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

Republic of Georgia

Integrated Natural Resources Management in the Republic of Georgia Program

Technical Summary Report

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Republic of Georgia

Funding for this publication was provided by the people of the United States of America through the U.S. Agency for International Development (USAID) under Agreement No.CA # AID-114-LA-10-00004, as a component of the Integrated Natural Resources Management for the Republic of Georgia Program. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Agency for International Development of the United States Government or Florida International University.



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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 Sakao community of Oni 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/

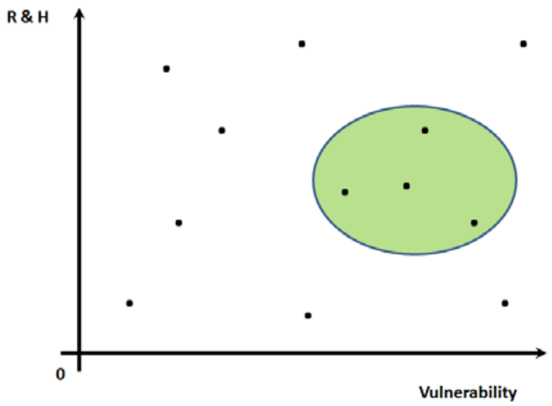
One of the most important stages of the selection process was the identification of selection criteria. These criteria included:

**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).

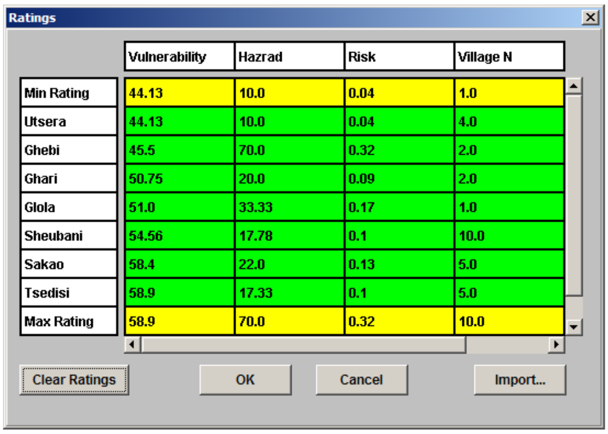



Along with the abovementioned, other criteria were also used for the selection of pilot communities: location of a community within a single watershed, potential impact on other communities, area of the community, number of villages in the community, size of population, area of forested land, etc.

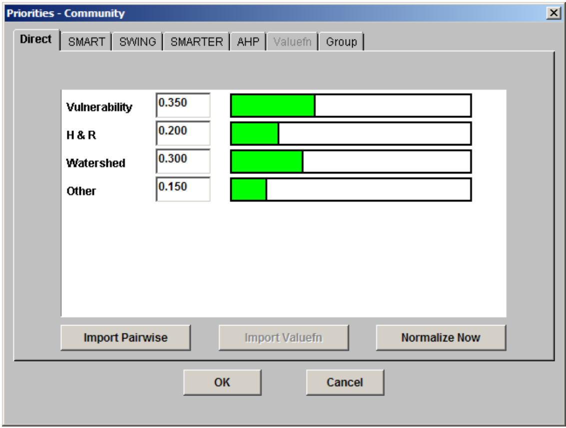
After identification of criteria the data corresponding to these criteria were integrated into the special web-based database. Each criterion was assigned a weight for formulation of a final decision.

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

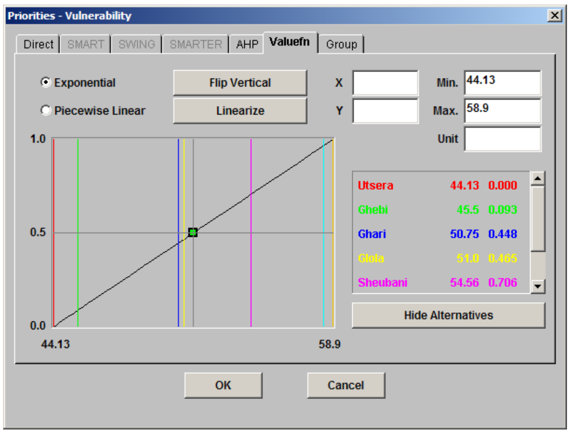
[3] Assessment of the vulnerability to natural disasters and climate change of INRMW program targeted municipalities. Adaptation and mitigation plan

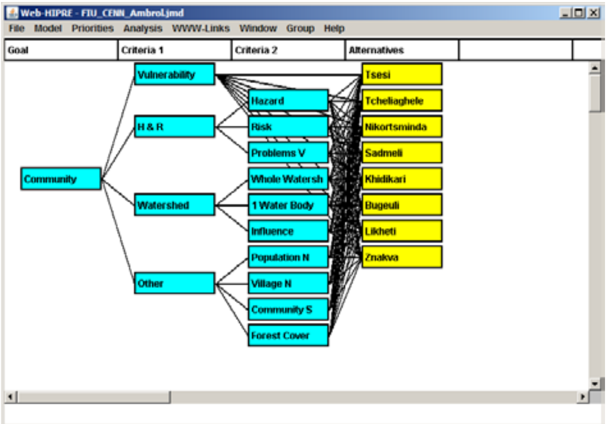


| | Vulnerability | Hazrad | Risk | Village N |
|---|---|---|---|---|
| Min Rating | 44.13 | 10.0 | 0.04 | 1.0 |
| Utsera | 44.13 | 10.0 | 0.04 | 4.0 |
| Ghebi | 45.5 | 70.0 | 0.32 | 2.0 |
| Ghari | 50.75 | 20.0 | 0.09 | 2.0 |
| Glola | 51.0 | 33.33 | 0.17 | 1.0 |
| Sheubani | 54.56 | 17.78 | 0.1 | 10.0 |
| Sakao | 58.4 | 22.0 | 0.13 | 5.0 |
| Tsedisi | 58.9 | 17.33 | 0.1 | 5.0 |
| Max Rating | 58.9 | 70.0 | 0.32 | 10.0 |

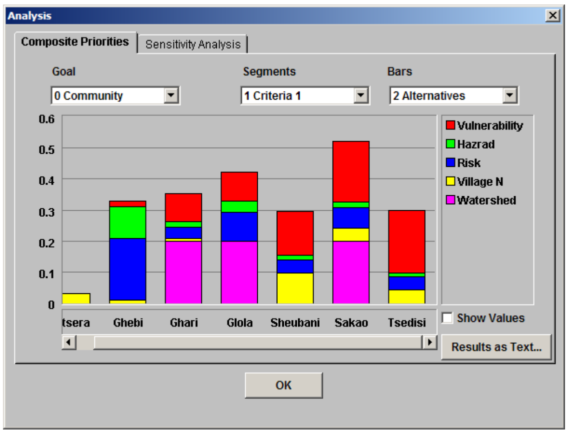



Following weighting the data was standardized and a so-called criteria tree was developed.




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_Oni.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.

**1.** Units of analysis → **2.** Existing problems → **3.** Climate change → **4.** Cumulative impact → **5.** CCA & DRR Planning

### 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 Sakao community is located in the central part of the Oni municipality on the southern branch of the Shoda-Kedela gorge and covers the Sakaura River watershed. The Sakaura River is a right tributary of the Rioni River and flows into Rioni on the territory of the community near the village Lagvanta. The Sakaura River watershed actually coincides with the territory of the community. Larger tributaries of the Sakaura River include the rivers Badeura, Khideshlebi and Khojora. There are also small nameless streams taking their rise on the southern slope of the Shoda gorge and its branches.

The Sakao community is comprised of the following villages: Sakao (1,050 m above sea level), Khideshlebi, Mazhieti, Bortso and Lagvanta. The villages of the community are located along the Sakaura River. The average distance between the villages and the municipal center is around 8 km. The total area of the community is 38,039 ha.

Oni municipality is located within the marine humid subtropical climate zone and is characterized by vertical zoning: 300-900 m above sea level the climate is moderately humid with cold winters and long, warm summers. Mean annual temperature is $10^0$C; -$10^0$C in January and $20^0$C in July; absolute minimum - $27^0$C, absolute maximum - $36^0$C. Mean annual precipitation is 1,000-1,100 mm. Maximum precipitation falls in spring, minimum – in summer. Highland climate with permanent snow and glaciers is found in high, mountainous areas of the municipality.

Forests, occupying large areas, are the main natural resource of the community. 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 an silver fir form high-productive virgin forest massifs. At an elevation of up to 1,000-1,100 m above sea level broadleaved forests with a rich floristic composition 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 trees form pure 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, landslide prevention and recreational functions.

Fauna in 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, white breasted marten, yellow breasted marten, otter, budger, lynx, squirrel, hare and weasel. From birds: snowcock, black grouse, wood pigeon, thrush, mistle thrush, woodpecker, jay, raven, European bee-eater, chaffinch, boreal owl, golden eagle, northern goshawk, Eurasian sparrowhawk, cinereous vulture, black kite, vulture, falcon and white-tailed eagle. Trout is widespread in the rivers.

*Population*

There are 148 households in the Sakao community. Population – 279.

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

***Table 1 Population and gender structure of the Sakao community***

| village | male | female | total |
|---|---|---|---|
| Sakao | 58 | 71 | 129 |
| Mazhieti | 19 | 26 | 45 |
| Bortso | 10 | 10 | 20 |
| Lagvanta | 35 | 25 | 60 |
| Khideshlebi | 9 | 16 | 25 |
| Total | 131 | 148 | 279 |

As the Table shows, the villages of the community are very small. The population of these villages does not exceed tens of people. The age structure of the population is alarming; the share of people of a pensionable age is large (35%) and the share of children is very small (up to 10%). During the working meetings the population noted that in 2012 no child had been born in the community, while 13 people died. According to the local population the reason for this situation is that the only school in the community was closed 5 years ago and the local children have to go to the school of the neighboring community, which is rather inconvenient. Therefore, the families with children of a school age have to leave the community to ensure adequate education for their children.

The Sakao community has one more feature which is characteristic for the Racha region in general, a sharp seasonal variation in the population. Due to the hard natural, social and economic conditions the population leaves the community in winter and migrates to cities (Oni, Ambrolauri, Kutaisi, Tbilisi). In summer they return to the community and carry out agricultural activities until next winter. Many families that have permanently resettled from the community have retained houses and spend summers in the community. Therefore, only 100 households (up to 200 people) stay in the community during winter seasons. While in summer the population sharply increases and exceeds 279 (population of the community according to the statistical data).

An absolute majority of the local population is self-employed. The main source of their income is revenues from small private farms. At the working meetings the local community members stated that only 15 people have salaried work, not exceeding 10% of the able-bodied population.

According to the statistical data obtained during the working meetings with the local population 75 community members (about 30% of the local population) are below the poverty level, which is quite a high index.

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

## 3. Units of analysis of the Sakao 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 Sakao 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 Sakao community is discussed in the context of the Oni 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 Sakao community:

- Agriculture and agricultural lands – primarily pastures and haylands of the community, arable lands and perennials as the main source of income and food security of the community.
- Rivers flowing in the territory of the community – especially the Sakaura River (the right tributary of the Rioni River), the watershed of which coincides with the territory of the community, as well as the Rioni River – as the main source of natural hazards in the community.
- infrastructural facilities located in the territory of the community – including motor roads, bridges, drainage canals, drinking water supply infrastructure, residential houses, electricity transmission lines, etc.

Below are given a short descriptions of each components 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 Sakao community is 6,388 ha, including up to 181 ha of arable lands, 36 ha of perennials, 5,553 ha of pastures and haylands and 619 ha of abandoned and uncultivated lands. As a result of the land privatization process, each household owns 0.95 ha of agricultural lands, including pastures and haylands.

Corn and haricot are the main crops. The average productivity of corn is 2.0-2.5 tons per ha, the productivity of haricot is 600 kg per ha. The average productivity of potato is 6-10 tons per ha. From vegetables, tomato, onion, cabbage, beet, carrot, coriander, parsley are cultivated.

Perennials include vine, apple, peach and walnut plantations. High quality table and wine grapes do not grow under local climate conditions, therefore vine growing in the community is not commercial.

There is no irrigation system in the Sakao community. The amount of annual precipitation is sufficient for grain crops, fruit gardens and vineyards. Only in drought years would irrigation be required. However, according to the locals the majority of precipitation falls over a short period of time and periods of drought are common.

*Animal breeding*

Animal breeding is the leading agricultural activity in the Sakao community due to the shortage of arable lands and the short vegetation period. Currently there are 280 heads of cattle in the community. The local population is also engaged in rabbit breeding. There are up to 50 rabbits in the community. This is a relatively new direction in local agriculture involving more and more farmers.

Compared to the area of available pastures the number of livestock in the community is rather low due to the high migration level of the population. The area of pastures and haylands considerably exceeds the current amounts of livestock. As a result the potential of pastures is not fully used.

Chickens (around 400) constitute the major share of poultry. Other species are rare.

Beekeeping is also developed in the community. Currently there are 150 beehives. However the number of beekeepers is not large and only 8 household are engaged in commercial beekeeping. Mainly honey and wax candles are being produced.

Pig breeding is a traditional activity in the Sakao community and the Racha region is 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 Sakaura River and its general hydrological characteristics*

The Sakaura (Sakao) River takes its rise from a small spring flowing on the left slope of the Lechkhumi range, at an elevation of 2,940 m above sea level, and enters the Rioni River from its right side at the village Lagvanta.

The length of the river is 30 km, its total drop equals 2,121 m, average gradient – 77 ‰. The area of the watershed is 169 km$^2$. The mean elevation of the watershed is 2,000 m.

The river has 13 insignificant tributaries the total length of which is 45 km.

At the study section the average annual discharge of the river is 7.65 m$^3$/sec, maximum discharge of 1% probability - 170 m$^3$/sec.

Flood period starts from the beginning of April and lasts until the end of August/beginning of September and reaches its peak in May-June.

### 3.3 Infrastructure

*Water supply infrastructure*

The population of the community mainly uses spring water for drinking, however, some villages (the village Lagvanta) of the community suffer from water shortages.

The population receives drinking water through pipes connected to water collectors (the length of the system is about 13-14 km). According to the locals, the water collectors and part of water distribution system are in a satisfactory condition. The process of rehabilitation of the system is ongoing – the old iron pipes are being replaces by plastic ones. At the moment about 70% of the system is rehabilitated. According to information provided by the locals asbestos pipes, common in Soviet times, have been never used in the water supply infrastructure. Water is being supplied 24 hours a day.

There is no irrigation system in the Sakao community.

*Road and social infrastructure*

An 11 km long section of the main motor road (to the Sakao gorge – the village Lagvanta – the village Khideshlebi) crosses the territory of the community. This is the only road connecting the villages of the community to one another and the community to the outer world. The condition of the road (at the time of field studies) can be assessed as catastrophic. According to the locals these roads have never been in such a poor state before. The roads are impassable for light vehicles. According to the local governor the rehabilitation of the roads, covering these roads with pebbles, is planned. The condition of these roads is determined by the absence of drainage canals; as a result the roads are damaged by water. Covering the roads with pebbles is a temporary solution that will not ensure a long term solution to the problem. The condition of the roads complicates communication between the community and the outer world, and determines the high level of vulnerability of the community to natural disasters.

Access roads to agricultural lands (pastures-haylands) and the bridges on these roads are also in a bad condition. Due to this the local population is not able to fully use the existing pastures and haylands and therefore only a small part of the available pastures and haylands is loaded while the majority is not in use (used by tens of families in the past). Therefore both loaded (overgrazed) and unused (afforested) areas are being degraded.

There are 324 residential houses in the Sakao community (Sakao – 118, Bortso – 34, Lagvanta – 28, Khideshlebi – 84). These houses are mainly two-storied, where the first floor is built of stone and the second floor of wood.

The whole of Sakao community is provided with electricity. The electricity transmission system covers the whole territory of the community. The total length of transmission lines is 16 km. According to the locals the electricity transmission infrastructure (electricity transmission lines, poles) is in a good condition. The process of installation of individual electricity meters is complete.

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

There is no drainage system in the community. This creates a serious problem in the damage of the road infrastructure.

The community has got no sewerage system. The population uses simple latrines constructed themselves.

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

There are no infrastructure facilities posing a threat to the community.

*Medical service*

Medical services to community members are provided at the ambulatory located in the village Sakao. According to the locals the building of the ambulatory is in a satisfactory condition. 1 nurse works at the ambulatory. Periodically (once a week) a doctor from Oni visits the community to provide services. In emergency cases a first aid brigade comes from the city of Oni, with a call time of about 30 minutes.

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

***Table 2. Units of analysis identified in the Sakao community***

| Unit of analysis | Description/Importance |
|---|---|
| Agriculture/Agricultural lands | • Agriculture is the main source of income for the community<br>• Total area of agricultural lands is up to 6,500 ha.<br>• Main crops – corn, haricot<br>• Animal breeding is the main agricultural activity: 280 heads of cattle<br>• Rabbit growing – 50 rabbits<br>• beekeeping – 150 beehives |
| Hydrographical network | • The Sakaura River (right tributary of the Rioni River) is the main river of the community<br>• Drinking water is supplied mainly from springs<br>• No irrigation system<br>• The rivers of the community are the main source of hazards occurring in the community |
| Infrastructure | • The condition of the road infrastructure determined the degree of vulnerability of the community to natural disasters<br>• Road infrastructure (roads, bridges, drainage canals) determines the condition of agricultural lands (unused pastures/haylands)<br>• 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 Sakao community

The present chapter contains a brief description of problems and challenges faced by the Sakao community. Special emphasis is placed 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 Sakao community*

The agricultural sector of the Sakao 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. The local population uses manure to fertilize their lands, however, the existing practice of manure storage is inadequate due to the absence of and/or improperly organized manure storage facilities (Pic. 1). The current storage facilities do not ensure preservation of nutrient content in manure. Manure stored in this manner, or so-called fermented manure, is ineffective at increasing soil fertility.

The major part of the arable lands of the community is tilled using live pulling forces (mainly oxen), as only a small part of the arable lands can be tilled using machinery. This makes agriculture more time and labor intensive, 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.

**Pic. 1. The Sakao community. The existing practice of manure storage**

The process of degradation of pastures-haylands is one of the most important problems for the Sakao community. This process has two causes: 1. high level of migration leading to a reduction in the number of livestock in the community. The area of the available pastures-haylands is much more than is required by the existing livestock, therefore large areas are not used. In most cases this results in afforestation of valuable pastures and haylands. 2. Poor the condition of access road infrastructure (roads, bridges) forces people to use nearby agricultural areas that are already overgrazed. At the same time a larger part of pastures and haylands are not in use, leading to their degradation though afforestation. According to the locals around 60 ha of lands are already afforested due to this reason.

Problem's with pig breeding (the community's traditional agricultural activity) are mainly associated 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 diseases that can be treated with medication or vaccination are not taken. Non-vaccination is the primary 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 the death of non-vaccinated animals.

*River erosion*

Identification/survey of hazardous sites and sites exposed to risks as a result of floods and flash floods has been undertaken on the rivers of the Sakaura River basin and the areas adjacent to the Rioni River within the territory of the Sakao community. This identification/survey was carried out in accordance with the results of the 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 Sakaura River gorge and the Rioni River gorge, within the Sakao community, were investigated. Four hazardous sites were identified in the territory of village Lagvanta in the Sakao community.

The village Lagvanta is located at the confluence of the Sakaura River. The sides of the river are populated. Different types of bank protection structures (gabion toes and linear walls, berms built of boulders tied with thick wire, etc.) have been built there at different times (Pic. 2, 3).

**Pic. 2. The village Lagvanta. The Sakaura River. The toe of the gabion**

**Pic. 3. The village Lagvanta. The Sakaura River. Boulders tied with wire**

In most cases the parameters of the existing structures do not correspond to the design hydrological characteristics of the river – the gabion walls lack protection mattresses, at certain locations the structure is unfinished (Pic. 4), the laying of tied boulders is being destroyed due to subsurface erosion (Pic. 5) resulting in exposure of the eroded cliff bank, etc.

**Pic. 4. The village Lagvanta. The Sakaura River. Unfinished bank protection structure**

**Pic. 5. The village Lagvanta. The Sakaura River. Destroyed rockfill berm**

The width of the floodplain on the study site is 80 m, elevation – 0.3-0.4 m. The surface of the floodplain in not even, it is blocked with boulders and dumped rocks. During floods the 1.0 m high floodplain is completely covered with water. The width of the riverbed is 5-8 m, average depth – 0.5-0.6 m.

As has been already mentioned, 4 hazardous sites were identified during the field study.

**The first site** – is located 950 m away from the conjunction of the rivers Rioni and Sakaura (Pic. 6, 7). River erosion occurring at this site threatens the access routes to the bridge. The site urgently requires rehabilitation.

**Pic. 6, 7. The village Lagvanta. The Sakaura River, I hazardous site**

**The second site** – is located 560 m from the conjunction of the rivers Rioni and Sakaura (Pic. 8). Due to the low elevation of the floodplain terrace water entering the village and causing damage to houses, agricultural lands and utilities is expected during floods and flash floods. Large boulders stockpiled by the population on the river bank can be used to reinforce the bottom of the gabion wall.

**Pic. 8. The village Lagvanta. The Sakaura River, II hazardous site**

**The third site** – is located at the bridge located at the conjunction of the rivers Rioni and Sakaura, on the right side. A gabion wall has been constructed at this site to protect the residential house and the household plot, however, the wall cannot ensure protection of the area from floods due to its insufficient height. Therefore the residential house and the household plot are exposed to risk.

**The fourth site** - the local community plans to build a church on the territory of the cemetery, located on the left side of the bridge at the conjunction of rivers. This part of the river bank is periodically covered with water and undergoes scouring. Due to this, the church has not yet been built. The cemetery is also exposed to risk. Therefore the population want to protect this section of the river bank from floods and scouring.

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 locals recall the events of 1987 when all bridges over the Sakaura River, as well as roads and agricultural lands (arable lands, pastures) were damaged. The most severe damage from flash floods is reported in the village Lagvanta, located at the lowest altitude where residential houses, household plots, agricultural lands and infrastructural facilities (roads, bridges, electricity wiring, et.) are threatened.

*Denudational processes*

**The village Khideshlebi**

The village Khideshlebi is located on the south facing landslip slope of the Sakaura River. Some active areas are recorded on the slope. The study area is built of sandstone and clay shale of the upper Sori sublayer of the Aalenian layer ($J_2S_2$), of the Middle Jurassic age and is covered by Quaternary delluvial loamy soils. The crest of the landslide is curved. Its surface is characterized by a wavy-hilly relief with landslip steps and gullies. Its gradient varies between 30-60$^0$. Subsurface water outlets are recorded on its surface. An active landslide body covers the lower part of the slope and is based on the Sakaura Riverbed. Ground masses slip on the contact surface between clay shale and delluvial loamy soils. The landslide body is about 350 m long and 400-450 m wide.

Residential houses and household plots of the population are located on the above-mentioned slope and affects 9 households (Makvala Khidesheli, Suliko Kapianidze, Mikheil Khidesheli, Gocha Khidesheli, Givi Khidesheli, Ruslan Khidesheli, Ilo Khidesheli, Tamar (Chikviladze) Khidesheli and Tamar Khidesheli).

Earthquakes that occurred in recent years have contributed to the damage of residential houses along with landslides. Streams flowing from the slopes also scour the foundations of the residential houses already damaged by earthquakes. These processes further accelerate damage to the houses and widen the existing cracks.

A number of outlets for subsurface waters were recorded in the yard of the house of Makvala Khidesheli (X-369448; Y-4723847). An activated landslide body has split the household plot, damaged perennials and made the majority of it useless for agriculture (coordinates - X-369427; Y-4723919 and X-369436; Y-4723895 – Pic. 9, 10, 11, 12). A similar picture is observed in the plots of nearby households mentioned above. Secondary landslides observed within the large landslide body are regressive and approach the residential houses. Although signs of new deformations have not yet been observed under the houses, regular monitoring is required. Acceleration of the landslide body will further damage the houses and make them inhabitable.

**Pic. 9, 10, 11, 12. The village Khideshlebi. the Landslide body**

The residential houses of Tamar (Chikviladze) Khidesheli (coordinates - X-370201; Y-4723191) and Tamar Khidesheli (coordinates - X-370239; Y-4723156 and X-370274; Y-4723159) located on the active landslip site have been damaged as a result of earthquakes and are now unfit for habitation.

**Pic. 13, 14. The village Khideshlebi. Residential houses damaged as a result of landslide activity**

Based on this it can be concluded that the landslide body developed in the mentioned populated area is large and complicated and substantial measures at this site will be costly and difficult to implement.

The process threatens residential houses, household plots, agricultural lands and utility lines. In case of its acceleration the landslide process will block the Sakao riverbed and pose a risk of large-scale natural disasters to the downstream villages.

**Sakao-Mazhieti motor road**

A landslide process is observed on the Sakao-Mazhieti motor road on the south-east faced landslip slope (coordinates - X-371669; Y-4720958 and X-371607; Y-4720968). The landslide body is dissected by gullies developed by seasonal flows. The relief is gullied and stepped, hilly and cracked. The study area is built of Jurassic ($J_2$) sandstone and clay shale covered by delluvial loamy rocks with shingle and cobble aggregates. Outlets of subsurface waters in the form of springs and seeps are recoded on the surface. The landslide is circue shaped. The thickness of the circue is 3-4 m. The length of the landslide is 250 m, width – 100 m, area – 0.02 km$^2$. Delluvial formations slide over Liassic sandstones of the Middle Jurassic ($J_2$) period. The landslide process is triggered by the steepness of the slope, scouring of the bottom of the slope (left bank) by the Sakaura River and the saturation of rocks with excessive precipitation (Pic. 15, 16, 17, 18).




**Pic. 15, 16, 17, 18. Landslide process at Sakao-Mazhieti motor road**

The process damages the motor road. Often the road becomes impassable.

**Lagvanta-Sakao motor road**

A landslide developed along the Lagvanta-Sakao motor road, on the left bank of the Sakaura River, covers the south-west faced erosion-denudational landslip slope (with an average gradient of 35-$40^0$), and is characterized by hilly-wavy relief and located on the left bank of the Didruskhevi River, a left tributary of the Sakaura River near the St-George Chapel (coordinates - X-372877; Y-4720367. X-372900; Y-4720357 and X-372921; Y-4720339 – Pic. 19, 20, 21, 22). Its relief is stepped, hilly and gullied. The landslide slope is built of Aalenian and Bajocian sandstone, clay shale and tuff-breccia layers of the Middle Jurassic Period ($J_2$) covered by loamy rocks with shingle and pebble aggregates of different thickness. The landslide body covers the middle and lower parts of the slope and is based on the Sakaura Riverbed. Many outlets of subsurface waters are recorded on the surface of the slope. According to the local community members a landslide occurred in 1940 at this site, blocked the Sakaura Riverbed and created a lake. Steep landslide steps are developed on the hilly relief of the dynamic landslip slope. Curved landslip steps of a secondary genesis are recorded in the large landslide body. The landslide body reaches the Sakaura Riverbed, where its tongue undergoes intensive scouring. This is a coastal landslide. The length of the landslide is 1,000 m, width – 450 m, area – 47.2 $ha^2$. The landslide was triggered by the impact of groundwater on the quaternary layers, steepness of the slope, weakened physical-mechanical characteristics of the rocks and erosive activity of the Sakaura River.

**Pic. 19, 20, 21, 22. Landslide process at the Lagvanta-Sakao road**

The mentioned process threatens the utility systems of the community. If the riverbed is blocked by landslides (as happened in 1940), the development of strong mudflows is expected. This process will threaten not only the downstream villages of the Sakaura community (the village Lagvanta) but also the whole Oni municipality. At the working meeting local community members recalled that during a similar natural event that occurred in 1940 the authorities had to evacuate the population from Oni.

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

***Table 3. Problems identified in the Sakao 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 soil productivity. | • Agriculture / agricultural lands |
| Degraded (afforested) agricultural lands – pastures. Small number of livestock and poor state of access roads to agricultural lands. | • Agriculture / agricultural lands |
| Pig breeding – improper practice of management | • Agriculture |

| Identified problems/impacts | Corresponding units of analysis |
|---|---|
| leading to deaths of animals, degradation of the traditional activity and reduction of incomes from agriculture. | |
| Floods and flash waters occurring as a result of river bank erosion cause serious damages to the community. | • Agricultural lands<br>• Hydrographic network<br>• Infrastructure – (residential houses, household plots, motor roads, electricity transmission lines, cemetery, etc.) |
| Landslide processes cause damages to the community. Blocking of the riverbed leading to large-scale disasters is expected. | • Agricultural lands<br>• Hydrographic network<br>• Residential houses and household plots<br>• Infrastructure - (motor roads, electricity transmission lines, etc.) |

## 5. Climate change and its consequences

After identification of the existing challenges in the community trends in climate change were identified to determine the potential direct impacts of climate change in terms of emerging new challenges and 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, etc.). | • Increased vulnerability of agricultural crops to climate change<br>• Changed agricultural calendar<br>• Decreased incomes from agriculture | • Agriculture / agricultural lands |
| Increase of precipitation (annual precipitation, duration of humid periods, daily precipitation – intensive rainfall).<br>Increase of the probability of extreme precipitation events – increase in number of days when daily precipitation exceeds 10, 20, 50 and 90 mm.<br>Increase of the number of cases when precipitation exceeds mean annual precipitation by 200 mm and more. | • Increase of annual discharge of the Rioni river and its tributaries<br>• Expected increase in frequency and intensity of floods, especially flash waters and increase of the associated risks of inundation of riverside areas and acceleration of erosion processes<br>• Increase of the risk of mudflow occurrence and their intensity<br>• The areas already prone to floods, flash waters and landslide will face increased risks<br>• Increased vulnerability of agricultural crops to climate change<br>• Accelerated degradation of agricultural lands<br>• Decreased incomes from agriculture | • Agricultural lands<br>• Hydrographic network<br>• Infrastructure – residential houses, household plots, drinking water supply system, motor roads, electricity transmission lines, engineering and structures and utilities, etc.) |
| Decrease in wind speed. | • Reduced wind erosion<br>• Reduced soil degradation | • Agriculture / agricultural lands |
| Reduction in vegetation period. | • Increased vulnerability of agricultural crops to climate change<br>• Changed agricultural calendar<br>• 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 Sakao community

At this stage 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 the results of experts' work and participatory working meetings with the local population.

*Impacts on agriculture*

Climate change scenarios predict an increase in mean annual precipitation by 124-172 mm. Precipitation will increase mainly in winter, however certain increases will also be observed in spring and summer. In that case of such a change in precipitation distribution the vegetation period will be better provided with water between 2020 and 2050. However, the change in temperature regime should also be taken into account. Mean annual temperature will increase by 1.2-1.4$^{0}$C, in summer this index will reach 1.4-1.8$^{0}$C. At the same time, an increase in the number of tropical nights and hot days in summer will increase demands on irrigation water.

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

*Negative natural phenomena*

Analysis of the existing situation shows that the Sakao 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 flash floods.

Strong landslide hotspots existing in the territory of the community cause serious damage to the residential houses and agricultural lands of the local population and utilities. These landslides have the potential to develop into mudflows, which pose a serious risk of large-scale natural disasters not only to the Sakao community, but also to the whole Oni municipality. The scale and nature of natural processes are described in detail in Chapter 4.

According to the existing climate change scenarios increased occurrence and intensity of floods and flash floods are expected due to increased precipitation. These processes will also lead to the acceleration of river erosion.

Moreover, the forecasted changes in amounts and distribution of rainfall will lead to increased risks of the development of landslide processes which are already a critical problem for the community.

Therefore, damages caused by negative natural phenomena to the Sakao community will presumably increase. The areas currently being threatened by these hazards will be most affected.

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

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

***Table 5. Combined impacts identified in the Sakao 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. Acceleration of landslide processes is expected too. | • Agricultural lands<br>• Hydrographic network<br>• Infrastructure |
| Acceleration of landslide processes will result in increased damages of agricultural lands, especially residential houses and utilities. Increased risks of catastrophic mudflows in downstream areas. | • Agricultural lands<br>• Hydrographic network<br>• Residential houses<br>• Infrastructure |

## 7. Adaptation and disaster risk reduction activities

The final stage of the selected methodology of 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 set of activities for each impact identified for the Sakao community have been selected in close cooperation with the experts of relevant fields.

*Agriculture*

As has been already mentioned, the main impact of climate change on agriculture in the Sakao 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 Sakao 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 Sakao 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.

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 Sakao 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 Sakao community. To increase the productivity of cattle improvement in the local breeding stock is required, which will enable a doubling of milk yields. 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. To prepare silage and other nourishing hay, alfalfa and barley have to be sown on unused plots.

The Small quantity of livestock in the Sakao community is determined by the high rate of migration. The area of available pastures and haylands considerably exceeds the current amounts of livestock. Actually the potential of pastures is not fully used. In most cases this leads to afforestation of valuable pastures and haylands. For proper management of pastures and maintenance of their fertility livestock should be evenly distributed on pastures to avoid overgrazing. Usually, livestock grazes on nearby easily accessible areas, therefore owners/herdsmen should relocate herds to unused areas. Livestock can be attracted with rock-salt.

***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 Sakao 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.).

***8** Biological resources*

Organized collection of wild plant products such as different mushrooms and berries, codling, chestnut, medicinal herbs, etc. in accordance with the standards pertinent to organic agriculture and processing (e.g. juice, dry fruits) (if needed) can be developed in the Sakao 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 studies.

**The first site –** river erosion occurring at this site threatens access routes to the bridge. To protect the river bank from erosion a 60 m long gabion should be constructed from the left abutment downstream. A gabion should also be built on the right bank – 20 m upstream from the right abutment. The estimated volume of the gabion is 390 $m^3$.

The estimated cost of construction-assembling works is 62,000 GEL.

**The second site** – intrusion of water masses into the village causing damage of houses, agricultural lands and utilities is expected during floods and flash floods. To solve the problem the bottom of the existing gabion wall should be reinforced (large boulders stockpiled by the population on the river bank can be used for this purpose).

Construction of a new gabion is also required. The new structure should start from the existing gabion wall. Its length should be 60 m. The estimated volume of the gabion is 300 $m^3$.

The estimated cost of construction-assembling works is 48,000 GEL.

**The third site** – the parameters (height) of the existing gabion wall cannot ensure the protection of the area (residential house, household plots) from floods. To solve the problem an additional layer (1.0 m high) of gabion boxes should be added to the existing structure. The estimated volume of the gabion is 50 $m^3$.

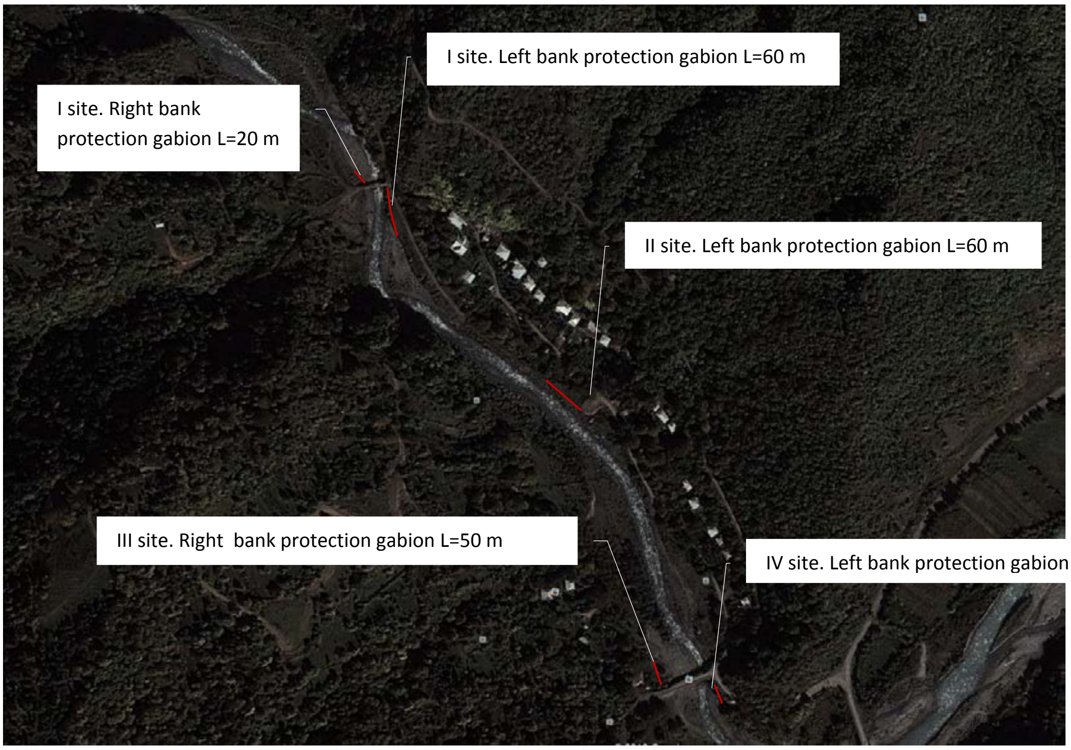
The estimated cost of construction-assembling works is 8,000 GEL.

**The fourth site** - erosion occurring at this site threatens the cemetery of the village Lagvanta. At the working meetings local community members stated that they had planned to build a church on the territory of the cemetery but canceled the plans due to erosion process and the risk of floods and flash floods.

To solve the problem and protect the area a 20-30 m long gabion should be constructed. The estimated volume of the gabion is 150 $m^3$.

The estimated cost of construction-assembling works is 24,000 GEL.

Picture 23 shows hazardous sites in village Lagvanta, identified during the field study carried out at the Sakaura River and proposed locations for the implementation of bank protection activities.




**Pic. 23. The village Lagvanta. Proposed locations for implementation of bank protection activities**

**Denudational processes**

*Village Khideshlebi*

As has been already mentioned (in Chapter 4), the main problem for the village Khideshlebi is landslide processes that cause damage to the local population's infrastructure (residential houses, household plots and agricultural lands). Two different landslide sites are distinguished in the village due to their complexity of their nature.

The first site covers the left, south facing slope of the Sakaura River, where residential houses and household plots of the local population area located (Makvala Khidesheli, Suliko Kapianidze, Mikheil Khidesheli, Gocha Khidesheli, Givi Khidesheli, Ruslan Khidesheli, Ilo Khidesheli, Tamar (Chikviladze) Khidesheli and Tamar Khidesheli – 9 households) – coordinates - X-369448; Y-4723847, X-369427; Y-4723919, X-369436; Y-4723895.

Activation of the landslide at this site will further damage the residential houses and make them uninhabitable. To mitigate the process and extend the service life of these houses implementation of temporary measures is recommended. Specifically, drainage systems have to be built in the yards of the mentioned households to collect groundwater and direct it to the nearest natural water courses through drainage canals. Reinforcement and waterproofing of the foundations of the residential houses will also be required. The houses have to be rehabilitated considering the degree of their damage.

The residential houses of Tamar (Chikviladze) Khidesheli and Tamar Khidesheli (coordinates - X-370201; Y-4723191 and 1. X-370239; Y-4723156. 2. X-370274; Y-4723159 accordingly) belong to the second site located on a dynamic landslide body. These houses have been severely damaged by earthquakes and landslides and are unfit for habitation. Results of the detailed field observations show that no mitigation measures can be applied in this case and these households have to be resettled to geologically stable areas.

Based on this it can be concluded that the landslide body developed in the mentioned populated area is large and complicated and any substantial measures on this site will be costly and difficult to implement. The recommended measures are temporary, and do not solve the problem in the long run.

*Sakao-Mazhieti motor road*

Landslide processes developed on the Sakao-Mazhieti motor road, on the south-east facing landslip slope (coordinates - X-371669; Y-4720958 and X-371607; Y-4720968), damages the motor road resulting in frequent interruptions in transportation.

Due to the large scale and diversity of landslide process, as well as the high sensitivity of the rocks in the area, implementation of any major protection measures at this section of this road is not deemed appropriate. Permanent monitoring of the landslide body and periodical cleaning of the road from landslide masses are recommended.

*Lagvanta-Sakao motor road*

The landslide body is located on the left bank of the Didruskhevi River – a left tributary of the Sakaura River near the Saint George Chapel (coordinates - X-372877; Y-4720367. X-372900; Y-4720357 and X-372921; Y-4720339).

Steep landslide steps have developed on the hilly relief of the dynamic landslip slope. Curved landslip steps of a secondary genesis are recorded in the large landslide body. The landslide body reaches the Sakaura riverbed. The mentioned process threatens the utility systems of the community. There is also a risk of blocking of the riverbed by landslides, which may lead to a large-scale natural disaster posing a threat not only to the Sakao community but also to the whole of Oni municipality (as happened in 1940).

Due to the existing situation, construction is not recommended at this site.

To suspend the process in the short term, surface and ground waters have to be regulated and directed to the existing water courses, forest cover should also be rehabilitated. However, due to the large scale and diversity of the landslide process and the sensitivity of main rocks of the area, implementation of any major protection measures at this section of the road is not deemed appropriate. Permanent monitoring of the process and establishment of early warning systems is important to prevent the worst case scenario of the processes development.

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

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

| **Activity** | **Aim** | **Estimated budget** | **Duration[6] (ST; MT; LT)** | **Responsible institution** | **Potential Source of Funding** |
|---|---|---|---|---|---|
| Global aim of the activities:<br>• Adaptation and increase the resilience of agriculture of the Sakao community to climate change and natural disasters<br>• 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<br>• Increase of the moisture content and retention capacity of soils<br>• Increase of soil fertility<br>• Increase of the content of organic substances in soils | < 50,000 | **ST** | • Local farmers<br>• Agricultural development services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• 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<br>• Increase of the content of organic substances in soils<br>• Increase of the moisture content and retention capacity of soils | < 50,000 | **ST** | • Local farmers<br>• Agricultural development services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• NGOs |

[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 |
|---|---|---|---|---|---|
| Introduction of the practice of mulching on agricultural lands, under perennials and annual crops. Application of both dead mulch and cover plants. Combination of dead mulch and cover crops. Education and awareness-raising of farmers on mulching. | • Increase of the productivity of perennials<br>• Retention of moisture in soils<br>• Improvement of soil structure<br>• Accumulation of biological nitrogen in soils<br>• Protection of soils from erosion<br>• Ensuring additional forage basis for animal breeding | < 50,000 | **ST** | • Local farmers<br>• Agricultural development services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• 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<br>• Regulation of surface runoff<br>• Abatement of soil erosion/reduction of the loss of topsoil<br>• Increase of soil fertility<br>• Reduction of vulnerability of soils to extreme precipitation events | < 50,000 | **MT** | • Local farmers<br>• Agricultural development services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• 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<br>• Regulation of surface runoff<br>• Abatement of soil erosion/reduction of the loss of topsoil | < 50,000 | **MT** | • Local farmers<br>• Agricultural development services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• NGOs |

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

| Activity | Aim | Estimated budget | Duration[6] (ST; MT; LT) | Responsible institution | Potential Source of Funding |
|---|---|---|---|---|---|
| Development of pig breeding:<br>• Observation of health care and sanitary-hygienic rules in animal breeding<br>• Regular implementation of necessary preventive measures including vaccination<br>• Awareness raising of the population on practices of sustainable use of pastures | • Development of traditional pig breeding in the community<br>• Increase of incomes from animal breeding | < 50,000 | **ST** | • Local farmers<br>• Agricultural development services<br>• Veterinary services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• 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<br>• Increase of the productivity of agricultural crops through increased pollination | < 50,000 | **ST** | • Local farmers<br>• Agricultural development services<br>• Local self-governance | • Local farmers<br>• Agricultural development service<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| Global aim of the activities:<br>• Mitigation of hazards faced by the Sakao community and reduction its vulnerability to natural disasters and climate change<br>• Reduction of risks of natural disasters in the Sakao community<br>• Adaptation to climate change | | | | | |
| I site (chapter 7 – river erosion) – construction of protection gabions at the bridge over the Sakao river on the right and left banks (60 m | • Abatement of river erosion<br>• Reduction of the risk of floods and flash waters | 40,000 | **MT** | • Municipal government<br>• National Environmental Agency | • Local budget<br>• State budget<br>• Development agencies |

| Activity | Aim | Estimated budget | Duration[6] (ST; MT; LT) | Responsible institution | Potential Source of Funding |
|---|---|---|---|---|---|
| and 20 m long accordingly).<br>Total volume - 390 $m^3$ | • Protection of the bridge | | | • Ministry of Regional Development and Infrastructure | (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| II site (chapter 7 – river erosion) – reinforcement of the bottom of the existing protection wall at the Sakao river. Construction of an additional 60 m long gabion.<br>Total volume - 300 $m^3$ | • Abatement of river erosion<br>• Reduction of the risk of floods and flash waters<br>• Protection of residential houses and household plots<br>• Protection of infrastructure and agricultural lands of the community | 30,000 | **MT** | • Local self-governance<br>• Municipal government<br>• National Environmental Agency<br>• Ministry of Regional Development and Infrastructure | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| III site (chapter 7 – river erosion) – adding a layer (1 m high) of gabion boxes on the existing protection structure.<br>Total volume - 50 $m^3$ | • Abatement of river erosion<br>• Reduction of the risk of floods and flash waters<br>• Protection of residential houses and household plots<br>• Protection of infrastructure and agricultural lands of the community | 5,000 | **MT** | • Local self-governance<br>• Municipal government<br>• National Environmental Agency<br>• Ministry of Regional Development and Infrastructure | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| IV site (chapter 7 – river erosion) – construction of a 20-30 m long protection gabion.<br>Total volume - 150 $m^3$ | • Abatement of river erosion<br>• Reduction of the risk of floods and flash waters<br>• Protection of the cemetery of | 15,000 | **MT** | • Local self-governance<br>• Municipal government<br>• National Environmental Agency | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, |

| Activity | Aim | Estimated budget | Duration[6] (ST; MT; LT) | Responsible institution | Potential Source of Funding |
|---|---|---|---|---|---|
| | the village Lagvanta<br>• Protection of infrastructure lands of the community | | | • Ministry of Regional Development and Infrastructure | Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| The village Khideshlebi. Implementation of erosion control measures in residential area (coordinates X-369448; Y-4723847, X-369427; Y-4723919, X-369436; Y-4723895 – chapter 7 – Denudational processes):<br>• Construction of a drainage system<br>• Channeling water collected by drainage systems into natural water courses through drainage pipes<br>• Reinforcement of foundations of residential houses<br>• Waterproofing of foundations of residential houses<br>• Rehabilitation of damaged residential houses | • Protection of the population from landslides<br>• Protection of residential houses and agricultural lands from landslides<br>• Stabilization of the existing landslide body (within the indicated coordinates)<br>• Protection of utilities from damage | 50,000 – 100,000 | **MT** | • Local self-governance<br>• Municipal government<br>• Regional government<br>• National Environmental Agency<br>• Ministry of Regional Development and Infrastructure | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| Resettlement of 2 households (Tamar (Chikviladze) Khidesheli and Tamar Khidesheli) (coordinates - X-370201; Y-4723191 and 1. X-370239; Y-4723156. 2. X-370274; Y-4723159) to other geologically stable site suitable for habitation. | • Protection of the population from landslides<br>• Reduction of the vulnerability to natural disasters | < 50,000 | **ST** | • Local self-governance<br>• Municipal government<br>• Regional government<br>• National Environmental Agency<br>• Ministry of Regional Development and | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |

| Activity | Aim | Estimated budget | Duration[6] (ST; MT; LT) | Responsible institution | Potential Source of Funding |
|---|---|---|---|---|---|
| | | | | Infrastructure | |
| Implementation of landslide control measures at Sakao-Mazhieti motor road (coordinates - X-371669; Y-4720958 and X-371607; Y-4720968):<br>• Permanent monitoring of landslide processes<br>• Periodical cleaning of road from landslide masses. | • Protection of utilities from landslide processes<br>• Ensuring uninterruptible communications between the villages<br>• Reduction of the vulnerability of the community to natural disasters | < 50,000 | **MT** | • Local self-governance<br>• Municipal government<br>• Regional government<br>• National Environmental Agency<br>• Ministry of Regional Development and Infrastructure | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |
| Implementation of landslide control measures at Lagvanta-Sakao motor road (coordinates - X-372877; Y-4720367. X-372900; Y-4720357 and X-372921; Y-4720339):<br>• Regulation of surface and ground waters and their channeling to natural surface water courses<br>• Rehabilitation of forest cover on the landslide body<br>• Periodical cleaning of road from landslide masses<br>• Permanent monitoring of the process and establishing an early warning system<br>• Development of efficient natural disaster response plans for the community and the | • Protection of utilities from landslide processes<br>• Reduction of the vulnerability of the community to natural disasters<br>• Ensuring uninterruptible communications between the community and outer world<br>• Reduction of risks of natural disasters in Oni municipality | 50,000 – 100,000 | **MT** | • Local self-governance<br>• Municipal government<br>• Regional government<br>• National Environmental Agency<br>• Ministry of Regional Development and Infrastructure | • Local budget<br>• State budget<br>• Development agencies (USAID, UNDP, EU, Dutch government, GIZ, Sida, etc.)<br>• NGOs |

| Activity | Aim | Estimated budget | Duration[6] (ST; MT; LT) | Responsible institution | Potential Source of Funding |
|---|---|---|---|---|---|
| municipality and training of rescue services in implementation of measures considered in the plans | | | | | |

## Global Water for Sustainability Program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