (Global Forest Watch 2021). As a result of prevailing drought conditions and continued hot temperatures, wildfires have caused extensive damage to mountain ecosystems. Under the observed and projected changes in Armenia's climate, further aridification creates conditions for more frequent and more intense wildfires. The mountain forests of South Caucasus, where fires were not an intrinsic factor for many years, thus have become much more vulnerable and sensitive (Adaptation Fund 2018; The World Bank Group and the Asian Development Bank 2021a).

Burned area in the Khosrov Forest State Reserve, Armenia ©Sustainable Caucasus

Forest fires are often caused by the burning of agricultural residue after harvest in lands adjacent to forests. This practice coincides with the highest risk period for wildfires in July to September, when also heatwaves are most likely. The number of heatwaves has increased by 40 per cent in the period 1980-2012 compared to 1948-1980 (United Nations Development Programme [UNDP], Bureau for Crisis Prevention and Recovery 2013). Recent models for Armenia project a potential increase of the annual probability of a heatwave to 18 per cent under a high emission scenario by the end of the century (The World Bank Group and the Asian Development Bank 2021a). Due to the close interrelation of climatic factors and wildfires, fire regimes respond rapidly to climate change and climate variability (UNDP/GEF 2012). Changing climate conditions can lead to lengthened fire seasons, and more frequent droughts and heatwaves could significantly exacerbate the risk of forest fires in Armenia.

A volunteer from the Lore Rescue Team in Stepanavan, Armenia, preparing a mobile water pump provided by the project ©Sustainable Caucasus

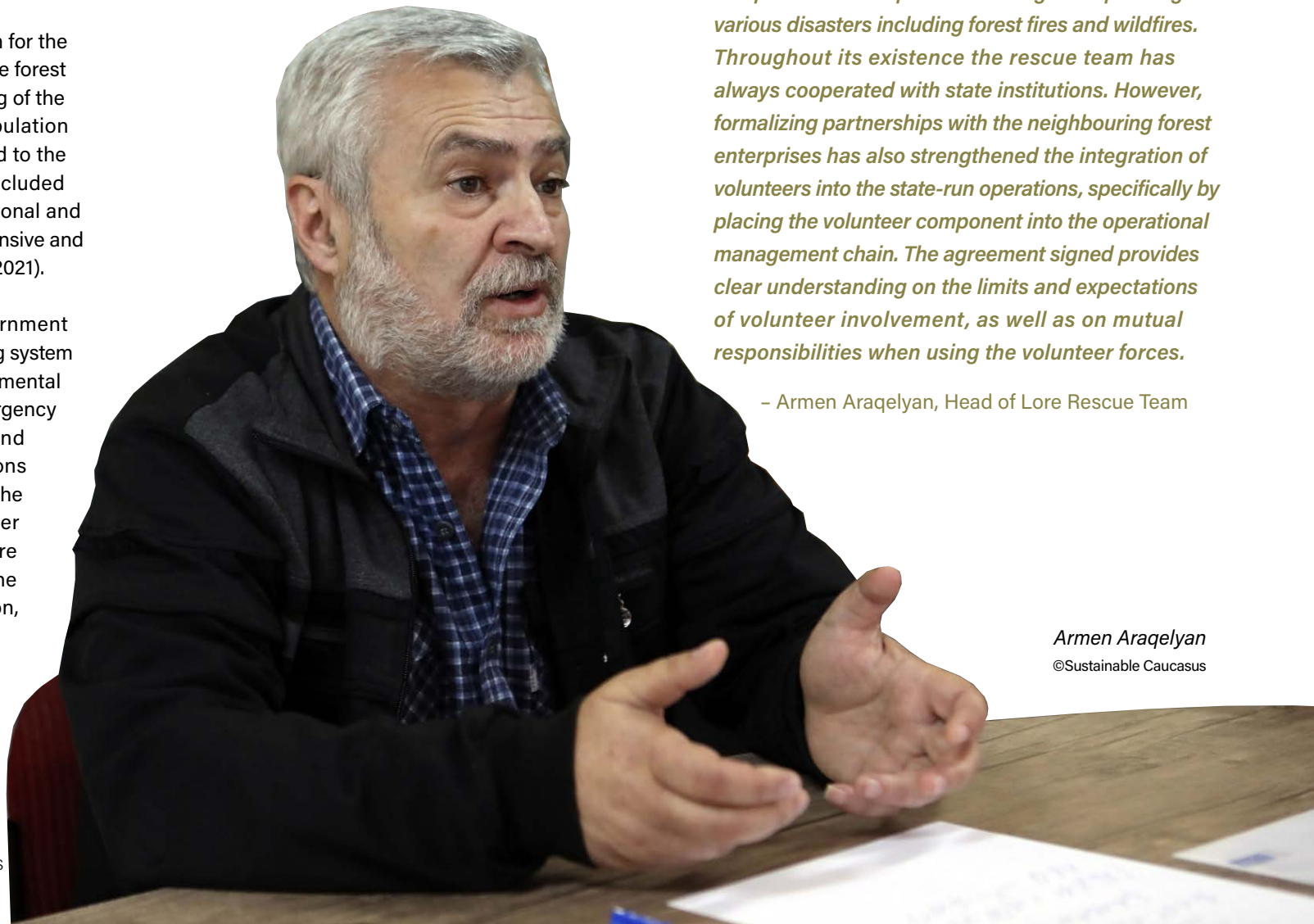
How can it be solved ...

The overall goal of the project "Addressing climate change impact through enhanced capacity for wildfires management in Armenia" was to strengthen wildfire early warning and monitoring systems, improve and enforce relevant policy and regulatory frameworks, define roles and responsibilities of respective national structures, and develop necessary technical capacities at national and local levels (TFD 2021).

For revising and updating policy and legislation for the prevention of wildfires as part of the sustainable forest management system in the country, the drafting of the Law on "Disaster Risk Management and Population Protection" has been supported and submitted to the Government for endorsement in 2020. This included specific inputs on wildfire management at national and local levels, while also addressing gender responsive and risk informed development mechanisms (TFD 2021).

To strengthen technical capacities, the government decided to establish an operational early warning system (EWS) under the auspices of the Inter-Governmental Task Force coordinated by the Ministry of Emergency Situations. In total 10 EWS were procured and installed in the Gegharkunik and Syunik regions of Armenia. The systems were integrated with the existing national EWS thus ensuring the proper management and dissemination of the wildfire warnings to the communities located nearby the forests or Specially Protected Areas. In addition, community administration representatives were trained on the installation and use of these EWS, fostering gender-balanced participation. Also, a digital platform was created for wildfire management and the use of EWS, now managed under the Ministry of Environment (TFD 2021).

Moreover, two new weather stations were installed in the territory of the Khosrov Forest State Reserve in March 2021, which are now able to deliver accurate data and forecasts for wildfire risk with significantly improved accuracy, lead time and spatial resolution (TFD 2021). This will help authorities to predict, detect and warn of forest fires more efficiently.



Armen Araqelyan
©Sustainable Caucasus

> *"Since its establishment, the Lore Rescue Team has been involved in firefighting operations, supporting the efforts of the regional rescue service of the Ministry of Emergency Situations. With our quite advanced skills in using modern technologies, in particular drones, we have been involved in forest monitoring activities. Members of the rescue team are internationally certified rescuers and possess the required knowledge for operating in various disasters including forest fires and wildfires. Throughout its existence the rescue team has always cooperated with state institutions. However, formalizing partnerships with the neighbouring forest enterprises has also strengthened the integration of volunteers into the state-run operations, specifically by placing the volunteer component into the operational management chain. The agreement signed provides clear understanding on the limits and expectations of volunteer involvement, as well as on mutual responsibilities when using the volunteer forces.*
>
> – Armen Araqelyan, Head of Lore Rescue Team

In addition to the preventive measures, training was delivered on minimizing fire damage. The training included innovative EbA measures from the Food and Agriculture Organization of the United Nations (FAO) forest and landscape restoration course, targeting forest authorities and surrounding communities. Furthermore, firefighters were provided with new equipment to improve efficiency during their interventions. For better access to forests, and particularly protected areas, off-road vehicles were provided, and water tanks added to improve fire suppression activities in remote and hard-to-reach forest locations. Due to their rugged terrain, mountain regions are particularly troublesome for firefighters, making appropriate equipment crucial.

Finally, a new forest management agreement, the first of its kind, was established between the NGO Lore Rescue Team in the communities of Stepanavan and Tashir (Lori region) and the government. The project coordinators emphasized that actions are needed at several levels, including coordination at the policy level, strengthening of the relevant institutions, and support for firefighters on the ground, to efficiently improve forest fire suppression.

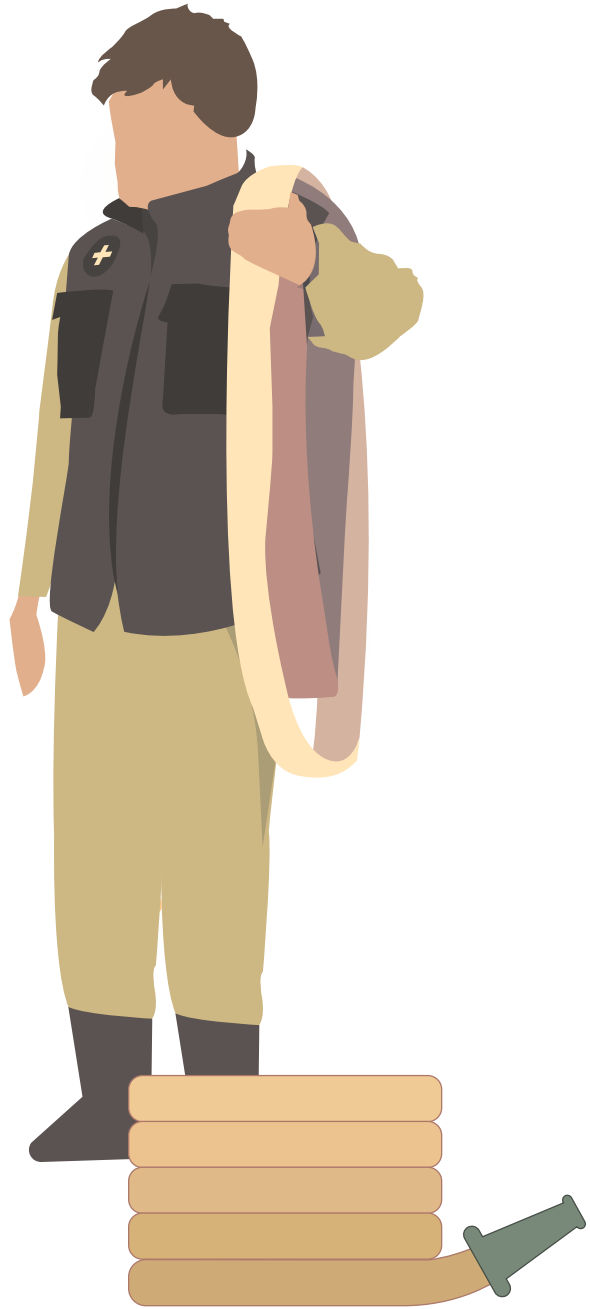
Who is benefitting ...

This solution improved Armenia's policies and tools to combat forest fires, and maintain forest cover and biodiversity, in the context of warming temperatures. The new EWS covers over 27,367 hectares of forest, especially in the country`s biodiversity rich ecosystems. Khosrov Forest State Reserve was specifically targeted with improved weather forecasting, and communication networks that was an issue when coordinating forces to fight forest fires. Over 56,865 people from 3 consolidated communities with 32 settlements have benefited from these measures. New and upgraded equipment (five off-road vehicles and 12 water tanks for off-road vehicles) was distributed to ensure the accessibility to remote and difficult forest locations during the wildfire emergency response. Overall, 360 firefighters, 30 of them women, received training and proper equipment in combating fires in remote mountainous terrain (TFD 2021).

... and how could it work elsewhere?

The broad approach taken to combine activities that strengthen technical capacities, improve forecasting and weather services and foster national policy integration, helps ensuring sustainability and secures embedding in existing structures. While the overall maintenance of the procured EWS was handed over to and will be carried out by communities, the overall coordination and accountability lies with the Ministry of Emergency Situations. Thus, an important success factor is the vertical and horizontal coordination between local and national actors and institutions. Also, the nationwide integration of the installed EWS and weather stations ensures proper embedment into an existing system of early warning and data management.

Further replication possibilities in other forest areas of Armenia are being considered (TFD 2021). Also, beyond the country, this inclusive approach is equally suitable in regions with a similar climate and landscape, including hilly and mountainous terrain, that face increased risk of wildfires due to climate change and the need to establish an operational disaster risk management system.



SOLUTIONS | Erosion control

Given their high-altitude climate and steep topography, mountain regions are particularly exposed to erosion (Hilton and West 2020). In the South Caucasus, water erosion is one of the most pertinent agents of soil degradation, and controlling this process is a major challenge (Olsson et al. 2019). Land degradation caused by erosion is decreasing the quality of pastures and agricultural land. Due to the predicted increase in the frequency of intense rainfall, the pressure from erosion will likely be further exacerbated (Shatberashvili et al. 2015; Borrelli et al. 2020).

The rate of exposure is central to understanding the risk of erosion. Human activities have interacted with vegetation cover for centuries in the South Caucasus, but more recent intensification in land use has reduced vegetation and increased the soil's exposure to erosion (Nikolaishvili and Dvalashvili 2015). A combination of human activities and climate change factors are therefore degrading land cover, negatively impacting the livelihoods of mountain communities and biodiversity in these areas.

A range of measures to improve land-use practices can be implemented to adapt to the increased risk of water erosion and reduce the land's exposure. The following solutions have proven successful in the South Caucasus. These solutions involve applying Ecosystem-based Adaptation (EbA) approaches such as increasing vegetation cover to protect the soil and increase uptake of water, thereby taking advantage of ecosystem services. There are also examples of how to create better institutional responses and infrastructure, providing a holistic set of adaptation solutions to erosion control.

Flourishing dams

What is the issue ...

Sheep herding is a traditional and deeply rooted activity in the Tusheti region, located in the mountains of north-eastern Georgia. The region is renowned for producing high-quality wool and Tushetian Guda cheese. The landscape is particularly suitable for herding, with high mountains and steep slopes offering large areas for pasture. Over the centuries, human activity has shaped this landscape, reducing forest cover to free up space for pasture.

Until the end of the Soviet era, herding was a profitable activity sustaining livelihoods in the mountains. Cattle herding has since been unregulated and left the land significantly more exposed to land erosion. Erosion is now threatening infrastructure such as houses, farms, and road networks across the region.

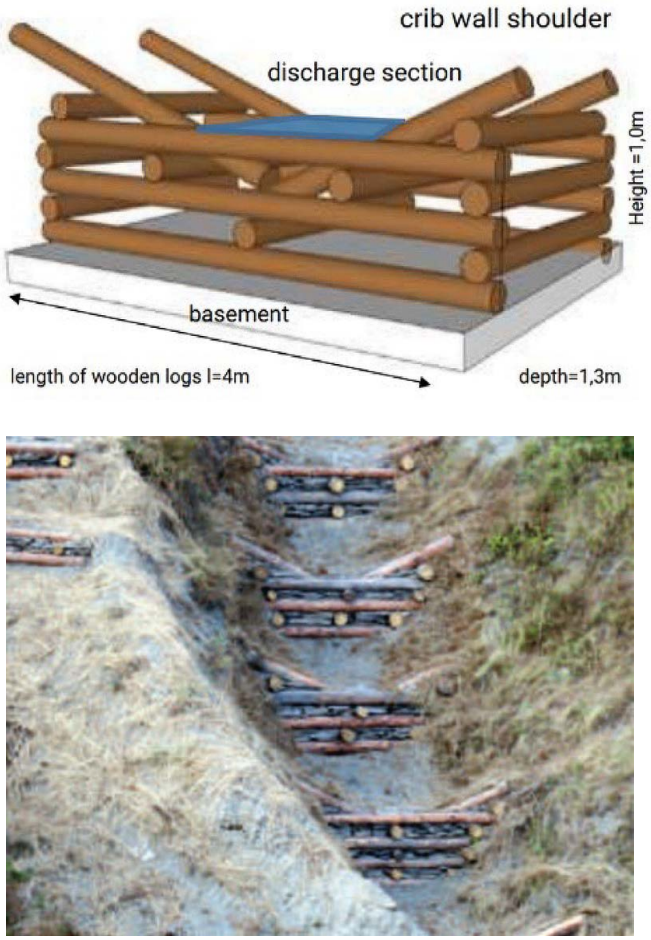
Erosion marks on pasture above the Jvarboseli village in Tusheti ©Sustainable Caucasus

By 2050, Georgia is expected to experience an average temperature rise of about 0.8-1.4°C, along with an increased incidence of natural hazards including landslides, mudslides, floods, and droughts (UNDRR 2019). It is also expected that heavy precipitation events will increase in Georgia, and the mountainous region of Tusheti will experience less predictable rainfall (Elizbarashvili et al. 2017). This, combined with unsustainable land use practices, will further increase the risk of erosion, landslides, and mudslides.

How can it be solved ...

To reverse land erosion, the two villages of Jvarboseli and Shenakho were part of an initiative applying an integrated approach consisting of erosion control through wooden check dams, tree planting and rotational grazing.

Erosion gullies are constantly getting larger and deeper, such as the one in Jvarboseli village which was formed after a large-scale landslide in 2004. The gullies expand because vegetation does not grow due to excessive erosion. This leads to a lack of root systems to stabilize the soil, creating a continuous erosive process. To break this cycle and improve conditions for vegetation to grow in the erosion gullies of both villages, vegetated wooden check dams were used to stabilize the beds of these steep gorges. The check dams were made from large pieces of wood assembled in a three-layer horizontal structure, filled with drainage material and reinforced by locally available stones to prevent the structure from eroding. Branches and rooted woody plants were embedded into the walls to strengthen the sides, and measures were applied on the overhanging edges of gullies by rounding them and



Left: Sketch of the structure of wooden check dams (from Rauch, Rauch and Kirchmeir 2016). Centre and right: Wooden check dams installed in a gully in Jvarboseli village (before and after) ©Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ 2019/Sustainable Caucasus)

preparing them for replanting to ensure vegetation growth. In certain cases, the upper parts of the gullies were also targeted by creating tranches perpendicular to the slope and planting appropriate vegetation (Rauch, Rauch and Kirchmeir 2016).

In addition, long-term measures are necessary to stabilize the soil. Therefore, 3,000 seedlings of local tree species were planted in strategic places along the upper parts of Jvarboseli village. Reforestation strengthens ecosystem services, e.g., by regulating water movement, filtering water and air and forming a natural barrier that helps decrease the village`s risk of landslides, mudslides and avalanches (Makino and Rudolf-Miklau 2021).

One further activity of this integrated erosion control solution was the introduction of rotational grazing, which can be an effective tool for pasture management, giving plants time to grow and thus limiting soil erosion. Rotation pastures systems operate with several pasture units (paddocks) divided by fences. While one pasture unit is used, the grasses and herbs can grow back on the other paddocks within a regeneration period of four to six weeks (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH [GIZ] 2019). It is sometimes considered the most effective measure to stop erosion if coupled with a wider pasture management scheme and supported by governing structures at the local and regional level to establish knowledge and infrastructure for pasture monitoring (Neudert et al. 2019). Monitoring and in-depth knowledge are important since rotational grazing can have adverse effects if done incorrectly, e.g. if resting periods are too short (Weber and Horst 2011).

In the village of Shenakho, rotational grazing was introduced by dividing the upper part of the village into different paddocks. In another part of the village, fences were installed to prevent livestock from entering specific parcels of land and ensure fast recovery of the vegetation. Farmers in both Shenakho and Jvarboseli as well as regional and national experts also received theoretical and practical training, which will help them to pass on the methods within their communities and to other areas.

"First, we needed to recognize the causes and then find the solution of erosion. In the case of Tusheti, overgrazing was a major problem that resulted in the loss of the plant root systems and the development of large and deep gorges which became the location for recurrent landslides. We first treated the cause and set fences to avoid grazing activities in the damaged area over the gorge. We got a positive outcome from this project.

– Irakli Aptarauli, Head of Natural Resource Management at Tusheti Protected Landscape

Who is benefitting ...

A combination of the solutions described was implemented in the two villages of Jvarboseli and Shenakho. In total, 27 erosion-limiting structures were installed in gullies to prevent further erosion and stabilize the soil to enable vegetation regrowth. More than 400 metres of gullies' overhanging edges were rounded and prepared for replanting. An additional several rows were dug upstream of the main gullies. About 5,000 tree seedlings – mostly local Scots pine (Pinus sylvestris) and Goat willow (Salix caprea), but also bushes such as Tscirtsceli (Sorbus caucasigena) and common Juniper (Juniperus communis) were planted in the upper parts of the village. Raspberry, a thorny bush, was also planted to deter animals from eating the small plants and seedlings. A total of 28.7 hectares of pasture were included in the rotational grazing scheme.

... and how could it work elsewhere?

These measures are applicable for municipalities facing water-induced erosion processes and pressure from unsustainable herding practices. The presented solution can be implemented with relatively simple machinery and few resources, using local tools and materials. Important aspects to consider include building local ownership and capacity, supported by training on the theoretical approach and practical exercises in the field, and continued monitoring.

Villagers in Tusheti ©Sustainable Caucasus

Rotational pasture delimited by a fence in Shenakho village ©Sustainable Caucasus

Revitalizing ancient wines

What is the issue ...

The municipality of Keda is located in the mountainous (Upper) Adjara region, in south-western Georgia. Most of the settlements in this municipality are located along steep, subtropical mountain slopes on either side of the Adjaristskali River. Keda is already prone to landslides, flash floods and mudflows. Climate change projections of further increasing temperatures and slightly wetter conditions in this area are likely to increase the frequency of these events in the future.

During the Soviet period, the village Merisi in Keda municipality was one of the most vital winemaking centres of the Adjara region, and collective farms were strewn all over the slopes of the village. Three main grape varieties were used: Chkhaveri, Tsolikouri, and Aligoté. These wine grapes, with their developed perennial root system, enhanced soil health and stability and reduced the risk of landslides. However, very few of these vineyards remained as the villagers had since abandoned winemaking for widespread cultivation of annual crops, a switch that substantially reduced soil stability on the mountainous slopes, especially where crops require frequent watering. Annual crops, such as corn or certain vegetables, when sown on a mountain slope, often increase the risk of landslides because they lack deep roots to restrain the soil.

How can it be solved ...

With the support of the United States Agency for International Development (USAID), the Caucasus Environmental NGO Network (CENN) initiated re-establishing wine production in the region by building on historically farmed crops, which not only aimed at stabilizing steep slopes and preventing erosive processes but also provided additional economic opportunities to Keda municipality.

Erosion on the slopes of the Merisi village required urgent attention, but any proposed solution also needed to promote cultural and economic development for it to be sustainable. For this reason, the Chkhaveri grape – a grape endemic to the Adjara and adjacent Guria regions – was selected and promoted among the villagers. Chkhaveri wine is in high demand in both domestic and international markets providing for a profitable income opportunity.

Vineyard on steep slope ©Sustainable Caucasus

> *Our village is populated on the mountain slopes; hence, landslides and avalanches are usual events here. In 2012, experts explained that we were also causing land degradation when we were farming annual crops and advised us to plant Chkhaveri grape and produce wine or sell as grapes. Chkhaveri is a native grape to my village abandoned many years ago when Georgian wine was not famous internationally. However, today's demand for Chkhaveri is high, and farming is profitable. The soil of my land improved, it seems the experts were right.*
>
> – Aslan Gogolishvili, project beneficiary

Aslan Gogolishvili ©Sustainable Caucasus

However, since traditional and specialist knowledge is required for cultivating and use of Chkhaveri grapes for winemaking, local specialists have offered to give free consultations to other villagers should they want their own vineyard. Also, the Keda Local Action Group has been established to support broad local participation in the Chkhaveri variety grape revitalization program.

Who is benefitting ...

The project was launched in 2012 as a pilot and covered Merisi village in Keda municipality, in the Adjara region. Since then, Chkhaveri winemaking has become a popular practice in the region. In total, 40 families were provided with up to 1,000 Chkhaveri saplings and received special training in the cultivation of Chkhaveri grapes. Small manuals on grapevine cultivation were disseminated.

Information about the solution has also been widely disseminated, convincing of the benefit of planting a vineyard – as opposed to investing in grey infrastructure – on slopes at risk of natural hazards and strengthening villagers' knowledge significantly.

Furthermore, this combination of high-value products with regional history and traditional skills provides a strong basis for developing ecotourism activities, diversifying the local economy and reviving viticulture in the region.

> *A healthy soil is essential for our village to have a successful farming practice, which is a primary income source for the local population. The Chkhaveri project showed that perennial crops reduce soil degradation and give economic benefits. Moreover, by this project, the abandoned Chkhaveri grape variety was revived and attracted eco-tourists to the village.*
>
> – Jaba Lortkipanidze, local coordinator of the Chkhaveri project in Merisi

... and how could it work elsewhere?

While local species of grape might not be adapted to different climates or soils, this solution has shown that replacing annual crops with perennial crops, including local native varieties of grapes, can be transferred within Georgia and beyond. Part of the solution lies in reviving local knowledge and ancestral practices that are adapted to the local landscape and climatic preconditions. Lastly, providing additional income opportunities and using nature as an ally against erosion are key success factors for this solution.

Vineyards and corn planted next to each other in the Keda municipality ©Sustainable Caucasus

Easy cleanse – great effect

What is the issue ...

The village Ehen is situated in Azerbaijan`s Ismayili District, a mountainous district in the south-east of the Greater Caucasus. The village, like much of the district, is under pressure from accelerated erosion processes and unsustainable land use practices. Natural erosion has been one of the central geomorphological processes forming the mountain landscape in the Ismayili District throughout history, however soil erosion is expected to drastically worsen during this century. Data models have predicted an increase in soil loss rates in the district, with barelands and grasslands predicted to experience the most severe erosion (Bayramov et al. 2019). Changing precipitation patterns due to climate change is one of the factors further driving these changes (Shatberashvili et al. 2015; Bayramov et al. 2019).

A wooden check dam under construction in the pasture area of the village Ehen, Azerbaijan ©Sustainable Caucasus

Land degradation, caused by many years of unsustainable land use and poor land management, is also playing an important role in contributing to erosion. In particular livestock grazing is leading to decreased vegetation cover and heightened exposure to rainwater, including on steep mountain slopes. When water falls on degraded land, it tends to percolate the soil less and thus runs faster down the slope. This worsens the erosion process and eventually creates gullies. These gullies continue to deepen unless something is done to reduce or stop the flow of water.

How can it be solved ...

To combat erosion in Ehen, participatory community-based erosion control solutions were implemented. Among the stakeholders involved were livestock farmers, shepherds, and smallholder farmers, with a particular focus on the participation of women. The solutions´ building blocks followed an inclusive EbA approach, including bioengineering methods to slow down the movement of water and reduce its eroding power (wooden check dams, tree planting) as well as providing community support to diversify income opportunities.

In total, nine degraded pastures and land areas with previous forest cover were selected by the village stakeholders together with the sustainable land management specialists. Four sites are located above the village, where there is a risk of increasing rockfall, erosion and flooding by surface water run-off, while the other five sites are located below the village, where the villagers aimed to restore their land to improve productivity.

Of the nine sites, two were selected to deal specifically with erosion gullies; one site above the village where

Tree planting near Ehen, Azerbaijan ©Sustainable Caucasus

there is a high risk of flooding into the village, and the other located below along the road, where there is a high risk of road damage if the gullies continue to deepen. On one site, a hazelnut plantation was established, which simultaneously prevented erosion, increased vegetation cover and provided an opportunity for income generation.

Establishing a tree nursery with local seeds has been gradually extended by the community with planting especially fruit trees. This growing orchard has proven effective to stop erosion by increasing vegetation cover on the slopes, while also diversifying income. The installation of a drip irrigation system in the orchard required a significant investment with external funding, however, it allowed the villages to efficiently water the orchard. The valley was once known for growing hazelnuts and walnuts, as well as medicinal plants and honey. Reviving some of these activities was prioritized, once again to offer varied income opportunities.

Who is benefitting ...

The solutions were primarily developed using resources from the village only with active participation of the local population investing their time and labour. This had several advantages, including the opportunity for on-the-job training for villagers, as well as increased ownership and the ability to carry out any repairs or modifications to the erosion control structures without external assistance. A further advantage was the minimal budget required. Villagers were compensated financially for their work and provided with material such as timber, mesh-wire fencing, water tanks and irrigation equipment.

Rehabilitating vegetation on eroded sites where gullies already exist also helps protecting roads and other infrastructure as well as restores healthy soils and thus overall increases agricultural productivity, including for wild herbs. Villagers, especially women, benefit with increased earnings from collecting healing herbs and selling them in a local market nearby Ehen village.

... and how could it work elsewhere?

This EbA approach has great potential for replication in other mountain communities in Azerbaijan and across the region. Soil erosion is a problem for many mountainous areas, and the presented solution is relatively simple and affordable, requiring little external assistance. Again, local ownership, awareness of natural processes and ecosystem services, as well as providing income opportunities, are important aspects when designing this inclusive approach.

> ***"This project united the whole village and taught us how to act together and solve community problems. Twenty-five hectares of heavily eroded lands in the mountain part of Ehen village were protected from erosion by fencing and planting native trees. Some community members were working on this project and earned 15-20 Azerbaijani manat per day. Project experts provided great information sessions to locals, and we gained good experience in erosion prevention measures. Ehen village is very famous for healing herbs: the project planted plenty of seeds of healing herbs in the mountainous parts of the village. Our people now collect and use or sell them for medical treatments. The solutions for the problem were wisely thought through; as a result, we can see the improved soil quality and halted erosion process.***
>
> – Mammadov Umudaga, local resident of Ehen

Mammadov Umudaga ©Sustainable Caucasus

SOLUTIONS | Water harvesting and retention

Armenia, Azerbaijan and Georgia are all predicted to become drier in parts due to more variable precipitation in the future (Muccione and Fiddes 2019; The World Bank Group and the Asian Development Bank 2021a-c). In Georgia, for example, the projected average decrease in annual precipitation by 2041-2070 in the eastern part is 9 per cent, while in the west the decrease is predicted to range between 3.6 and 15.3 per cent (Georgia, Ministry of Environmental Protection and Agriculture 2021). In addition, rising temperatures will further limit future water availability, increase evaporation, and reduce water accumulation and storage in the form of snow and ice in the mountains. The Caucasus glaciers will lose, in a high-emission scenario (RCP8.5), more than 80 per cent of their mass (Hock et al. 2019b). This will severely compromise the role of mountains as water towers for downstream communities, leading to seasonally reduced access to water (Muccione and Fiddes 2019).

While heavy rain and associated floods occur more often than drought in the South Caucasus mountains, the latter often has a higher economic cost since it causes significant problems for people's health and their livelihoods (UNDRR 2009). Farmers face the biggest challenges during droughts, with increased stress for crop yields predicted in the decades to come. Remote communities' drinking water can also be imperilled, so solutions are required to reduce their exposure.

Adaptation to new water regimes is necessary, however, changing political systems and a lack of socio-economic resources have left the South Caucasus with largely poor water management structures, making communities vulnerable to drought events. With the development of new irrigation systems during the Soviet era, traditional water systems were often not maintained. However, after the collapse of the Soviet Union, many of these new water systems ended up fragmented and unreliable (Worden and de Beurs 2020). Improving water retention as well as access to clean water is therefore an important task for mountain communities across the South Caucasus. The following solutions offer some valuable approaches, including renovation of degraded infrastructure and the restoration of traditional systems.

Restoring lost resources

What is the issue ...

The Karnut water reservoir, located in the Shirak region of Armenia, was created in the early 1970s to provide water for irrigation of the surrounding cultivated lands. The dam wall, which measures 34 metres high and 710 metres long, creates a reservoir with a total capacity of 21.8 million cubic metres. Despite its size, the reservoir receives only small amounts of rainwater from its own catchment area and relies on water from the nearby Akhuryan and Jajur rivers that are diverted to the reservoir through a series of canals. These canals were built based on concrete structures set in the ground and strengthened with masonry.

Due to natural wear and tear, regular maintenance work is needed for the canals to function as intended. These canal structures are also threatened by more serious damage due to the increasing risk of floods and mudflows as a result of a warming climate and increased precipitation in the region (Armenia, Ministry of Environment 2020). In the early 2010s, a 240-metre-long section of a drinking water pipe, serving the community of Basen, was damaged by mudflow, leading to poor water quality and sanitary issues in the community. While the village once had an alternative drinking water option, this was abandoned several years ago due to carcinogenic asbestos-lined piping. Thus, the community of Basen found itself in a vulnerable position with regards to securing safe drinking water.

How can it be solved ...

The Basen community has regularly been experiencing issues with drinking water, and the population specifically requested a more sustainable solution which is adapted to future climate-related changes. The EU-financed Climate Forum East project provided support to bury the water pipeline underground to ensure drinking water quality. This was achieved by adding a chlorination station, a solution which was decided following multiple meetings between the Basen community and local authorities.

Involvement of the residents of Basen from the outset was considered vitally important to foster community ownership. Project staff provided training and seminars and facilitated discussions about Armenian commitments and measures in the framework of national adaptation planning (Country Water Partnership 2016), linking international climate agreements to the local scale and addressing the challenges of intensified climate hazards in recent years. This approach helped improve inhabitants' understanding and support of concrete implementation of adaptation measures.

After completing project implementation, the new infrastructure was handed over to the community, as per written agreement between Climate Forum East as the donor, implementing agencies and local partners. The municipality committed to ensuring further maintenance of the chlorination station, and proper service and renovation of the irrigation infrastructure. The municipality also took responsibility for the establishment of regular monitoring and control measures of the chlorination station's proper performance. In addition, this created an opportunity to add water meters to measure the actual quantity of drinking water used by residents.

Karnut reservoir, used for drinking water and irrigation, serving the Basen village (1590 masl) among others. In the foreground, an existing canal that transports water to the reservoir ©Sustainable Caucasus

Who is benefitting ...

The entire population of Basen village has benefited from the solution – a total of 1,775 people from 459 households. The freshwater capacity of the chlorination station is about 110 litres per second. With the new underground pipes, floodwater or mudflow is kept out, and the risk of waterborne disease infection is greatly reduced. With the municipality and community in charge of maintenance, they now have the tools to better adapt to the different scenarios of climate change and use water resources more consciously.

... and how could it work elsewhere?

The solution shows benefits in terms of approach and implementation mechanisms. It is a small-scale and affordable adaptation solution that the community can initiate and handle itself through the strengthening of existing capacities. It has proven successful to break down international agreements to the local level and ensure long-term maintenance of newly introduced adapted infrastructure. Upscaling the solution might require external funding which for example can be found through linking the project to national adaptation targets or working alongside private actors.

Chlorination station equipment installed in Basen. Hayk Mnatsyan (pictured) is the village administration specialist for the station ©Sustainable Caucasus

> ***"Finally, our kids and our people enjoy clean spring water. Hopefully when the new water pipe will be installed, we will have enough water as well. There is a need for more initiatives like this to help people cope and adapt to the challenges caused by severe weather conditions. Look at our lands. They are becoming useless. We are getting used to regular hailstorms and droughts, which damage our crops and grassy meadows and cause stress for the people, whose main source of income comes from animal husbandry. Some have already left the village looking for work abroad. For the time being I also rely on remittances, but I prefer to work in my own village and earn income by myself. Thus, I fully support initiatives like this water project and am ready to do the utmost for the realization of any similar undertaking that will contribute to the community's wellbeing."***
>
> – Narine Atoyan, villager, responsible for operating the drinking water network for Basen, Shirak Armenia

Narine Atoyan ©Sustainable Caucasus

As good as new

What is the issue ...

Azerbaijan has several different climate zones, from the western mountains that are mild and humid, to the eastern lowlands where it is dryer and hotter, especially close to the Caspian Sea. The Talish mountains are located at the southern tip of the country, between the border with Iran and the Caspian Sea coastline. The climate is warm and dry during the summer months, and with the anticipated effects of climate change, summer will be even warmer with longer dry spells. The region is, however, expected to experience a slight annual precipitation increase, concentrated in the spring. Heavy rainfall events are also forecast to increase in intensity (The World Bank Group and the Asian Development Bank 2021b).

In Gajimarda, a village in the Talish mountains, the community's main activity is horticulture, especially growing citrus fruits such as mandarins, oranges, feychoa, and lemons. These fruits require substantial irrigation, for which the community relies on a reservoir. The reservoir has a capacity of 240,000 litres connected through a series of tubes to the various community members' fields. However, due to fluctuating river flow and aging irrigation infrastructure, the community has experienced frequent water shortages in recent years. As a result, the yield of the citrus fruits has sharply declined, and some trees started to perish.

Gajimarda village, Talish mountains, Azerbaijan ©Sustainable Caucasus

How can it be solved ...

Rehabilitating and improving the existing irrigation system in Gajimarda village, also considering current and future impacts of climate change, presented a simple solution that has made a big difference for the community and their livelihoods.

To rehabilitate the water system, the inside of the concrete reservoir was thoroughly cleaned, and any cracks or holes filled to ensure watertightness. The main metal pipeline leading out of the reservoir was replaced with plastic pipes of equivalent diameter and connected to 23 new water distributors. A total of 115 new outlet valves were created and connected to community members' plots. In addition, one tap point was built in the village for easy access to drinking water.

The rehabilitated water pipes are owned by the Astara Rayon Irrigation System Department, which is responsible for the operation and maintenance of the lines. During the project, the department conducted training for the Community Development Council for the preparation of a sustainability and maintenance plan to ensure the long-term durability of the pipelines. The community also agreed to contribute financially to the project, which gave them ownership and ensured that they were involved from the outset.

Who is benefitting ...

Overall, 2,146 residents from 180 families benefited from the rehabilitation of the irrigation system. Access to a

Top: Inside the 240,000-litre concrete reservoir. Bottom: Distributor of water from the main plastic pipe to the valves at the plots ©Sustainable Caucasus

more stable water source has resulted in an economic revival for the villagers and productivity has returned to previous levels. The new irrigation system ensures that the villagers are adapted to fluctuating river levels and increasingly dry summers. Leaks have been substantially reduced.

Women in the community have been highly engaged in agricultural production, including harvesting, irrigation, and delivery of products to the local market. Improving the local economy benefits the whole community and empowers families with more money for education, medical services, and social life.

… and how could it work elsewhere?

Rehabilitating irrigation systems can be an important solution in regions where water scarcity will become an increasing issue in the future. Water leaks in irrigation or drinking-water systems are quite common across developed and developing countries. Up-to-date infrastructure, in addition to a community-based management system where all community members are represented including women, low-income groups and local authorities, contributes to resilience for everyone against climate-induced water shortages.

The solution can be replicated in other mountain municipalities within Azerbaijan through the effective partnership of local communities and governmental water utilities, as well as in other regions with similar challenges. This project is an example of a public-private partnership between various stakeholders engaged in the water sector at the regional and national level.

Bakhishiyev and Billura Ilkham, a family beneficiary of the project ©Sustainable Caucasus

> ***Our village Gajimarda is a mountain village in the Talish mountains, which are famous for subtropical cultures – mandarin, orange, and feychoa. Access to water is an essential requirement for the 180 families in our community to have decent living conditions.***
>
> – Mr. Ilkham

> ***After repairing the irrigation system, I planted more vegetables than in other years, and my family's income increased tremendously. The increased revenue allows us to spend more for our children and travel to other regions of the country.***
>
> – Ms. Ilkham

Renewing the flow

What is the issue ...

In Azerbaijan, the Caspian Sea significantly impacts rainfall patterns. On average, the mountainous areas of Azerbaijan receive more rainfall than lowlands and coastal areas. While the country relies mostly on surface water for water use, underground water has been extracted to meet the increasing demand for fresh water since the early 2000s. However, underground water aquifers are not renewable sources, and they may well experience shortages in the future, a risk exacerbated by climate change. Furthermore, the country being downstream of major waterways is exposed to water withdrawal activities of its neighbours. The Kura River, for example, runs through Georgia, Armenia and Turkey before entering the Caspian Sea in Azerbaijan.

By the 2050s, the average temperature is expected to increase between 1.3°C and 2.3°C compared to pre-industrial levels, respectively according to the climate scenarios RCP2.6 and RCP8.5. Meanwhile, heavy rainfall events are likely to become more intense and less predictable. At present, the probability for the country experiencing a severe drought during a year is only 2 per cent. However, by the end of the century it is predicted to rise to 85 per cent in the high-emission scenario. These estimates reflect a transition to a chronically drought-affected environment in many regions of Azerbaijan and are likely to contribute to the expansion of arid ecosystems and desertification (The World Bank Group and the Asian Development Bank 2021b). The impacts of climate change will be felt most in the agriculture sector given that 80% of farming takes place in arid or semi-arid areas and is highly dependent on irrigation. Having higher responsibility for domestic tasks, women and girls will be more negatively affected by increased water scarcity that is expected due to climate change (Asian Development Bank 2019).

Irrigated land in the Mireshelli village ©Sustainable Caucasus

The community of Mireshelli in Agdam district is nestled in the foothills of the Lesser Caucasus, where the local inhabitants rely on agriculture for their livelihoods. Agdam is among the districts in Azerbaijan hardest hit by water scarcity and poverty, which is also contributing to forced economic migration withing Azerbaijan or abroad (International Organisation for Migration [IOM] Azerbaijan n.d.). While the use of electric and fuelled-pumped wells for groundwater extraction was commonplace during the Soviet era, their running costs could not be afforded anymore after Azerbaijan gained independence, leaving Agdam communities suffering from a lack of drinking and irrigation water. Villagers meet their water needs with the well of poor quality and artesian water from remote distances. Given traditional gender roles, it is mostly women that take long walks every day to fetch water for drinking, cooking, washing and irrigating their fields (Swiss Confederation FDFA 2016).

How can it be solved ...

The South Caucasus region has long been inhabited by populations who have developed and relied on traditional knowledge and skills to overcome water-related challenges. Over 3,000 years ago, the development

A rehabilitated Khariz providing water in Agdam district, Azerbaijan ©Sustainable Caucasus

of so-called *Khariz*, also named *Qanat*, was a way to transport water from water sources to distant locations in arid and semi-arid regions. In Azerbaijan, mountains have been a reliable water source for centuries and many regions adopted the *Khariz* system, especially for irrigation purposes. However, this traditional water system has since seen a decline in use and interest, leading to a lack of maintenance and malfunctioning.

Supported by the Korean International Cooperation Agency (KOICA) and the International Organization for Migration (IOM), a four-year project (2018-2022) was initiated to rehabilitate the *Khariz* system in the community of Mireshell. This *Khariz* system, locally called *Shamsi*, was rehabilitated to provide all households with improved access to drinking water and to reduce the outmigration of farmers and other community members due to a lack of economic prospects. The initiative also included the reintroduction of traditional masons, called *Kankan*, who bring the skill set to build and maintain these traditional infrastructures.

The solution is built on a community-driven approach to tackle cross-cutting issues, including a gender dimension to improve the living and working conditions of women who are traditionally responsible for collecting water. Water resources are now more reliable and can be fetched closer to people's homes, which is reducing the workload for many women.

The principle of a *Khariz* system is simple: water from the mountains penetrates the ground and feeds the natural water table (aquifers), which is constantly renewed. A gallery is dug from the mountains to lower lands with a slight slope to make use of gravity. Additionally, ventilation shafts are built directly above the main gallery to improve flow and enable easy access for maintenance work. Since the system is powered only by gravity, it does not use any electricity or fossil fuels, and the water comes from a renewable source. It is thus a more sustainable and low-cost way for the communities to obtain water.

Who is benefitting ...

In January 2021 IOM Azerbaijan officially handed over the renovated *Shamsi Kahriz* to the community of Mireshelli village. The *Khariz* system has a discharge capacity of 27 litres per second. It supplies drinking water to 214 households, and it supplies irrigation water to 75 families and 90 hectares of agricultural land. The overall KOICA funded project has covered the districts of Agdam, Aghjabadi, Barda, Fuzuli, Ganja, Gazakh, Ghoranboy and Goygol in Azerbaijan. In total, the project aims to renovate 40 *Khariz* systems in the eight districts to secure water access for over 8,000 families.

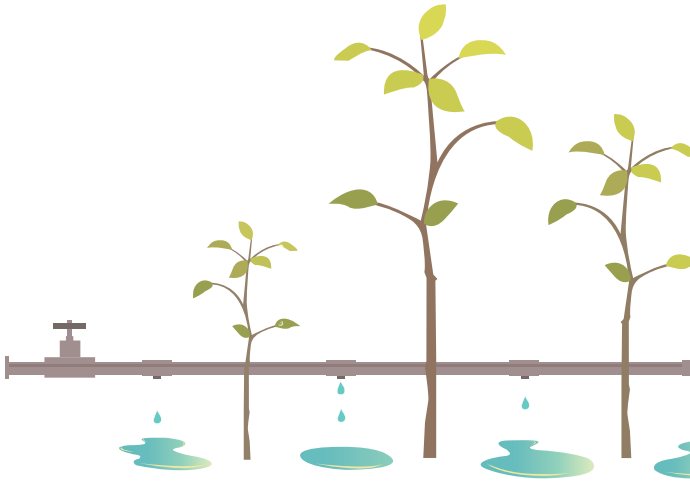
... and how could it work elsewhere?

About 1,500 *Khariz* are thought to have existed until the twentieth century in Azerbaijan, but many Khariz systems are now out of order in mountain regions. Mireshell demonstrates that traditional knowledge and practice can be rehabilitated, offering a viable and sustainable way for mountain communities to secure water supply without energy use. However, communities require technical support, funding, and assistance for cooperation with authorities. Critical to the success is the participatory approach, building on local knowledge and practices and fostering community ownership. Considering climate projections and including them into local development planning is another key aspect to enhance resilience to future climate conditions.

Such systems have also been adopted in other regions of the world. In 2014 these or similar water systems were estimated to be operational in 52 different countries, with about 30,000 galleries in use (Remini, Kechad and Achour 2014).

"Having access to water was a dream for our village, especially for us women. It is common to have a large family with three or four children in our community. A housewife's role in our village has always been a heavy burden because we were fetching water from long distances; water-borne diseases were another issue, especially in kids during the summer. The renovation of the Kahriz changed our lives. Now we have fresh water running right outside our door. The women of the village now have more time to spend with the kids and to take care of themselves too.

– Firuza Mammadova, local resident of Mireshelli



Firuza Mammadova ©Sustainable Caucasus

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The selected adaptation solutions portray cases and inspiration for achieving the United Nations 2030 Agenda for Sustainable Development and its 17 goals, especially Sustainable Development Goal (SDG) 5 on gender quality, SDG 6 on clean water and sanitation, SDG 13 on climate action, SDG 15 for life on land and SDG 17 on partnerships for the goals. Similarly to the SDGs, the solutions view different aspects of sustainable development and adaptation comprehensively, interconnected, and partly dependent on each other.

This solution united the whole village and taught us how to act together and solve community problems. Twenty-five hectares of heavily eroded lands in the mountain part of Ehen village were protected from erosion by fencing and planting native trees.

– Mammadov Umudaga, resident of the Ehen village

Finally, our kids and our people enjoy clean spring water. Hopefully when the new water pipe will be installed, we will have enough water as well. There is a need for more initiatives like this to help people cope and adapt to the challenges caused by severe weather conditions. Look at our lands. They are becoming useless. We are getting used to regular hailstorms and droughts, which damage our crops and grassy meadows and causing stress for the people, whose main source of income comes from animal husbandry.

– Narine Atoyan, villager, responsible for operating the drinking water network for the Basen village

A healthy soil is essential for our village to have a successful farming practice, which is a primary income source for the local population. The Chkhaveri project showed that perennial crops reduce soil degradation and give economic benefits. Moreover, by this solution, the abandoned Chkhaveri grape variety was revived and attracted eco-tourists to the village.

– Jaba Lortkipanidze, Local coordinator of the Chkhaveri project in Merisi