Community based climate change adaptation and disaster risk reduction action plan for the Likheti community of Ambrolauri Municipality, Upper Rioni Watershed, Republic of Georgia

Integrated Natural Resources Management in the Republic of Georgia Program

Technical Summary Report

Community based climate change adaptation and disaster risk reduction action plan for the Likheti community of Ambrolauri Municipality, Upper Rioni Watershed,

Republic of Georgia

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Contents

Preface

The present report has been developed within the framework of the program Integrated Natural Resources Management in Watersheds (INRMW) of Georgia, being implemented by the following partners:

- Florida International University (FIU)
- UNESCO-IHE Institute for Water Education
- CARE International
- Winrock International
- Caucasus Environmental NGO Network (CENN)

The geography of the program covers the following watersheds of Georgia: the Rioni River basin in West Georgia, and the Iori River and Alazani River basins in East Georgia. The following pilot watershed areas were selected for the implementation of the pilot program:

- Upper Rioni pilot watershed area – Municipalities of Oni and Ambrolauri
- Lower Rioni pilot watershed area – Municipalities of Khobi and Senaki
- Upper Alazani pilot watershed area – Municipalities of Akhmeta and Telavi
- Lower Alazani Iori pilot watershed area – Municipality of Dedoplistskaro

The program considers the development of a community based climate change adaptation and disaster risk reduction plan for one community in each targeted municipality.

The present report contains the community based climate change adaptation and disaster risk reduction plan developed for the Likhet community of Ambrolauri municipality (Upper Rioni pilot watershed area).

1. Methodology

Process

The process of developing the community based climate change adaptation and disaster risk reduction plan consisted of the following main stages:

- selection of a pilot community;
- community mobilization and working meetings with community members with the purpose of identification of urgent issues;
- experts' field visits to targeted communities;
    - working meetings with local communities;
    - field examination of hazards identified during working meetings with community members;
    - finalization of recommendations with community members;
- final report.

A brief overview of the methodology used at the key stages of the plan's development is given below.

Selection of pilot communities

The INRMW program considered selection of one community in each targeted municipality where participatory community based climate change adaptation and disaster risk reduction plans would be developed (7 communities in total).

A web-based decision support tool[1] developed by the Helsinki University of Technology was used to select targeted communities. This tool is often used for environmental research (e.g., EIAs, ESIAs).

The selection process comprised of the several stages:

- identification of selection criteria;
- data collection;
- integration of data into the web system;
- data processing (weighting, standardization, "criteria tree");
- web analysis of results;
- validation of the results of the web-based decision;
- finalization of the results with implementing partners.

[1] http://www.hipre.hut.fi/

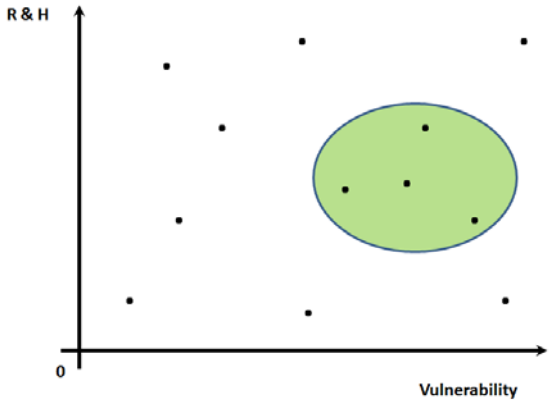
One of the most important stages of the selection process was the identification of selection criteria. These criteria included:

INRMW program pilot community – pilot communities should be selected from pilot communities of the INRMW program. Therefore communities with a small number of members were excluded from the very beginning**.** This approach ensured the availability of a Community Based Organization (CBO) in each selected community (the INRMW program has established CBOs in pilot communities) which would be responsible for the development of adaptation plans.

vulnerability of the community – vulnerability of communities to climate change and natural disasters was one of the main selection criteria. The highest value of vulnerability was used as a selection criterion. The vulnerability of the targeted municipalities of INRMW program was assessed at the previous stages of the program[2].

hazard and risk index of the community – hazard and risk indices of the communities were taken into account during the selection process (hazards and risks of the targeted municipalities of INRMW program were assessed at the previous stages of the program)[3]. An average value of hazard and risk was used as a selection criterion. The diversity of natural hazards identified in the community was given special attention.

The diagram below illustrates the selection criteria. The diagram shows that communities with high vulnerability and medium hazard and risk values were given preference in the selection process (see Diagram below).

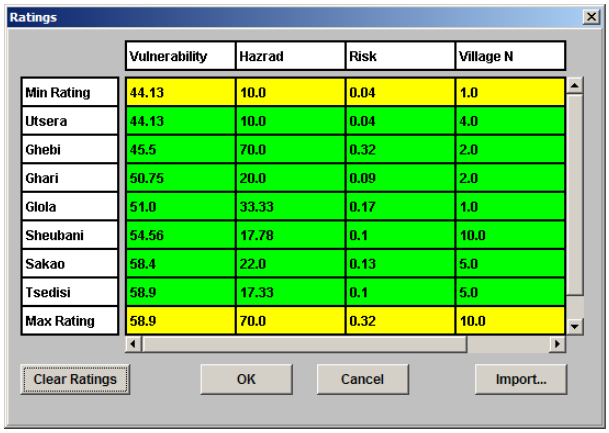


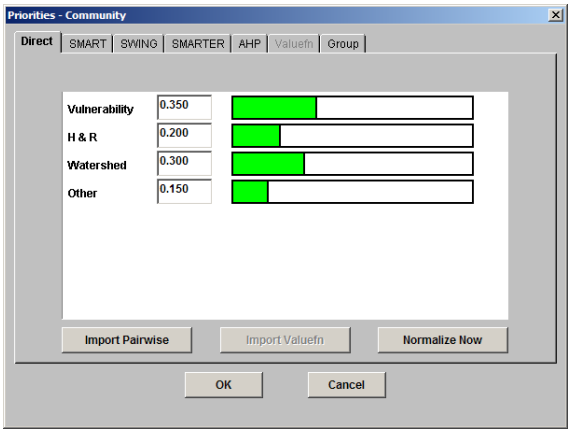
Along with the abovementioned, other criteria were also used for the selection of pilot communities: location of a community within a single watershed, potential impact on other communities, area of the community, number of villages in the community, size of population, area of forested land, etc.

After identification of criteria the data corresponding to these criteria were integrated into the special web-based database. Each criterion was assigned a weight for formulation of a final decision.

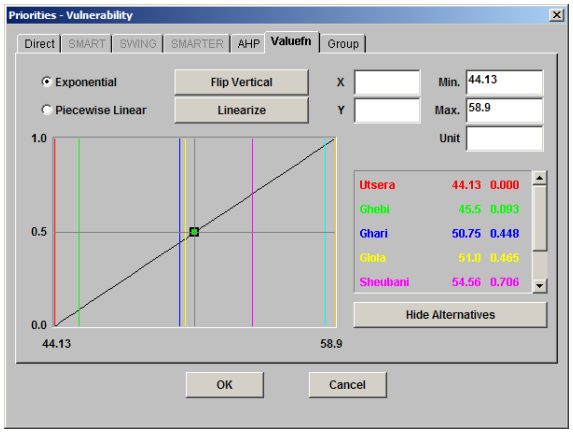
[2] see reports – Assessment of the vulnerability to natural disasters and climate change of INRMW program targeted municipalities. Adaptation and mitigation plan.

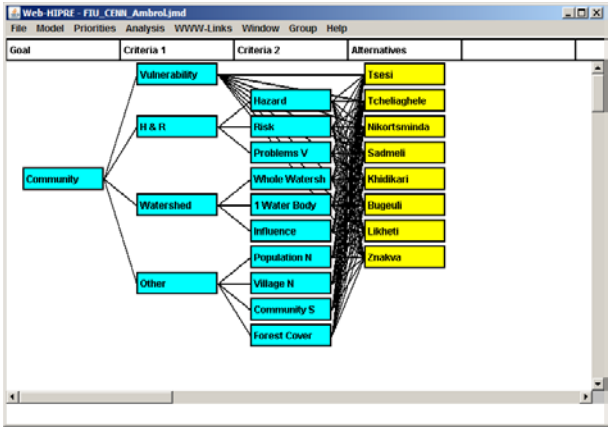
[3] Assessment of the vulnerability to natural disasters and climate change of INRMW program targeted municipalities. Adaptation and mitigation plan



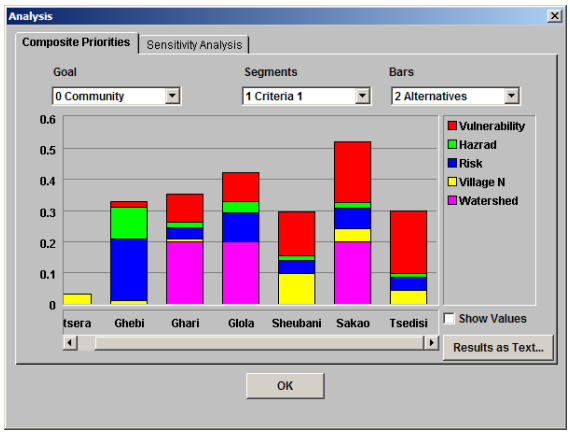


Following weighting the data was standardized and a so-called criteria tree was developed.





The system allows for multi-criteria analysis of the results, based on which potential targeted communities were identified.[4]



At the final stage of the selection process the data was communicated to the INRMW program implementing partners. On the basis of consultations the following communities were selected:

[4] for details refer to: http://www.hipre.hut.fi/ FIU_CENN_Ambrolauri.jmd

INRMW program targeted municipalities	Selected community
Oni	Sakao
Ambrolauri	Likheti
Senaki	Zemo Chaladidi
Khobi	Sagvichio
Akhmeta	Jokolo
Telavi	Ikalto
Dedoplistskaro	Samtatskaro

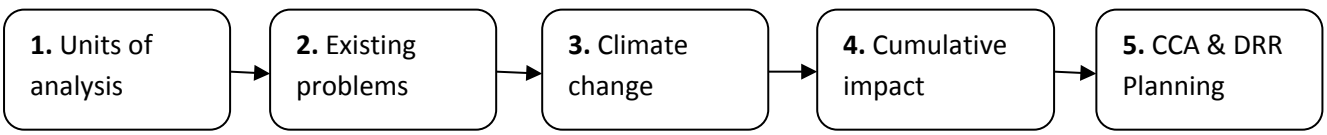
Development of community based natural hazards risk reduction and climate change adaptation plans

Participatory approaches implying the involvement of local community members at all stages of the plan development were used.

Experts were also involved in the process. They visited the local communities to study the situation on the ground and took part in the development of relevant recommended actions. It should be mentioned that the main purpose of the process was to discuss issues of natural disaster risk reduction in the context of climate change. Therefore the main goal was to study those geomorphological processes (erosion, mudflow, landslide, floods and flashfloods) occurring in the community, which are the main causes of natural disasters. Thus the experts of relevant fields were involved in this process.

Since the economies of the targeted communities are based mainly on agriculture, the agriculture expert was involved in the process of developing climate change adaptation and natural disaster risk reduction plans. Therefore, analysis of the agricultural sector and relevant recommendations constitute an important part of the final plans.

The process of the development of plans was divided into several logically linked stages that eventually formed the structure of the final versions of the plans. The diagram shows the general framework of the planning methodology. A brief description of each stage and the activities implemented at these stages is given below.



Stage 1: Identification of units of analysis

The aim of the first stage is to identify key aspects of the community (natural components, infrastructure, activities), to be analyzed at the next stages in the context of climate change and natural disasters.

Stage 2: Identification of existing problems

The aim of the second stage is to better understand the natural disaster related problems faced by the community. At this stage existing (not future) potential problems should be identified. The identified difficulties and problems should be linked to those units of analysis that have been identified at the first stage of planning.

The first two stages are the most important components of the planning process since the outcomes of these stages determine a content and character of the next stages of planning. The involvement of the local community is especially important at these stages. Therefore, the first two stages of the development of the present plan were implemented based on the working meetings with local community members.

Stage 3: Future climate change and its consequences

The aim of the third stage is to determine the patterns of climate change and its direct potential impact on units of analysis and the community in general. Climate change scenarios have been developed within the INRMW program during the process of assessing the vulnerability of targeted areas to natural disasters and climate change. Therefore the results of this assessment have been used in this case.

Stage 4: Combined impacts

The aim of this stage is to determine the interrelation between direct impacts of climate change and current problems and challenges. Therefore the aim of this stage is to develop a matrix of combined impacts.

To evaluate the level of impact on a specific unit of analysis the following matrix was used:

Scales of impact	**High**			
	Medium			
	Low			
		Low	**Medium**	**High**
		Duration of impact		

where the vertical axis shows scales of impacts of climate change and natural disasters. In this regard the following three levels are identified:

- low – impact occurs locally;
- medium – impact occurs in a considerable part of the community (about half of the community);

- high - impact occurs in the major part of the community.

The horizontal axis indicates scales and duration of impact caused by climate change and natural disasters. In this regard the three levels are distinguished:

- low – short-term impact (impact occurs during a relatively short period of time and quickly diminishes. Consequences of the impact are evidenced seasonally, during one or two days a season);
- medium – medium-term impact (consequences of the impact occur during a certain period of time, however they diminish with time. Consequences of the impact are evidenced seasonally, during up to one month a season);
- high – long-term / permanent impact (consequences of the impact occur over long periods of time or they never diminish).

Stage 5: Identification and planning of risk reduction activities

The aim of the final fifth stage is the development of an action plan that will ensure avoidance or mitigation of negative consequences of impacts identified at the previous stages. At this stage the involvement of experts is important. Therefore, the planning process at this stage has been implemented in close cooperation with the experts of relevant fields.

2. General characteristics of the community

Location and natural environment

The Likheti community is located in the eastern part of Ambrolauri municipality. The territory of the community mainly covers the upstream and source areas of the Lukhunistskali River (right tributary of the Rioni River). The Lechkhumi range borders the community to north-west, and the Sakao ranges to the north-east. The majority of the Lukhunistskali River gorge is hilly. Both slopes are dissected by the gorges of the relatively large and small tributaries of the Lukhunistskali River. Watersheds of all these rivers are located within the territory of the community. The most notable among them are the rivers Kheoristskali and Dziragululi (right tributaries of the Lukhunistskali River).

The community is comprised of three villages: Abari (880 m above sea level), Uravi (1040 m above sea level), and Likheti (820 m above sea level). The villages Abari and Uravi are located along the Lukhunistskali River gorge and the village Likheti - in the gorges of the rivers Kheoristskali and Lukhunistskali. The junction of these rivers is located within the territory of the village. The villages are located 19 km from the municipal center.

The climate of the Likheti community and the Ambrolauri municipality in general is transitional from moderate to humid subtropical. The dominance of a humid subtropical climate is conditioned by the geographical location and relief of the municipality. The climate of the low mountainous zone of the Ambrolauri municipality is characterized by moderate cold winters and relatively hot summers, while in the high mountainous zone climate is humid-mountainous with snowy winters. Mean annual temperature is 9-10^{0}C (in the lower zone), and 4-5^{0}C in the mountains. In the lower part of the municipality mean temperature in January is between 1.5-4^{0}C and 18-24^{0}C in July. Annual precipitation is 1,000-1,500 mm, in mountains this index reaches 1,600-1,800 mm.

Forests are the main natural resource of the community and the Amdrolauri municipality in general. All conifer species spread in the Greater Caucasus, such as fir, silver fir, pine, yew and juniper are found in the territory of the community. In the central part of the Greater Caucasus, at an elevation of 1,100-1,600 m above sea level, fir and silver fir form high-productive virgin forest massifs. At an elevation up to 1,000-1,100 m above sea level broadleaved forests of a rich floristic composition, comprised of beech, oak, chestnut, ash-tree, maple, linden, sour cherry, Caucasian pear, crab apple tree, etc. are found. At an elevation of 1,100 m and above, beech forms pure stands and mixed stands with conifers as the elevation increases. White birch, mountain maple and Caucasian mountain ash grow in the zone of subalpine forests. The majority of the forests of the community and the forests of the municipality in general have water regulation, erosion control, avalanche prevention and recreational functions.

Plant species included in the Red List of Georgia including yew, chestnut, Georgian hazelnut, etc. are spread in local forests. Clear cut areas located on slopes near villages are visible in aerial photos. Forests growing in these areas have been destroyed as a result of human activity, specifically due to unregulated and unsystematic harvesting and clearing for agricultural purposes.

The fauna of the forests of the community is comprised of more than 20 species of mammals, up to 50 species of birds and more than 10 species of reptiles and amphibians. From large mammals there

are found tur, chamois, deer, wild boar, fox, wolf, bear, marten, otter, badger, lynx, squirrel, hare, etc. From birds: snowcock, black grouse, thrush, mistle thrush, woodpecker, jay, raven, boreal owl, golden eagle, northern goshawk, Eurasian sparrowhawk, cinereous vulture, black kite, vulture, falcon, etc. Trout is widespread in the rivers.

Population

There are 400 households in the Likheti community. Population – 1,069.

According to information obtained during field works the population is distributed across the villages as follows (Table 1):

Table 1 Distribution of households and population in the Likheti community

Village	Household	Population
Likheti	181	459
Abari	56	174
Uravi	163	436
total (Likheti community)	**400**	**1,069**

The villages of the Racha region are characterized by low population. In an absolute majority of the villages the population does not exceed a few tens of people. In this regard the Likheti community is an exception. The table shows that the community is comprised of rather large (on a region scale) villages. The population of the community exceeds one thousand.

The share of the people of pensionable age is large (about 35%) and the share of children is very small (10-12%). The share of children in the total population is decreasing due to labor migration. The able-bodied population mainly leave the community, resulting in a decreased share of children and an increased share of people of pensionable age.

The Likheti community has one more feature which is characteristic of the Racha region in general. This is a sharp seasonal variation in the population. Due to hard natural, social and economic conditions the population leaves the community in winter and migrates to the large cities (Ambrolauri, Kutaisi, Tbilisi). In summer they come back to the community and carry out agricultural activities until the following winter. Those families that have resettled from the community long ago but have retained links and houses spend summers in the community.

An absolute majority of the local population is self-employed. The main source of their income is revenues from small private farms. The share of employed people amongst the able-bodied population is about 30% (181 people). 11% (68 people) are employed in the public sector (school, administration, ambulatory, etc.), while 19% (113 people) of able-bodied population are employed in local private enterprises (mainly in the construction of the Lukhuni Hydro Power Plant).

According to information obtained during working meetings about 25% of the local population is below the poverty level, which is quite a high index.

Such social-economic conditions determine the high rate of migration. Youth constitute the majority of migrants. The local population mainly moves to the large cities of Georgia (Kutaisi, Tbilisi) in search of temporary jobs. External migration is also observed (Turkey, Greece, Austria, Spain, etc.). According to locals money sent by migrants is the main source of income for the local population.

3. Units of analysis of the Likheti Community

The first stage in the methodology of planning the community based climate change adaptation and disaster risk reduction activities considered the identification of those units of analysis that are most vulnerable to hazardous natural processes and would be more severely affected in the future under the forecasted climate change scenarios. At the same time, these units have an important role in the life of the community and determine the level of adaptation of the community to the expected impacts of climate change.

In the process of identifying units of analysis for the Likheti community, important issues associated with the risks of natural disasters and expected impacts of climate change were identified. The following sources of information were used to identify the units of analysis:

- DRR and Climate Change Reports for targeted watersheds including upper Rioni watershed area developed within the framework of the INRMW program. The Likheti community is discussed in the context of the Ambrolauri municipality.

- Meetings with the local population – the aim of these meetings was to study the views of the local community on problems, existing situation, expected impacts of natural disasters and climate change in the life of the community, as well as their perception of methods of future development for the community.

- The expert team working on community based adaptation plans was an important source of information. The team was involved in community meetings, as well as in collection of baseline information and identification and planning of relevant adaptation activities at the final stage of the process.

Based on these information sources and consultations with the local population and expert team the following environmental components have been determined as units of analysis for the Likheti community:

- Agriculture and agricultural lands – as the main source of income and food security of the community.

- Rivers flowing in the territory of the community – as the primary cause of natural hazards occurring in the community.

- infrastructural facilities located on the territory of the community – motor roads, bridges, drainage canals, drinking water supply infrastructure, residential houses, electricity transmission lines, etc.

Below is given a short description of each component and brief characteristics of their role and importance in the life of the community.

3.1 Agriculture and agricultural lands

Crop growing

The total area of agricultural lands in the Likheti community is 1,585 ha, including around 88 ha of arable lands, 69 ha of perennials (including 19.5 ha of vineyards), 52 ha of unused lands, 137 of haylands and 1,211 ha of pastures. As a result of the land privatization process, each household received 0.95 ha of agricultural lands, including haylands and arable lands.

Corn and haricot are the main crops. The average productivity of corn and haricot is low (corn - 1.0 tons per ha, haricot – 150 kg per ha). Potato is characterized by average yields - 20-25 tons per ha. From vegetables the highest yields are recorded for onion, garlic, pepper, beet, and carrot. Cucumber and tomatoes are also being cultivated in small amounts.

High quality table and wine grapes do not grow under local climate conditions, therefore vine growing in the community is not commercial, unlike the villages in the lower zone of the Ambrolauri municipality.

Fruits include pear, apple, peach, plum, damson.

There is no irrigation system in the Likheti community. Amounts of annual precipitation (1,120 mm) are sufficient for grain crops, fruit gardens and vineyards. Only in drought years would irrigation be required.

Animal breeding

Animal breeding is the main agricultural activity in the community, due to the limited arable lands. Currently 746 heads of cattle, 110 pigs, 30 horses, 10 sheep and 9 goats are recorded in the community.

There is a balance between the number of livestock and available pastures in the community. 1,211 ha of pastures can fully satisfy the green mass needs of the existing livestock. For proper management of pastures and maintenance of their fertility livestock should be evenly distributed over pastures to avoid overgrazing of their separate parts. Usually, livestock grazes on nearby, easily accessible areas, therefore owners/herdsmen should relocate herds to unused areas.

Chickens (around 940) constitute the major share of poultry. Turkey, duck and goose exist in small amounts.

Beekeeping is well-developed in the community. Currently there are 515 beehives. One beehive produces on average 10 kg of honey, i.e. more than 5 tons of honey a year is produced in the community.

Pig breeding is a traditional activity in the Likheti community and the Racha region in general. However, according to the local population the number of pigs has sharply decreased due to African Pig Plague. They consider that there is no sense in the development of pig breeding.

3.2 Rivers flowing on the territory of the community

The Rioni River and its general hydrological characteristics

The Rioni River takes its rise on the southern slopes of the Greater Caucasus at the foot of mount Pasi at an elevation of 2,620 m and flows into the Black Sea at the city of Poti.

The length of the river is 327 km, the total drop equals 2,620 m, average gradient – 7.2 ‰. The area of the watershed is 13,400 km^2. The mean elevation of the watershed is 1,084 m.

The river gorge from its source up to the city of Oni is V-shaped, afterwards it becomes box-shaped. The slopes of the river gorge are dissected by the gorges of tributaries, the majority of which are characterized by the occurrence of mudflows. The width of the bottom of the riverbed varies between 0.1-1.5 km. The river terraces are two-sided and their height varies between 2-6 m, width – 250-600 m, length – 0.3-5 km. The floodplain is built of alluvial materials. Its width is within 50-400 m, and its height is 1-15 m. During floods and flash floods the depth of water covering the floodplain reaches 0.3-0.8 m.

The riverbed branches within a curved and angled gorge. The width of the flow varies between 6-60 m, depth – within 0.5-3.0 m, velocity – from 0.7-1.5 m/sec to 2-4.2 m/sec. The bottom of the riverbed is covered with pebbles and stones, at certain location the riverbed is rocky. The banks of the river are high, reaching 2-8 m at the locations where the river banks merge with the terraces.

The river is fed by glacier, snow, rain and ground waters; however, snowmelt and rain waters play the most important role. The hydrological regime of the river is characterized by spring floods and flash floods all year round. Monthly distribution of discharge is not even. Maximum discharge is recorded in May, minimum – in January.

High levels of floods and flash waters seriously threaten agricultural lands and infrastructure that exists on the river.

The Lukhunistskali River and its general hydrological characteristics

The Lukhunistskali River takes its rise from a small spring on the southern slope of the Lechkhumi range, 1.3 km south-east of mount Lukhunistsveri, at an elevation of 2,650 m above sea level. The Lukhunistskali River flows into the Rioni River from its right site at the village Tsesi.

The length of the river is 39 km, the total drop is 2,038 m, average gradient – 52.2. The area of the watershed is 293 km^2. The mean elevation of the watershed is 1, 750 m.

The main tributary of the Lukhunistskali River is the Kheoristskali River (14 km). 32 small tributarie,s with a total length of 18 km, flow into the Lukhunistskali River.

The flow regime of the river has been studied at two stations: at the village Uravi (1936-1937) and at the village Tsesi (1930-1935).

The width of the river varies between 5 m – 12 m. Its average width is 7 m, average depth - 0.7 m. Its velocity varies between 1.0 m/sec – 3.0 m/sec. The bottom of the riverbed is uneven and made up of cobble and pebbles.

3.3 Infrastructure

Water supply infrastructure

The community mainly uses spring water for drinking. A small part of the population uses artesian wells.

Major parts of the three villages of the community are provided with drinking water supply network. The population receives drinking water through pipes laid from water collectors. According to the local community members the drinking water supply infrastructure in the villages Uravi and Abari are in a good condition. The situation is different in the village Likheti where the system requires rehabilitation.

There is no irrigation system in the Likheti community.

Road and social infrastructure

A 14 km long section of the main motor road (to the Lukhunistskali River gorge) crosses the territory of the community. This is the only road connecting the villages of the community to each other and the community to the outer world. The main motor road is in a normal condition due to the construction of the Lukhuni Hydro Power Plant in the Lukhunistskali River gorge, close to the community.

Periodic rehabilitation of the main motor road of the gorge for the hydro power plant's construction purposes ensures uninterrupted transportation.

However, the internal roads, the total length of which is about 25 km, are in a poor state and require rehabilitation. The access roads (to pastures and haylands) are also in a bad condition. Restricted transportation caused by the state of the roads determines the community's high degree of vulnerability to natural disasters.

The houses of the community are mainly two-storied, where the first floor is built of stone and the second floor is wooden. Such constructions constitute about 90% of the houses of the community. Some portion of the population of the village Uravi lives in multistory apartment buildings. These buildings were constructed as accommodation for workers of the arsenic extraction and processing factory that operated in this area during Soviet times.

The Likheti community is provided with electricity. The electricity transmission system covers the whole community. The total length of electricity transmission lines is 15 km. According to the locals

part of the electricity infrastructure is outdated and has to be rehabilitated. This leads to frequent electricity cuts, especially in bad weather.

So-called collective meters (measuring electricity consumption for a group of households) are still in use, this is often a source of conflicts between neighbors as energy consumed by each household and corresponding costs are difficult to determine. Individual electricity meters are installed only at 30% of households, however, according to locals the process of installing individual meters is underway.

There is no gas pipeline in the community and therefore natural gas is not available for the locals.

Drainage systems do not exist in the community. The only exception is the village Abari, where drainage canals are built along a small section (60-70 m). Non-existence of a drainage system negatively affects the road infrastructure of the community.

Sewerage systems exist only in the apartment blocks of village Uravi. Without a sewerage system, waste waters flow into the Kheoristskali river without being treated. Other villages are not provided with sewerage systems. The population uses simple latrines built themselves.

There are no dumpsites in the community. The population throws garbage in the nearby ravines and litters the environment.

Hazardous structures

In terms of hazardous structures the situation existing in the village Uravi of the Likheti community is noteworthy. Specifically, two arsenic processing plants and one chemical plant were operating in the village Uravi and its adjacent areas between 1933-1994. The mentioned plants were extracting arsenic ore from arsenic deposits located in the sub-Alpine and Alpine zones south of the village Uravi.

At present, the sites of former arsenic processing and chemical plants in Uravi and adjacent areas are covered with harmful waste generated by these facilities over decades. There are also old buildings and their ruins.

Toxic chemical substances contained in the mentioned wastes cover large areas adjacent to these facilities. Part of the wastes generated as a result of extraction and processing arsenic is scattered on the surface, while another is stored in concrete sarcophaguses. These sarcophaguses were used for storing hazardous wastes generated not only by these facilities, but also for waste from factories of other regions of the Soviet Union. At present the sarcophaguses are damaged, so rainwater can easily penetrate and therefore the risk of pollution of the Lukhunistskali River with hazardous chemical substances exits. Arsenic processing (separation of arsenic containing ash) led to the pollution of soils in the production area. The result of a number of studies carried out in the area show that the concentration of arsenic in the soils of the production area exceeds acceptable standards by several times. Soil contamination creates health problems for the local pollution and affects the quality of local agricultural produce.

Currently the project "Arsenic containing mine waste in Georgia" is being implemented by the Dutch company Witteveen & Bos Consulting in cooperation with the Ministry of Environment and Natural Resources Protection of Georgia and the bodies of local government of the Racha-Lechkhumi – Zemo Svaneti region. The project is developing a detailed assessment of the situation in the village Uravi and adjacent areas and implementing remediation of hazardous wastes generated as a result of arsenic processing.

Medical service

In the village of Uravi the ambulatory is located in the building of the former polyclinics. There is also an ambulatory in village Likheti. One local nurse is providing medical services in each ambulatory. Periodically (once a week) a doctor from Ambrolauri visits the community to provide medical services. In emergency cases a first aid brigade comes from the city of Ambrolauri.

Table 2 provides a summary of information on the units of analysis for the Likheti community identified during working meetings with the local population and consultations with relevant experts.

Table 2. Units of analysis identified in the Likheti community

Unit of analysis	Description/Importance
Agriculture/Agricultural lands	• Agriculture is the main source of income for the community. • Total area of agricultural lands is up to 6,500 ha • Main crops – corn, haricot • Animal breeding is the main agricultural activity. 750 heads of cattle • Poultry breeding - 940 heads • Beekeeping - 515 beehives
Hydrographical network	• The Lukhunistskali River (right tributary of the Rioni River) is the main river of the community • Drinking water is supplied mainly from springs • No irrigation system • The rivers of the community are the main source of hazards occurring in the community
Infrastructure	• The condition of the road infrastructure determines the degree of vulnerability of the community to natural disasters • Wastes of the former arsenic enterprise is a serious problem for the community • Road and social infrastructure is important for the development of the community and improvement of the living conditions of the population

4. Problems/challenges faced by the Likheti community

The present chapter contains a brief description of problems and challenges faced by the Likheti community. A special emphasis is put on those natural hazards that determine the risk profile and the potential/ability of the community to adapt to expected climate change. The interrelation of these problems with the units of analysis identified at the first stage of planning is also described.

Problems of agricultural sector in the Likheti community

The agricultural sector of the Likheti community faces a number of problems. The main problems related to crop growing include low fertility of soils, single-cropping and improper system of soil fertilizing, leading to low yields and incomes from agriculture under conditions of limited agricultural lands. The local population uses manure to fertilize their lands, however the existing practice of manure storage is inadequate due to manure storage facilities that do not ensure preservation of nutrient content in manure. Manure stored in this manner or so-called fermented manure is ineffective for increasing soil fertility.

From mineral fertilizers local farmers use only ammonium nitrate in small amounts. The majority of the arable lands of the community are tilled using live pulling forces (mainly oxen), since only a small part of arable lands can be tilled using machinery. This makes agriculture time and labor consuming, but has some benefits. In this case soils are not trampled with heavy agricultural machinery and their properties related to water and air content do not worsen.

The problem of pig breeding (a traditional agricultural activity) is associated mainly with the negligence or partial implementation of animal health care and sanitary-hygienic rules. In most cases the population is not informed and pays inadequate attention to the health of domestic animals. As a rule, preventive measures against those diseases that can be treated with medication or vaccination are not taken. Non-vaccination is the main reason for deaths of animals in the community. According to the locals, animals died from African Pig Plague, however, the signs of this disease are similar to those of Classical Pig Plague which also causes deaths of non-vaccinated animals.

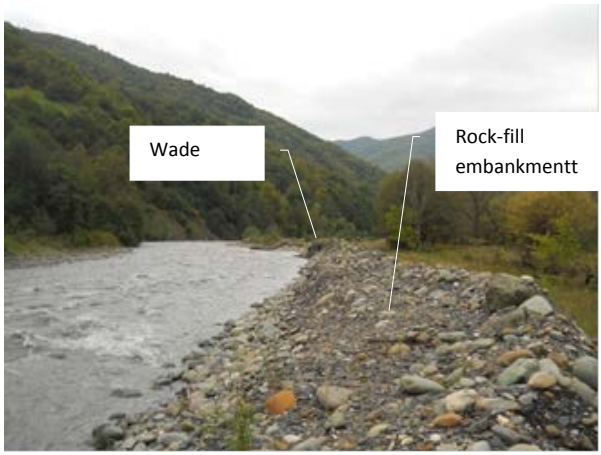
River erosion

Identification/survey of hazardous sites and sites exposed to risks as a result of floods and flash floods on the rivers of the Lukhunistskali River basin and the areas adjacent to the Rioni River (within the territory of the Likheti community) has been carried out. This survey was conducted in accordance with the results of consultations and working meetings with the local population during the field studies undertaken within the framework of the INRMW program. During the field study the Lukhunistskali River gorge and the Kheoriststali river gorge (a tributary of the Lukhunistskali River) were investigated. Three hazardous sites have been identified in the territory of the village Likheti of the Likheti community.

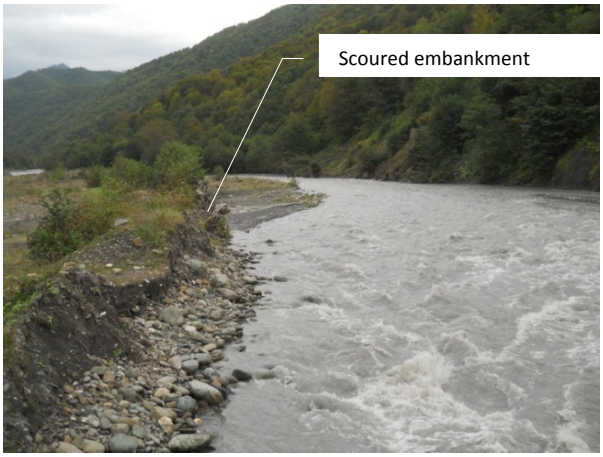
The first site (coordinates - X-356481; Y-4718172 WGS 1984 UTM Zone 38N) – on the right bank of the Lukhunistskali River. Floods occurring at this site result in the inundation and scouring of the riverside zone at the wooden bridge (Pic. 1) over the Lukhunistskali River.

Pic. 1. The village Likheti. Wooden bridge over the Lukhunstskali river

From time to time local community members clean the riverbed and build a rock-fill embankment on the right bank of the river from extracted materials (Pic. 2, 3), however, the rock-fill embankment cannot ensure protection of the population and access ways to the bridge due to the character of the mountain river. The river's activity results in the damage of bridges, residential houses, household plots and the infrastructure of the community (roads).



Pic. 2. The village Likheti. Rock-fill embankment built on the right bank of the Lukhunistskali River



Pic. 3. The village Likheti. Scoured rock-fill embankment on the rigt bank of the Lukhunistskali River

Two hazardous sites have been identified on the left bank of the Kheoristskali River in the village Liketi – in the environs of the transformer station of the village and in the Metrevelis neighborhood.

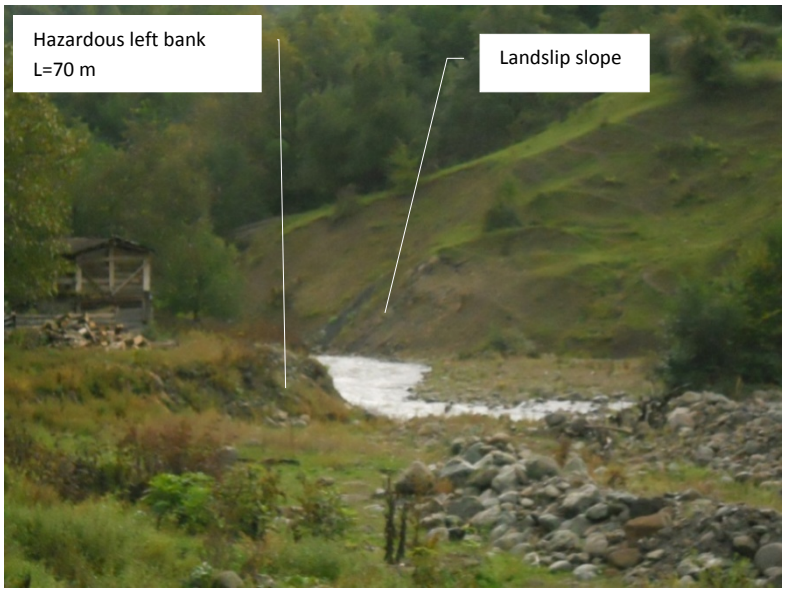
The second site (coordinates - X-355644; Y-4718558 WGS 1984 UTM Zone 38N) – the study site is located on the right bank of the Kheoristskali River – a tributary of the Lukhunistskali River. At this section the river demonstrates the character of a mountain river. At this section the riverbed is filled with boulders (Pic. 4) and has a high gradient. During flash waters and floods the river scours the left bank, where the transformer station of the village is located (Pic. 5).

Pic. 4. The village Likheti. Riverbed of the Kheoristskali River

Pic. 5. The village Likheti. Riverbed of the Kheoristskali River , I site - transformer

The acceleration of the process will threaten the electricity systems, the internal road, and agricultural lands of the community.

The third site (coordinates - X-355721; Y-4718343 WGS 1984 UTM Zone 38N) – floods occurring on the Kheoristskali River threaten a residential house located on the edge of the left bank of the river in the village Likheti (Pic. 6). The situation is aggravated by the presence of a landslip slope on the right bank of the river. During floods this slope is being disintegrated, putting excessive pressure on the left bank.



Pic. 6. The village Likheti. Riverbed of the Kheoristskali riverbed, the Metrevelis' neighborhood

If the process develops further it will threaten not only the residential house located in the vicinity of this site, but also household plots and agricultural lands of the other dwellers of the Metrevelis neighborhood and the internal road and the bridge over the Kheoristskali River. According to information obtained from the local population during working meetings, the mentioned house was abandoned by its dwellers after it was damaged by the flood that occurred in 1972. However, some years ago descendants of this family have resettled on this territory.

The results of the working meetings carried out with the local population show that flash floods and their associated consequences create serious problems in the community. The most severe damages from flash floods are reported in the village Likheti (due to the hazardous sites described above) located at the lowest altitude, where residential houses, household plots, agricultural lands and infrastructural facilities (roads, bridges, electricity wiring, etc.) are threatened.

Denudational processess

Village Likheti

The village Likheti is located on the right bank of the Lukhunistskali River, on its south-east facing slope. The gradient of the upper part of the slope in within 40-50^0 and in its lower part decreases to 7-10^0. The population is mainly settled on the flattened area – on the high terrace of the Lukhunistskali River. The area is built of the Jurassic clay shale and sandstone ($t_1^3\rho_1$), covered by Quaternary alluvial cobble-pebble and delluvial clay rocks.

The activation of the landslip slope occurred in 2010 on the household plot of Kukuri Malakshidze, north of his residential house (coordinates: 1. X-355761; Y-4717817. 2. X-355737; 4717805). The length of the activated landslide body is 60-70 m, width – 25-30 m. The gradient of the slope is 40-50^0 (Pic. 7, 8).

Pic. 7, 8. The village Likheti. Landslide body activated in 2010

The landslide is developed in delluvial sediments overlaying Lower Jurassic clay shale and sandstones. No outlets of groundwater are recorded on the slope. It is covered mainly with acacia forest. The trees are inclined toward the slope (some of them have fallen). The thickness of the landslide is 5-6 m. One part of the landslide has progressed into the back wall of the house of Kukuri

Malakshanidze. The eastern part of this wall is damaged, while the ancillary building is completely destroyed.

Removal of landslide masses from the backyard, after the activation of the landslide, did not have positive effects as the activity of the landslide (transporting ground masses to the wall of the house) did not stopped.

The process threatens not only the residential house and household plot of the mentioned community member, but also household plots and ancillary buildings of his neighbors, as well as the internal communications of the village.

Village Abari

The village Abari is located on the south-east facing landslip slope of the Lukhunistskali River. The study area is built of clay shale and sandstones of the Lower Sori sub-layer of the Toarchian layer of the Lower Jurassic age ($J_1^3S_1$) covered by delluvial brownish clay-loamy sediments of varying thickness. The surface of the landslide is hilly and wavy, with outlets of groundwater recorded (Pic. 9, 10).


Pic. 9, 10. The village Abari. Surface of the landslide body

The landslide is based on the Lukhunistskali riverbed. At present no deformations are observed on the motor road laid along the riverbed. Reinforcement works have been carried out at this section of the road (coordinates: X-357522; Y-4719478) – (Pic. 11, 12).


Pic. 11, 12. The village Abari. Motor road laid along the riverbed of the Lukhunistskali River

In the case of activation of the landslide the motor road will be damaged. The landslip area covers the household plots of Lia Rekhviashvili and Rusudan Rekhviashvili. The landslide has already damaged ancillary buildings (coordinates: X-357565; Y-4719518) – (Pic. 13, 14).

Pic. 13, 14. The village Abari. Buildings damages by landslides

A drainage canal was built on the surface of the landslide to collect surface flows, however, the canal has been destroyed and is inoperative.

Further development of the process will threaten the houses and household plots of the mentioned villagers and the main motor road.

Table 3, below, contains a summary of information on the problems and challenges identified on the basis of working meetings with the Likheti community, consultations with relevant experts and the impacts on their units of analysis:

Table 3. Problems identified in the Likheti community and corresponding units of analysis

Identified problems/impacts	Corresponding units of analysis
Degraded agricultural lands – arable lands. Inadequate soil cultivation practices leading to low fertility of soils	• Agriculture / agricultural lands
Pig breeding – improper practice of management leading to deaths of animals, degradation of the traditional activity and reduction of incomes from agriculture	• Agriculture
Floods and flash waters occurring as a result of river bank erosion cause serious damages to the population of the community	• Agricultural lands • Hydrographic network • Residential houses and household plots • Infrastructure - motor roads, electricity transmission lines, etc.
Landslide processes cause damages to the local population	• Agricultural lands • Residential houses and household plots

Identified problems/impacts	Corresponding units of analysis
	• Infrastructure - motor roads

5. Climate change and its consequences

After identification of the existing challenges in the community climate change trends were identified to determine the potential direct impacts of climate change in terms of new challenges and the aggravation of already existing problems in the community. Climate change trends have been identified on the basis of local knowledge/experience as well as using the results of the climate change studies carried out at the previous stages of the program[5]. Table 4 contains the trends of climate change with descriptions of the potential direct impacts and indication of those units of analysis that might be potentially affected by the mentioned changes.

Table 4. Climate change and potential direct impacts

Climate change trends	Direct impacts	Corresponding units of analysis
Expected increase of all parameters of air temperature (mean annual, maximums)	• Increased vulnerability of agricultural crops to climate change • Changed agricultural calendar • Decreased incomes from agriculture	• Agriculture / agricultural lands
Increase in annual precipitation. Changes in seasonal distribution patterns of precipitation. Increase of the cases when precipitation exceeds mean annual precipitation by 200 mm and more.	• Maintained high risks of floods and flash waters • High probability of inundation of riverside areas and acceleration of erosion processes as a result of floods, flash waters and river erosion • Maintained and increased risks of activation and development of old landslide processes • Increased risks and intensity of landslide processes. High probability of the development of new landslide hotspots • The areas already prone to floods, flash waters and landslides will face increased risks • Increased vulnerability of agricultural crops to climate change • Accelerated damage/degradation of agricultural lands as a result of natural processes • Decreased incomes from agriculture	• Agricultural lands • Hydrographic network • Infrastructure – residential houses, household plots, drinking water supply system, motor roads, electricity transmission lines, engineering and structures and utilities, etc.
Reduction of vegetation period	• Increased vulnerability of agricultural crops to climate change • Changed agricultural calendar • Decreased incomes from agriculture	• Agriculture / agricultural lands

[5] see INRMW program, report - Assessment of the Vulnerability to Natural Disasters and Climate Change for Upper Rioni Pilot Watershed Area & Plan of Mitigation and Adaptation Measures.

6. Combined impacts in the Likheti community

The potential combined impacts of the challenges faced by the community and the consequences of climate change on the units of analysis have been assessed on the basis of experts' work and participatory working meetings with the local population.

Impacts on agriculture

In the case of predicted climate change scenarios an increase in mean annual precipitation by 25-77 mm is expected in the Likheti community. Precipitation will increase mainly in winter. An insignificant decrease in precipitation will be observed in summer. In terms of precipitation the situation in the Likheti community will not change significantly by 2020-2050 (certain increase in annual precipitation, as well as changes in seasonal distribution of precipitation are expected). However, the temperature regime will change considerably. Mean annual temperature will increase by 1.5-1.8^{0}C, in summer this index will reach 2.1-2.4^{0}C. At the same time, an increase in the number of tropical nights from 2 to 26 in summer will determine increased demands on irrigation water for agricultural crops and agriculture in general.

Based on the above-mentioned it can be concluded that climate change will have a substantial impact on the agriculture of the Likheti community.

Negative natural phenomena

Analysis of the existing situation shows that the Likheti community is being affected by negative natural phenomena such as river erosion, leading to inundation of the territory of the community and causing damage to infrastructure during floods and especially during flash floods.

Strong landslide hotspots existing in the territory of the community cause serious damage to residential houses and agricultural lands of the local population and utilities. The scale and nature of the natural processes is described in detail in Chapter 4.

According to the existing climate change scenarios the high risk of floods and flash floods will be maintained due to increases in precipitation and changes in its distribution pattern. This process will lead to the acceleration of river erosion.

The predicted increase in certain parameters of precipitation (increase of cases when annual precipitation exceeds mean precipitation by 200 mm or more) and changes in the distribution of precipitation point to increased risks of landslides, which are already a serious problem for the community.

Therefore, damage caused by negative natural phenomena to the Likheti community will presumably be increased. The areas currently being threatened by these hazards will be most affected.

Analysis of the combined impacts of climate change shows that climate change will have a big impact on the development of hazardous natural processes in the Likheti community.

Table 5, below, contains a summary of the information on combined impacts.

Table 5. Combined impacts identified in the Likheti community

Combined impact	Corresponding units of analysis
Soil degradation (deterioration of quality), reduction of the volumes and deterioration of the quality of agricultural products due to the change in temperature and precipitation patterns determining increased demands of agriculture on irrigation water. Resulting decrease of incomes from agriculture	• Agricultural lands
Accelerated floods, flash waters, river erosion will lead to increased damages of agricultural lands and infrastructure of the community	• Agricultural lands • Hydrographic network • Residential houses • Infrastructure
Acceleration of landslide processes will result in increased damages of agricultural lands, especially residential houses and utilities	• Agricultural lands • Hydrographic network • Residential houses • Infrastructure

7. Adaptation and disaster risk reduction activities

The final stage of the selected methodology for planning climate change adaptation and natural disaster risk reduction activities considers the development of an action plan to ensure prevention or mitigation of the negative impacts identified at the previous stages of planning. The following activities have been selected (in close cooperation with the experts of relevant fields) for each impact identified for the Likheti community.

Agriculture

As has been already mentioned, the main impact of climate change on agriculture in the Likheti community will be manifested in an increased demand for irrigation water. Therefore the moisture content in soils has to be increased through improvement and protection of soils. This is especially relevant for moisture loving plants and crops with a long vegetation period. Searching for ways to solve this problem is the most important issue for the adaptation of agriculture in the Likheti community to future climate change. Therefore, this was the main issue discussed at the meetings with local community members. The recommendations given below have been developed on the basis of the results of these meetings. It should be taken into account that irrigation practices cannot be introduced in the Likheti community due to its specific relief.

1 *Increasing moisture content in soils*

a) Increasing soil fertility on the basis of the studies on the existing productivity of arable lands and considering the characteristics of agricultural crops will be required. The content of organic matter in soils should be increased, since the organic matter of soils is able to retain about 10 times as much water as its weight. Therefore its content determines the ability of soils to retain moisture. This can be achieved through the application of organic fertilizers. Taking into account the current level of soil fertility, application of 25-30 tons of composted manure, compost manure or compost per 1 ha is recommended. The amount of fertilizers can be increased depending on the needs of crops if applied to soils poor in organic matter.

The content of organic matter in soils can also be increased through sowing green manure (so-called green fertilizers). For this purpose mainly legumes (e.g., vetch, grass pea) are used. Green manure can be used under perennials (vine, fruits), as well as in the case of annual crops. To prepare land plots for autumn cereals (wheat, barley) green manure can be sowed in spring and ploughed into the soils during their flowering period, while in case of spring crops (corn, majority of vegetables and vine crops) they can be sowed in autumn (September-October) and ploughed into the soils prior to sowing main crops.

b) Mulching is an important activity for ensuring moisture retention in soils. Mulching is effective in the case of vines and other perennials. Mulching materials have to be made from locally available hay or crop remains. Hay used for mulching should not contain the seeds of weeds, therefore grass should be mowed during flowering season. Mulching under perennials has to be done in spring before rains, in the case of vegetables – after transplanting or when sprouts reach a desirable height.

Along with the dead mulch so-called live mulch can be used between the rows of perennials. For this purpose cover plants have to be sowed. Cover plants are comprised of legumes or a combination of legumes and grain grasses. Cover plants retain moisture in soils as well as revitalizing and improving their structure. The presence of legumes (vetch, grass pea, clover, etc.) in cover plants ensures the accumulation of biological nitrogen in soils and thus improves consumption of nitrogen by main crops.

A good example of natural vegetation under perennials is found in village Abari (Pic. 15), where green cover (species composition: grain crops and clover), developed under a fruit garden growing on the slope, serves as an effective mechanism for the protection of soil and improvement of its fertility. It can also be used as a hayland or pasture (when trees reach an adequate height).

Pic. 15. Village Abari. Green cover developed under fruit garden

The use of cover plants on arable lands is important in the case of spring crops, when soils are free from vegetation during autumn-winter and early spring. During this period cover plants can protects soils from erosion, retain moisture in soils, restrict the development of weeds, accumulate biological nitrogen and provide significant amounts of green mass that can be used as green fertilizers, forage and for preparation of mulch and nourishing hay.

Along with the abovementioned the implementation of the measures oriented at solving the existing problems, facilitating the growth of incomes from agriculture and thus contributing to building resilience and reducing vulnerability of the population to climate change and natural disasters is important for adaptation of the community to future climate change. The implementation of the following measures is suggested:

***2** Water erosion control*

The village Likheti and other villages of the community are characterized by a complex relief. The majority of agricultural lands are located on steep slopes. Therefore there is a high risk of the

development of water erosion on the lands occupied by perennials, arable lands and pasture-haylands. To control water erosion a network of water drainage, water collecting and water removal canals should be built.

Construction of drainage ditches is important for agricultural lands located on slopes. Ditches have to be built across upper or middle parts (if needed) of the slopes to collect and direct surface waters to natural water bodies (springs, rivers, ravines) or larger canals.

0.5-0.6 m wide buffer strips of perennial grasses are widely used for water erosion control. These strips retain loose-solid flows, contribute to the growth of crop productivity and increase soil humidity. The width of the buffer strip increases with the slope inclination. An anti-erosion effect is achieved when hoed plants and trees alternate with strips of grain crops or perennial grasses.

3 *Manure storages / composting*

Improvement of manure storage practices and manure composting that considers local conditions is important. Manure compost is a safe and valuable organic fertilizer that can be applied to all agricultural crops to improve soil productivity. Organized collection of manure and its protection from evaporation of nitrogen compounds and washing from precipitation ensures the protection of ambient air and surface and ground waters from pollution.

To make compost the following ingredients can be used, manure (cattle, pig, chicken, horse), straw (chopped to 10-15 cm), stubble (without seeds), green grass (without seeds), chips, twigs (chopped), trims of vine or fruit trees (healthy trees), leaves, vegetative wastes from kitchens, wastes of haricot and other legumes, egg shells, ash (in small amounts, not more than about 3% of the total volume), all types of green mass except poisonous and thorny plants can be used. The process of composting requires 3-4 months. Compost can be used as an organic fertilizer like manure and applied to soils in a similar manner.

4 *Improvement of local breeding stock*

Cattle breeding and animal breeding in general are the main agricultural activities in the Likheti community. To increase the productivity of cattle, improvement in the local breeding stock is required. This will enable local farmers to double milk yields that are currently 7-8 l per cow. Selection of relevant breeds is also needed for beef husbandry; breeds should be selected considering the conditions of mountainous relief and climate.

5 *Improvement of natural pastures-haylands*

The existing pasture-haylands create a good basis for the development of livestock breeding, however wise use of these lands and improvement of their productivity is required.

Mowing periods shall be adequately selected and observed. On one hand it has a strong effect on the nutrition value of hay: late mowing leads to the deterioration of hay quality, while on the another, early mowing leads to the decline of pasture productivity. E.g., the following schedule can be used: 1) In the first year mowing shall take place during ripening period of main forage grain crops; 2) In the second year – when crops begin to ear; 3) In the third year – during flowering; 4) In the fourth year – after seed fall.

Grazing height affects the productivity of pastures and their regeneration ability. The grazing height should not be lower than 4-5 cm, while the height of post grazing residual should not be at 10-15 cm. In this case the pasture will not be fully used.

During cold seasons, especially when the land is covered by snow, livestock shall be provided with succulent (e.g., silage) fodder and concentrated food along with dry fodder (e.g., hay, straw) to maintain their health and productivity during the winter seasons. The existing pasture-haylands create a good basis for the development of livestock breeding, however, wise use of these lands and improvement of their productivity is required. To provide the livestock with silage and other nourishing fodder suitable plots have to be selected from unused areas where alfalfa can be sowed and used as pastures. This plant can be used for 5 years and can be sowed twice a year from the second year of sowing; meaning up 10 t high-quality annual yield in cases of proper maintenance.

6 *Traditional agricultural activity - pig breeding*

The problem of pig breeding (traditional agricultural activity) is associated mainly with the negligence or partial implementation of animal health care and sanitary-hygienic rules. In most cases the population is not informed and pays inadequate attention to the health of animals. As a rule, preventive measures against those diseases that can be treated with medication or vaccination are not taken. Non-vaccination is the reason for the deaths of animals in the community. According to the locals the animals died from African Pig Plague, however the signs of this disease are similar to those of Classical Pig Plague, which also causes death in non-vaccinated animals.

Therefore, all required preventive measures have to be taken. Sick animals have to be isolated as soon as the first symptoms of disease become noticeable. Local veterinary services have to be immediately informed and all recommendations have to be implemented to diagnose, ensure adequate treatment and/or prevent the spread of the disease.

7 *Beekeeping*

Natural conditions in the Likheti community are favorable for beekeeping development. Both field and forest vegetation are available for bees and therefore beekeepers are able to produce diverse goods. To make beekeeping more profitable production of beekeeping products other than honey should be promoted. The role of bees in the growth of the pollination index of a major part of agricultural crops, leading to increased yields, can also be considered. To support the development of bee keeping nectariferous plants should be included in seed rotation, cover plants and pastures (sainfoin, alfalfa, clover, etc.).

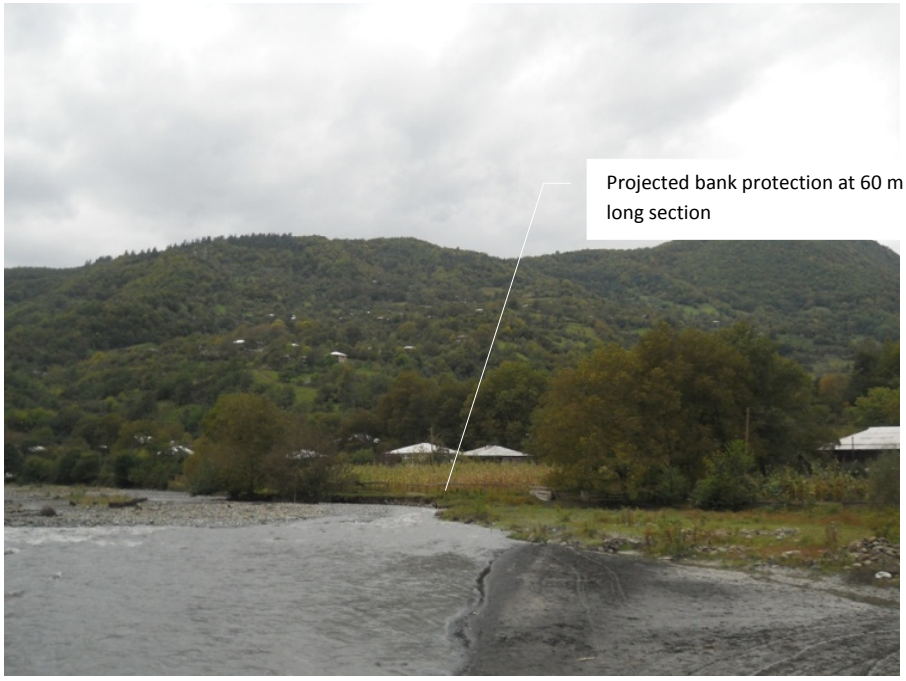
Effective and wise use of forest resources can offset the shortage of arable lands in the Likheti community. Wild plant products such as different mushrooms and berries, codling, chestnut, medicinal herbs, etc. can be collected. In accordance with the standards pertinent to organic agriculture and processing (e.g. juice, dry fruits) (if needed) can be developed in the Likheti community. Certified collection of wild plants would be an important step toward additional income generation, biodiversity conservation, and environmental awareness raising of local farmers.

Hazardous natural processes

River erosion

To mitigate river erosion and protect eroded river banks - which in turn will ensure protection of residential houses, agricultural lands and road and social infrastructure from flooding - the following activities should be implemented at the hazardous sites identified during field the studies.

The first site – the village Likheti, right bank of the Lukhinistskali River at the wooden bridge (coordinates - X-356481; Y-4718172 WGS 1984 UTM Zone 38N). Floods and flash floods occurring at this site result in the inundation of adjacent agricultural lands, river erosion at this location also poses a threat to the houses of the local population, the motor road and the bridge. According to information from the village governor, the implementation of bank protection activities is planned at this section. Specifically, a 60 m long gabion will be built on the right bank of the river, downstream of the bridge (Pic. 16), and a 20 m long gabion will be built upstream of the bridge, where the river has destroyed a rock-fill embankment and flows into the village.



Pic. 16. Village Likheti. 60 m long hazardous site downstream of the bridge

We consider that the rehabilitation of the destroyed section of the rock-fill embankment, even with the construction of a gabion, will not ensure protection of the area from floods and flash floods, since the embankment is expected to break at other sites as well. Therefore the protection structure should be built not only at the destroyed section along its full length (Pic. 17).

Pic. 17.Village Likheti. Planned bank protection activities on the Lukhunistskali River

At this study section the discharge of 1% probability is 220 m^3/sec. On the basis of the results of field work carried out with simple surveying instruments it has been found out that the maximum depth of river during floods, including scouring and flooding, is 3.8 m.

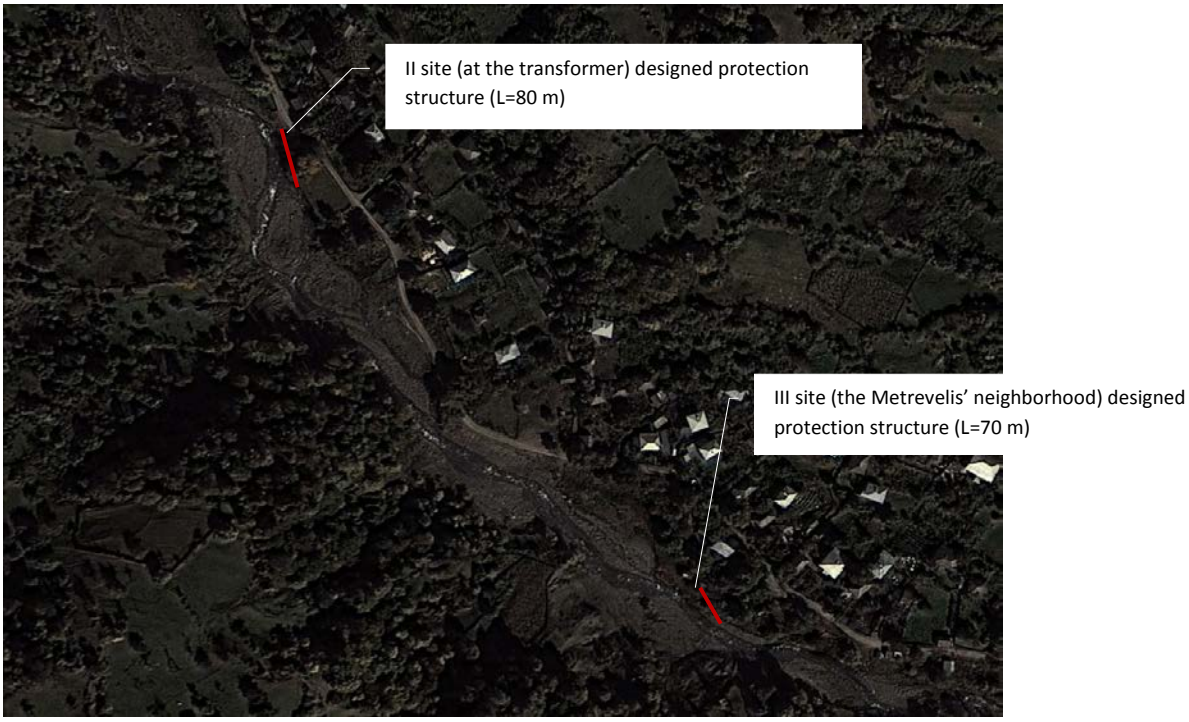
The length of the recommended protection gabion is 300 m. The estimated volume of the gabion is 1,350 $m^{3.}$ The estimated cost of construction-assembling activities is 220,000 GEL.

The second site – the village Likheti, left bank of the Kheoristskali River (coordinates - X-t355644; Y-4718558 WGS 1984 UTM Zone 38N). River erosion occurring at this site threatens the road, electricity infrastructure and agricultural lands of the community. To protect this hazardous site a rock-fill dam will have to be built from large boulders. However, due to restrictions on the use of available volcanic rocks for construction (forest strip, etc.) of the mentioned berm it is recommended to build 80 m long gabion (Pic. 18), the boxes of which have to be made with 5 mm diameter wire.

The length of the recommended protection gabion is 380 m. The estimated volume of the gabion is 1,350 $m^{3.}$ The estimated cost of construction-assembling activities is 55,000 GEL.

The third site - the village Likheti, left bank of the Kheoristskali River (coordinates - X-355721; Y-4718343 WGS 1984 UTM Zone 38N). River erosion occurring at this site threatens residential houses and household plots, agricultural lands and the road infrastructure of the community. To protect this hazardous site it is recommended to build a 70 m long gabion (Pic. 18), the boxes of which have to be made with 5 mm diameter wire.

The length of the recommended protection gabion is 300 m. The estimated volume of the gabion is 340 $m^{3.}$ The estimated cost of construction-assembling activities is 49,000 GEL.



Pic. 17.Village Likheti. Planned bank protection activities on the Kheoristskali River

Denudational processes

Village Likheti

As has been mentioned above (Chapter 4) on-going landslide process observed in the village Likheti (coordinates 1. X-355761; Y-4717817. 2. X-355737; 4717805) threaten residential houses and household plots of the local population. Internal communication lines are also threatened. The residential house of Kukuri Malakshanidze is under serious risk. The house has already been damaged by the landslide. To maintain the stability of this house and mitigate the process it is recommended to remove the ground masses transported by the landslide from the wall along a 1-1.5 m wide section and build a protection wall with a sloping abutment. Moreover, a drainage canal will have to be built at the bottom of the wall to avoid penetration of surface flows into the foundation of the building.

Village Abari

Landslide process recorded in the village Abari (coordinates: 1. X-357522; Y-4719478. 2. X-357565; Y-4719518) threaten residential houses, household plots, the main motor road, etc. (see details in Chapter 4). The process is accelerated by the destroyed drainage canal on the landslip slope that was constructed to regulate surface flow. Currently the canal is inoperative, therefore the landslide body is being saturated with water, which leads to activation of the landslide process.

To stabilize the process and prevent its further development the existing drainage system has to be completely rehabilitated to avoid saturation of the slope with surface water.

Table 6, below, contains a summary of information on climate change adaptation and natural disaster risk reduction activities to be implemented in the Likheti community.

Table 6 Summary of climate change adaptation and disaster risk reduction activities to be implemented in the Likheti community

Activity	Aim	Estimated budget	Duration[6] (ST; MT; LT)	Responsible institution	Potential Source of Funding
Global aim of the activities: • Adaptation and increase the resilience of agriculture of theLikheti community to climate change and natural disasters • Reduction of vulnerability of the community					
Application of organic fertilizers (manure, manure-compost, compost) to agricultural lands (25-30 tons per 1 ha) on a regular basis.	• Satisfying the increased demand of agriculture on irrigation water as a result of climate change • Increase of the moisture content and retention capacity of soils • Increase of soil fertility • Increase of the content of organic substances in soils	< 50,000	**ST**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • NGOs
Introduction of the practice of application of green manure (so-called green fertilizers) mainly legumes (e.g., vetch, grass pea) under perennials (vine, fruits) and annual crops (wheat, barley) agricultural lands. Education and awareness-raising of farmers on this issue.	• Increase of soil fertility • Increase of the content of organic substances in soils • Increase of the moisture content and retention capacity of soils	< 50,000	**ST**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • NGOs
Introduction of the practice of mulching on agricultural lands, under perennials and annual	• Increase of the productivity of perennials	< 50,000	**ST**	• Local farmers • Agricultural	• Local farmers • Agricultural

[6] Short-term (ST) implementation period – less than 1 year; medium-term (MT) – 1-5 years; Long-term (LT) – more than five years

Activity	Aim	Estimated budget	Duration[6] (ST; MT; LT)	Responsible institution	Potential Source of Funding
crops. Application of both dead mulch and cover plants. Combination of dead mulch and cover crops. Education and awareness-raising of farmers on mulching.	• Retention of moisture in soils • Improvement of soil structure • Accumulation of biological nitrogen in soils • Protection of soils from erosion • Ensuring additional forage basis for animal breeding			development services • Local self-governance	development service • NGOs
Construction of a network of water drainage, water collecting and water removal canals on agricultural lands (arable lands) located on slopes.	• Water erosion control • Regulation of surface runoff • Abatement of soil erosion/reduction of the loss of topsoil • Increase of soil fertility • Reduction of vulnerability of soils to extreme precipitation events	< 50,000	**MT**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • NGOs
Application of bioengineering methods against water erosion on agricultural lands. located on slopes: planting buffer strips (0.5-0.6 m wide, their width may increase with the growth of slope inclinations). Training and awareness raising of farmers on these issues.	• Water erosion control • Regulation of surface runoff • Abatement of soil erosion/reduction of the loss of topsoil • Increase of crop productivity	< 50,000	**MT**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • NGOs
Arrangement of manure storages and	• Preparation of high quality	< 50,000	**MT**	• Local farmers	• Local farmers

Activity	Aim	Estimated budget	Duration[6] (ST; MT; LT)	Responsible institution	Potential Source of Funding
introduction of composting. Education and awareness raising of farers on application of the method.	organic fertilizer • Qualitative improvement of soils • Protection of the environment from pollution (evaporation of nitrogen compounds, washing into surface water bodies)			• Agricultural development services • Local self-governance	• Agricultural development service • NGOs
Improvement of breeding stock of cattle.	• Increase of incomes from animal breeding	< 50,000	**MT**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • NGOs
Development of pasture and hayfield management plans: • Selection and observation of adequate mowing and grazing periods • Grazing height control • Equal load of pastures • Awareness raising of the population on practices of sustainable use of pastures	• Development of animal breading in the community • Improvement of forage reserve for animal breeding • Reduction of pasture degradation • Maintenance and improvement of pasture productivity	< 50,000	**MT**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs
Development of pig breeding: • Observation of health care and sanitary-hygienic rules in animal breeding	• Development of traditional pig breeding in the community	< 50,000	**ST**	• Local farmers • Agricultural development services	• Local farmers • Agricultural development service

Activity	Aim	Estimated budget	Duration[6] (ST; MT; LT)	Responsible institution	Potential Source of Funding
• Regular implementation of necessary preventive measures including vaccination • Awareness raising of the population on practices of sustainable use of pastures	• Increase of incomes from animal breeding			• Veterinary services • Local self-governance	• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs
Inclusion of nectariferous plants in seed rotation, cover plants and pastures (sainfoin, alfalfa, clover, etc.). Awareness rising of the population on the importance of these plants.	• Facilitation of the development of bee keeping in the community • Increase of the productivity of agricultural crops through increased pollination	< 50,000	**ST**	• Local farmers • Agricultural development services • Local self-governance	• Local farmers • Agricultural development service • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs
Global aim of the activities: • Mitigation of hazards faced by the Likheti community and reduction its vulnerability to natural disasters and climate change • Reduction of risks of natural disasters in the Likheti community • Adaptation to climate change					
Village Likheti. - I site (X-356481; Y-4718172. Chapter 7) – River erosion occurring at the bridge over the Lukhunistskali River. Construction of an additional protection gabion is planned on the right bank of the river (300 m long). Total volume - 1,350 m^3	• Abatement of river erosion • Reduction of the risk of floods and flash waters • Protection of residential houses and household plots • Protection of the motor road	130,000	**MT**	• Municipal government • National Environmental Agency • Ministry of Regional Development and Infrastructure	• Local budget • State budget • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)

Activity	Aim	Estimated budget	Duration[6] (ST; MT; LT)	Responsible institution	Potential Source of Funding
	• Protection of the bridge				• NGOs
Village Likheti. - II site (X-355644; Y-4718558. Chapter 7) – Left bank of the Kheoristskali river. It is recommended to build a protection structure on the left bank of the river. (Parameters: length - 80 m. Boxes have to be made of 5 mm diameter wire). Total volume - 380 m^3	• Abatement of river erosion • Reduction of the risk of floods and flash waters • Protection of agricultural lands of the community • Protection of electricity and road infrastructure of the community	32,000	**ST**	• Local self-governance • Municipal government • National Environmental Agency • Ministry of Regional Development and Infrastructure	• Local budget • State budget • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs
Village Likheti. - III site (X-355721; Y-4718343. Chapter 7) – Left bank of the Kheoristskali river. To protect the hazardous site a protection gabion has to be constructed (Parameters: length - 70 m. Boxes have to be made of 5 mm diameter wire). Total volume - 380 m^3 Total volume - 340 m^3	• Abatement of river erosion • Reduction of the risk of floods and flash waters • Protection of residential houses and household plots • Protection of infrastructure and agricultural lands of the community	30,000	**MT**	• Local self-governance • Municipal government • National Environmental Agency • Ministry of Regional Development and Infrastructure	• Local budget • State budget • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs
Village Likheti. Implementation of erosion control measures in settled area (coordinates: 1. X-355761; Y-4717817. 2. X-355737; 4717805. See details in Chapter 7 – Denudational processes) • Removal of ground masses transported to the house (Kukuri Malakshanidze) damaged	• Protection of the population from landslides • Protection of residential houses and agricultural lands from landslides • Stabilization of the existing landslide body (within the	50,000 – 100,000	**MT**	• Local self-governance • Municipal government • Regional government • National Environmental Agency	• Local budget • State budget • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs

Activity	Aim	Estimated budget	Duration[6] (ST; MT; LT)	Responsible institution	Potential Source of Funding
by the landslide at 1-1.5 m wide section • Construction of a protection wall with sloping abutment • Construction of a drainage canal. Directing collected surface waters from landslide body into natural watercourses • Rehabilitation of damaged residential houses	indicated coordinates)				
Village Abari. Implementation of erosion control measures on the landslide body existing in the community (coordinates:1. X-357522; Y-4719478. 2. X-357565; Y-4719518. See details in Chapter 7 – Denudational processes) • Regulation of surface and ground waters and their channeling to natural water courses • Rehabilitation of the old drainage canal on the landslide body • Permanent monitoring of the process and establishing an early warning system	• Protection of residential houses and agricultural lands from landslides • Stabilization of the existing landslide body (within the indicated coordinates) • Protection of utilities from damage • Reduction of the vulnerability to natural disasters	< 50,000	**ST**	• Local self-governance • Municipal government • Regional government • National Environmental Agency	• Local budget • State budget • Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.) • NGOs

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