# Assessment of Natural Disasters and Climate Change for Lower Rioni Pilot Watershed Area, Plan of Mitigation & Adaptation Measures

Republic of Georgia

Technical Report No. 20

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## Contents

## Abbreviations and Acronyms

| | |
|---|---|
| ACF International | Action Against Hunger |
| ADB | Asian Development Bank |
| CENN | Caucasus Environmental NGO Network |
| $CO_2$ | Carbon dioxide |
| EBRD | European Bank for Reconstruction and Development |
| ECHAM4 | Atmospheric General Circulation Model Developed at the Max Planck Institute for Meteorology |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations |
| FIU | Florida International University |
| GHG | Greenhouse Gases |
| GIS | Geographical Information System |
| GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit, GmbH (German Society for International Cooperation, Ltd.) |
| GLOWS | Global Water for Sustainability |
| GPS | Global Positioning System |
| ha | Hectare |
| HadCM3 | Hadley Centre Coupled Climate Model |
| INRMW | Integrated Natural Resources Management in Watersheds of Georgia |
| IPCC | Intergovernmental Panel on Climate Change |
| KfW | Kreditanstalt Für Wiederaufbau (German Development Bank) |
| km | Kilometer |
| $km^2$ | Square Kilometer |
| m | Meter |
| $m^2$ | Square Meter |
| $m^3$ | Cubic Meter |
| mm | Millimeter |
| NEA | National Environmental Agency |

| | |
|---|---|
| NGO | Non-governmental organization |
| PRECIS | Providing REgional Climates for Impacts Studies |
| ROFIU-GE | Representative Office of FIU in Georgia |
| Sida | Swedish International Development Cooperation Agency |
| SPI | Standardized Precipitation Index |
| t | tons |
| UNDP | United Nations Development Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNESCO-IHE | UNESCO Institute for Water Education |
| USAID | United States Agency for International Development |
| USD | United States Dollar |
| WB | World Bank |
| WI | Winrock International |

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## Methodology of Research

In the presented report, the methodological approach for issues of expected climate change adaptation and natural disaster risk reduction implies the analysis of the risks of natural disaster processes (landslide-mudflow processes, floods, droughts, etc.) and their adaptation measures on the pre-selected areas. The analysis considers the current climate (1996-2006 baseline period) and the expected changes between 2020 and 2050.

For the assessment of hazards caused by climate change, high-precision, forecasting climate models and development of corresponding scenarios for climate change are required. This would make possible to forecast the probability of extreme phenomena (maximum temperatures, droughts, abundant precipitation, floods, etc.).

The climate change scenario (which was used to analyze expected changes in the meteorological elements on the target territories between 2020-2050 presented in this report) was processed using the PRECIS regional model. This model used the ECHAM4 global model and the A2 and B2 scenarios of worldwide socio-economic development. The PRECIS regional model was calibrated on the territories of the municipalities presented in this report, using the results of actual meteorological observations during the baseline. This was the methodology for developing the scenarios of the modeled climate parameter (air temperature, atmospheric precipitation, wind, etc.) changes for the years 2020-2050 for the municipalities presented in this report.

Using the aforementioned scenarios within the target areas, taking into account the changes in climate between 2020-2050, the probability of occurrence of natural disaster processes has been estimated (mudflow, landslide, floods, droughts, uncomfortable temperatures), as well as their frequency and magnitude. In order to understand the probable future effect of climate change on target areas, it became necessary to prepare a short description of the components of the physical-geographic and socio-economic environment of these areas. Thus, the report briefly describes the geological composition, geo-morphological peculiarities, natural processes, soils, plant cover, and main fields of local economies for the target municipalities. Based on these components of expected climate change effect analysis, main problems and adaptation measures have been identified.

### Risk Assessment

Risk assessment is a process which defines the qualities of the risk and its type and is based on the combination of technical characteristics of hazards, population vulnerability and their exposure to risks. Therefore, disaster risk can be conceptually presented in the following way:

Disaster risk = hazard * vulnerability * quantity of elements exposed to the risk

When analyzing risks, three main components are usually identified:

- Hazard;
- Vulnerability and
- Elements exposed to the risk, which have spatial, as well as non-spatial characteristics.

Hazards are characterized by their temporal probability and intensivity, which derives from a frequency/magnitude analysis. In the formula, the hazard component relates to the probability of occurrence of hazardous processes in the concrete time period (baseline). During analysis, different types of hazards will be taken into account: floods, mudflows, erosion caused by rivers, landslides, rockfalls. For hazards assessment, the historical information about the occurred/recorded disasters and the scale of different disasters was used, as well as the information gathered by the fieldwork team within the scope of program. During the fieldwork, the natural hazards in the target areas were identified in detail using participatory methods. Subsequently, the spatial probability was calculated. The eventually used hazard information was based on the data of the recorded natural disasters.

To calculate the social, physical, ecological and economic vulnerability, a qualitative-spatial multi-criteria assessment technology was used. The following characteristics of the target areas were assessed: the demographic situation of the population, infrastructure, communications, economic and social characteristics of the community, ecological conditions of the target areas, and ability to respond to natural disasters. Finally, the vulnerability result was formalized and the extent of vulnerability was quantified on a scale from 0 to 100.

At the last stage of assessment, for all types of hazards (high, moderate, low) and taking into account the vulnerability of the elements exposed to risk, risk assessment was conducted based on the spatial analysis. Risks were defined on a scale from 0 to 1.

Additionally, we would like to mention that the fieldwork conducted within the scope of the program, included every community of the target river basins. Besides the vulnerability assessment, the field visits entailed first-hand inspection of territories containing the hazards, taking GPS coordinates and photo documentation.

**Greenhouse Gas Emissions**

This greenhouse gas (GHG) emissions study aims to identify the transport, agricultural, industrial, waste, and stationary GHG emissions emitted by target municipalities over two watersheds of Georgia, Roni and Alazani-Iori. These GHG emission estimations will be used to develop municipality-specific recommendations and action plans to reduce GHG emissions. Although the study focuses on data that relates to factors that can be impacted by local government, such as municipal and public buildings and transport means, a baseline study will also be completed for each municipality.

The methodology of the study was developed primarily using Intergovernmental Panel on Climate Change (IPCC) 2006 and 1996 Tier 1 methodologies for estimating national GHG emissions. Due to the unavailability of some data, the baseline results of this study entail some degree of uncertainty.

## Introduction

The present report was developed within the framework of the program “Integrated Management of Natural Resources in Watersheds of Georgia” (INRMW), implemented by a group of the following partners:

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

The geography of the program covers watersheds of Georgia: the Rioni River basin in West Georgia, and the Lori 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 areas - Municipalities of Khobi and Senaki.
- Upper Alazani pilot watershed area – Municipalities of Akhmeta and Telavi;
- Lower Alazani-Iori pilot watershed area – Municipality of Dedoplistskaro.

Within the framework of the program, it’s envisaged to assess the pilot watershed areas/municipalities with respect to their vulnerability to climate change and natural disasters; also, to develop a plan of corresponding mitigation and adaptation measures.

The present report reflects the assessment of the vulnerability of the Lower Rioni pilot watershed area to climate change and natural disasters. It should be noted that the INRMW Program targets the Lower Rioni pilot watershed area that includes the entire Senaki Municipality and four communities of the Khobi Municipality located on the banks of the Rioni River. Within the framework of the program, it’s envisaged to assess the pilot municipalities in respect of their vulnerability to climate change and natural disasters. On the basis of the assessment an action plan for corresponding adaptation and mitigation measures to climate changes and natural disasters is also presented.

# 1. General Characterization

## *1.1 General Information*

### Location

The targeted lower course of the Rioni River basin that includes the entire Senaki Municipality and four communities of Khobi Municipality on the banks of the Rioni River is located at 2,600 m. above sea level and comprises a central part of the Odishi Lowland in the lower part of the Tsivi and the Tekhura River watersheds and floodplains alongside the both banks of Rioni River. The territory of Senaki MunicipalityMunicipality consists of a line of hilly plain located at the north edge of Odishi Lowland which stretches up to 14,150 m. above sea level. From the north a line of the hilly plain is bordered by a belt of low mountains that is divided into the Eki Mountain (461 m) and the Nokalakevi Mountain Massifs (391 m) by the Tsivi River and Tekhura River gorges.

### Relief

The surface of the Odishi Lowland in the borders of the target areas of Senaki and Khobi Municipalities is constructed by Holocene age alluvial, alluvial-prolluvial, alluvial-swampy sands, silts, clays, grains and pebbles. Miocene, Pliocene and Pleistocene-age sandstones, marls, clays and alluvial-prolluvial sediments participate in constitution of the hilly plain. The Eki Mountain and Nokalakevi Mountain Massifs are composed of Cretaceous period and paleogyne limestones, marls, gypsum clays, etc.

The relief of the Odishi Lowland in targeted territories of the borders of Senaki and Khobi municipalities is moderately monotonous. From here to there the lowland surface becomes differentiated with small-scale hollows with small riverbeds and along the Rioni River it is covered by so called ex-Rioni beds, that the Rioni River left in past. In the border of hilly plain that is erosive-accumulative relief with terrace-like river gorges and wavy plain-hilly watersheds among them, this is advantageously developed there. On the slopes of the low mountains in the North part of Senaki Municipality erosive relief is more widespread and is represented mostly by river gorges. At the same area, where limestone is very common, superficial and underground carstic shapes, such as caves, carstic mines, etc., are intensively developed. Quite a deep canyon-like gorge developed where the Tekhura River crosses Mount Nokalakevi is also noteworthy.

### Hazardous Natural Disasters

The moderately uncomplicated relief of the lower Rioni River basin, quite humid climate and rivers develop risks of intensive river erosions, powerful (frequently disastrous) floods, freshets and partial landslide processes. It should be mentioned that in spite of frequent atmospheric precipitation and 24-hour heavy rains, in terms of less energetic relief, this territory suffers less intensive areal (flat) erosion. According to the General Anti-Erosion Scheme of Georgia, at the begining of the 20th century only 400 ha (out of total 9.1 thousand ha) agricultural lands of Senaki Municipality were under the areal erosion risk zone. Besides, for the beginning of the 2first century, 31 landslide districts, 1 mudflow- transforming drains, exposures of river bank erosion on 14 km and floods on 1,500 ha river bank territories were reported in the borders of Senaki Municipality. Landslide processes are developed on the slopes of low mountains in the north part of the Municipality. Riverbank territories are usually flooded along the lower courses of the Rioni and partially along the Tekhura Rivers.

As for the targeted territory of Khobi Municipality powerful (rarely catastrophic) floods and freshets should be distinguished from dangerous natural disasters. Damage scales in Odishi Lowland (most of which is in Khobi Municipality) caused by the Rioni and Khobistskali Rivers, are well reported and proved with appropriate facts. During last 100-120 years a part of Odishi Lowland located in Khobi Municipality experienced flooding several times (1895, 1922, 1983, 1987, 1996) caused by the abovementioned rivers that damaged significantly the local population, agricultural industry, insfrastructural units and others. A catastrophic flood occuring January 30-31, 1987 is of particular mention, as a 1 to 3 m torrent of the Rioni River covered around 10,000 ha of municipal area on the both banks of the river. As a result, the accident destroyed approximately 1,600 buildings (houses, public buildings, etc.), damaged or disabled a considerable number of infrastructure units (roads, melioration buildings, bridges and others), and more than 6,000 cattle perished. Similar catastrophic harm was caused only by two other floods of the Rioni River in 1895 and 1922.

On the territory of Khobi Municipality (as well as in the western part of Kolkheti Lowlands) tough floods and freshets result from intensive local rainfalls, when maximum charges of rivers exceed relief drainage possibilities, as well as by the excessive liquid charges produced in river basins outside the municipality during the intensive snowmelt and constant rainfalls, which generate transitive discharge in the Municipality.

According to some prevalent opinions, enhancement of extensive floods on Kolkhety Lowland rivers are a result of increasing agricultural usage of river basins. Consequently, forests out of all landscape components degrade in particular. Natural vegetation, as commonly acknowledged, has water-protecting and water-regulatory functions. Presumably, extensive degradation of natural vegetation resulted in devastation to the natural hydrological regime of rivers that intensified frequency and scale of floods and freshets.

### *1.2 Climate*

For the purposes of the INRMW program, assessment of climate aspects of the targeted area is of crucial importance. Consequently, the abovementioned component was assessed separately for Senaki and Khobi Municipalities despite the fact that the program does not imply the entire Khobi Municipality as a target area, but its Rioni-neighboring areas only. Besides, it should be noted that climate parameters of both municipalities were characterized according to the data provided by different meteorological stations that granted more accuracy of results.

#### *1.2.1. Senaki Municipality*

**Ongoing Climate Changes**

The territory of Senaki Municipality is included in sea subtropic humid zone and is featured with warm, mild winters and hot summers.

Climatic characterization of the municipality was accomplished based on data of the Senaki Meteorological Station. The station is located at 40 m above sea level. According to the observations from years 1936-1960, the average annual temperature was 14.5$^0$C; temperature equaled 5.4$^0$C in January, and 23.2$^0$C in August, with an absolute minimum of 17$^0$C and absolute maximum of 36$^0$C. the annual sum of active temperatures (above +1$^0$C) is 4,521$^0$C. Annual average relative air humidity reaches 74%. Annual precipitation is 1,699 mm (the maximum monthly sum in September is 177 mm; the minimum, in May, is 83 mm). Average annual wind speed is 2.7 m/s, maximum speed is 40 m/s. Generally, northeast and southwest winds prevail here.

Ongoing climate changes are assessed in accordance with meteorological observation data reported in 1957-2006.

In order to increase the validity of analyzed outcomes of observation materials climate parameters were evaluated with two methods: for each parameter, change trends in 1957-2006, assessment of trends' statistical validity and based on comparison of averages of two 25-year spans (1957-1981 and 1982-2006).

Consequently, it was stated that in 1957-1981 and 1982-2006 periods the average annual air temperature was almost unchanged because of cool winters and warmer summers and autumns in Senaki Municipality. As regards specific seasons, warming was detected in summers by 0.4$^0$C. In autumn, the temperature was relatively higher (0.1$^0$C). The absolute maximum temperature increased in summer and autumn (respectively 3.3$^0$C, 0.9$^0$C) and decreased in winter (approximately 2$^0$C). The absolute minimum exceeded in spring that is dangerous in the spring season because of vegetation period. Other seasons are marked with warming of the minimum temperature by 1-2$^0$C. The maximum exceeding of the minimum temperature is observed in summer and reaches 2$^0$C. Average maximum temperature increased approximately by 0.1$^0$C due to spring and summer warming. The biggest deviation is detected in winter (0.6$^0$C). In summer the average maximum is warmer by 0.5$^0$C, while this parameter does not change in autumn. The annual average minimum temperature is unchanged. In winters cooling was detected (0.5$^0$C), and in summer – warming (0.4$^0$C).

**Average relative air humidity.** In order to use a difference method, data of 1966-2006 were compared to the average climate indicators of 1936-1965 period span, and trends were constructed for the period of 1957-2006. According to the seasonal and annual meanings relative humidity between the two periods increased by 3.4%. Humidity increases reached their maximum in autumn and winter seasons.

**Total atmospheric precipitation** demonstrated a slight increase (7%, 113 mm) in autumn (11%, 52 mm.) and in winter (in summer and spring, precipitation increased about 2-3%). **Average maximum daily precipitation** increased in all seasons. Enhancement reached its maximum in autumn (13%, 6 mm.). In the second period exceeding in daily maximums was detected in all seasons except summer.

**Average wind speed**. Since 1992 data on wind speed has not been complete and could not be regenerated. Consequently, in order to use a difference method data from 1961-2006 were compared to climate indicators of previous span of 1937-1960, while the trends were constructed for 1957-2006. A comparison of the two spans revealed that wind speed decreased significantly in all seasons by 1-1.5 m/s. For annual averages difference between two discussed periods equals 1.2 m/s. According to the linear trends for maximum speed winds, designed for years 1970-2006, consistent tendency of their intensification happens in summer and autumn. Rising trends revealed also for averages of maximum annual wind speed as variance speed for the abovementioned period equals to annual 0.2 m/s.

Regarding the abovementioned data, on the territory of Senaki Municipality winters are more severe and rainier compared to the previous 25-year period span. Almost all temperature parameters discussed here decreased. Differences for average and minimum average temperatures between the two periods equals -0.5$^0$C, and for maximum average it is 0.6$^0$C (it enhances risks of winter freezing) that is proved by frequency of freezing days and nights at the beginning of winter. In terms of cooling of maximum temperatures, hot days are very rare. This season was featured with increased seasonal precipitation (7%, 29 mm) that was resulted by intensification of rainy days. Besides, the volume of average maximum precipitation is increased (3 %, 1mm). Compared to the previous period, the daily maximum is almost doubled (60 mm). Relative humidity is increased sustainably, while variance tendency for average wind speed is negative.

Variance of average and average minimum temperatures are not reported in spring. The average maximum has been become warmer (0.3$^0$C). Increases in absolute minimum were also observed (with 3$^0$C) though chances of freezing probably decrease as proved by the fact that the number of freezing days and nights are lessened. As maximum temperature rises, the number of hot days and nights increases. Seasonal precipitation as well as maximum daily volume substantially increases (respectively by 1.4 and 1.3 mm). Excessive daily maximums were at present either. All extreme indices (R10, R20, R50) prove the tendency of precipitation enhancement in this season. Among others, reliable tendencies of increase were revealed for the least precipitated days (R10, R20). Relative humidity increased as well (the difference between the two discussed periods equals 3%). Average wind speed for the two compared periods decreased by 1.4 m/s. Consequently, springs in Senaki Municipality have become more humid and less windy, while the vegetation period (<5$^0$C; >5$^0$C) has lengthened by 7 days.

In summer all average indicators of temperature are equally elevated (+0.4$^0$C). Also, temperature extremes are warmer. Absolute maximum was overlapped with 3$^0$C. The number of hot summer days and nights perceptibly increased. All indicators of summer warming are present. Between the two periods seasonal precipitation is slightly increased (3%, 15 mm; apparently, due to the total number of rainy days). The volume of maximum precipitation in a single day increased, while the number of moderately fewer rainy days (R10, R20) were reduced. Accordingly, strong daily rainfalls present certain risks for summer seasons. Reduction tendency of average wind speed is sustainable for this season. Consequently, summers in Senaki Municipality were warmer with more frequent heavy shower days.

In autumn the variation in average indicators of air temperature is insignificant. The increase in average temperature of 0.1$^0$C was due to slight elevation of minimums with 0.1$^0$C. Simultaneously, the number of hot days and nights rose in September. Compared to other seasons, the amount of precipitation (+11%) and average volume of maximum daily precipitation increased. A number of heavy shower days and almost all extreme climate indices (R10, R20 and R90) also increased. Due to these reasons risks of floods and landslides were intensified in this season. Similar to summers, due to a sustainable decrease in average wind speed, a sustainably increasing tendency of wind intensity was detected. Consequently, autumn was relatively warm and rainy.

### Extreme Occurrences

According to **mudflow and landslide processes** the lowland area of Senaki Municipality is in a hazardless and low-risk zone, and mountainous part ois in a risk zone for landslides. In relation to precipitation indices, the maximum amount of precipitation during 1 and consecutive 5 days as well as the number of days when the daily precipitation amount exceeds 10, 20, 50 and 90 mm and also, the number of enduringly rainy days during the observation period has been increased. The average amount of precipitation per day has also increased. Senaki Municipality is under rainy climate zone and 100 mm and more precipitation is observed there. As for the days with excessive mudflows, the number of days with more than 50 mm precipitation increased with 0.5 days per year, and the number of days with more than 90 mm precipitation is increased with 0.1 days. Here it should be mentioned that annual 200 mm and more precipitation is unchanged; that is a criterion for landslides. This indicates that risks of mudflows and landslides in the mountainous part of Senaki Municipality still exist.

***Table 1.1. The change in the amount of precipitation posing risks of mudflows and landslides in the period between 2020 and 2050 (Senaki Municipality)***

| Processes involving risks of mudflows and landslides | Total daily precipitation > 50 mm | Total daily precipitation > 90 mm | Increase in total yearly precipitation by 200 mm and more |
|---|---|---|---|
| Change in number of cases between the scenario and the first period of observation | +8 | +1 | 0 |

**Drought,** similar to other regions was assessed in accordance with the Standardized Precipitation Index (SPI). The tables below present the variation of the average number of severe and extreme droughts between the two periods.

***Table 1.2. Average number of severe droughts in different seasons according to the periods (Senaki Municipality)***

| Severe drought (SPI<-1.5) | 1-month | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1957-1981 | 14 | 7 | 21 | 19 | 19 |
| 1982-2006 | 3 | 4 | 13 | 8 | 8 |
| Difference | -11 | -3 | -8 | -11 | -11 |

***Table 1.3. Number of extreme droughts in different seasons according to the periods (Senaki Municipality)***

| Extreme droughts (SPI<-2.0) | 1-month | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1957-1981 | 10 | 15 | 6 | 9 | 10 |
| 1982-2006 | 10 | 5 | 3 | 1 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Difference | 0 | -10 | -3 | -8 | -10 |

As evident from the tables, in terms of increased precipitation the probability of the occurrence of severe and extreme droughts on the territory of the Municipality is reduced according to all time-scales. The drought index itself, for the entire observation period, especially for long-term droughts, showed atendency that indicates a decrease of precipitation deficiency. Besides, this municipality is in humid climate zone and no droughts threaten agriculture here.

### Expected Changes of Climate Parameters in Years 2020-2050

The scenario of climate change was assessed according to the PRECIS model, in which the ECHAM4 global model and two (A2, B2) scenarios of the world socio-economic development were used. For this purpose, data from the actual observations at Senaki meteorological stations were used.

Considering the abovementioned, the changes of climate parameters modeled for Senaki Municipality show the following outcomes:

**Yearly values of average temperature** show an increase according to both scenarios (warming is acuter according to B2 scenario). The average temperature in winter and summer seasons will rise by -2.5$^0$C. According to the A2 scenario air temperature rises by 1.5$^0$C in all seasons except spring, when air temperature will increase by 1$^0$C.

**Values of average maximum atmospheric temperature** also increase according to both scenarios in all seasons and, accordingly, yearly. According to the B2 scenario this parameter rises approximately 2.3$^0$C. In spring the annual increase of the average maximum atmospheric temperature equals 2$^0$C. According to the A2 scenario maximum temperature warms up mostly in autumn (by 1.4$^0$C), while in other seasons this indicator equals 1$^0$C.

**Average minimum temperature** experiences more warming in all seasons than average maximum. The annual minimum is expected to rise by 1.4-2.3$^0$C. In all seasons minimums will repeat the changing character of maximums. According to the B2 scenario this parameter increases further compared to the A2 scenario. Most of all winter and summer keep warming. According to A2, in all seasons this warming is lower by 1$^0$C. The yearly increase of the average minimal temperature is 0.9$^0$C according to the A2 scenario.

**Total annual precipitation** increases by 9% according to the B2 scenario and by 22% respectively. The change in precipitation in spring and autumn forecasted by B2 scenario is slight (1-2%); the winter and summer increases by 32-48%. By the B2 scenario, total precipitation of transitional seasons decreases slightly, while the increase of summer and winter precipitation is moderate (21%).

As regards the **maximum value of daily precipitation**, the highest amount of daily precipitation is expected in autumn. Its maximum value will reach 236.7 mm (compared to 183 mm in the observation period). **The average value of daily maximum precipitation,** according to the scenario, will increase in all seasons. Most of all average maximums of winter and summer precipitations are likely to increase, which indicate that intensity of precipitation will enhance in these seasons.

**The average wind speed,** according to the climate scenario, will reach mainly the same value as reported in the second observation period, when average wind speed decreased twice. Its yearly value will not change, but in winter it may increase by 0.1 m/s. In other seasons it will weaken.

According to both scenarios, **winter** (in years 2020-2050) in Senaki Municipality will warm up. According to the B2 scenario, all three parameters of temperature will increase by 2.3-2.8$^0$C, and according to A2 they will just slightly rise (by 1.1-1.4$^0$C). The number of days when the minimum temperature is below 0$^0$C, will increase approximately by 1.4 days (12%), and a number of days when the daily maximum is negative, will lessen by 100%. As expected, total seasonal precipitation will increase by 32% (A2 scenario) and by 21% (B2 scenario). The daily maximum precipitation, compared to the last observation period, will decrease by 4%, and the average value of daily maximum precipitation will increase by 6.7mm. As projected, this season will feature increased rainy days with 20, 50, 90 mm and more precipitation. Also, a slight decrease of rainy days with more than 100 mm precipitation is expected. According to both scenarios, average wind speed may decrease by 1.2 m/s. To sum up, in Senaki Municipality winters will become warmer in 2020-2050 with fewer freezing days and increased total and intensive precipitation.

**In spring** variations of average temperature are distinguished with the lowest increment. According to the scenarios, it may become warmer by 1-1.2$^0$C. The average minimum and maximum temperatures may rise similarly. According to the B2 scenario, similar to winters, all three parameters of temperature will warm more intensively than by A2. The number of freezing nights will be reduced by 37%. Freezing days are not expected. The number of hot days will extend by 4.3 days (22%). Occurrences of exceeding 20$^0$C minimum temperature will increase 3.5 times according to the scenario. Total seasonal precipitation, compared to the first period, will increase by 2% (A2 scenario) and decrease by 5% according to B2 scenario. In future the maximum amount of daily precipitation will increase, and the average value of daily precipitation maximums will slightly decrease. Similarly, the number of rainy days with 10 and 20 mm precipitation will change. Compared to the first period, their number will decrease by 10%, and the number of days with more than 50 mm precipitation will double. According to the scenario, days with more than 90 mm precipitation are expected. The average wind speed will not change. Consequently, spring in Senaki Municipality is expected to be warmer and moderately dry, with an increased amount of extreme precipitations.

According to A2 and B2 scenarios, the average **summer** temperature is expected to rise by 1.4-2.5$^0$C. The average minimum will increase more than the average maximum. Compared to the first period, the number of hot days will extend by 6.6 days (9%), and the number of tropical nights will increase by 21.6 nights (95%) and will reach 43.9 per season. According to the A2 scenario, total seasonal precipitation increases more (48%) than according to the B2 scenario (21%). The number of days with 10 and 20 mm precipitation keep decreasing and the number of days with more than 50 and 90 mm precipitation significantly increase, especially last one (3 times). The amount of maximum precipitation per day may increase by 29%, while the average value of daily precipitation may increase approximately by 24%. According to both scenarios average wind speed will lower compared to the first period but remains almost unchanged compared to the second period. Thus, summer in Senaki Municipality will be much hotter and rainy.

In accordance with the A2 and B2 scenarios, the average **autumn** temperature will rise by 1.5-2.2$^0$C. This season will be marked by a slighter increase of the maximum temperature, than of the minimum one. Presumably, the number of hot days will extend approximately by 9.7 days (38%) and occurrence of tropical nights by 2.1. Total seasonal precipitation will increase by 1% in reference to A2 scenario and will decrease similarly in reference to B2 scenario. The maximum amount of daily precipitation will increase significantly (by 44%) as will its average value (35%). The number of days when daily precipitation exceeds 50 and 90 mm will also increase. In return, the number of days when daily precipitation is less than 10 and 20 mm will be lessened. According to all precipitation data, autumn is expected to have a considerable risk of heavy showers.

**Extreme Occurrences**

**Mudflow and landslide processes**. As precipitation indices show, in 2020-2050 the maximum amount of precipitation during 1 and 5 consecutive days may increase in Senaki Municipality. Also, the duration of enduringly rainy and consecutively rainy days as well as the number of days with 50 and 90 mm precipitation is expected to increase. The average amount of precipitation per day will also increase. In precipitation indices is reduced number of days when total daily precipitation is more than 10 and 20 mm. This region features excessive precipitation. In the basic period, 90 mm and more precipitation was observed daily in summer and autumn, while according to the future scenario, this may occur in every season. Their number will extend by 4 days, and the number of mudflow-risk days with 50 mm and more precipitation will increase by 6 days.

***Table 1.4. The change in the amount of precipitation posing risks of mudflows and landslides in the period between 2020 and 2050 (Senaki Municipality)***

| Processes involving risks of mudflows and landslides | Total daily precipitation > 50 mm | Total daily precipitation > 90 mm | Increase in total yearly precipitation by 200 mm and more |
|---|---|---|---|
| The change in the number of cases between the scenario and the first period of observation | 6 | 4 | 2 |

The table shows that mudflow risk does not change in Senaki Municipality. Besides, it should be mentioned that an increase in total yearly precipitation by 200 mm and more, which is a criterion for mudflow risks, will be increased in both scenarios.

**Droughts**. The tables below demonstrate the average number of of severe and extreme droughts for all three periods.

***Table 1.5. Average number of severe droughts (different durations) in discussed periods (Senaki Municipality)***

| Severe drought (SPI<-1.5) | 1-month | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1961-1985 | 14 | 7 | 21 | 19 | 19 |
| 1986-2010 | 3 | 4 | 13 | 8 | 8 |
| 2020-2050 A2 | 18 | 19 | 13 | 12 | 14 |
| 2020-2050 B2 | 10 | 19 | 11 | 5 | 9 |

***Table 1.6. Average number of recurrence of extreme droughts (different duration) in discussed periods (Senaki Municipality)***

| Extreme drought (SPI<-1.5) | 1-month | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1961-1985 | 10 | 15 | 6 | 9 | 10 |
| 1986-2010 | 10 | 5 | 3 | 1 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| **2020-2050 A2** | 7 | 3 | 3 | 3 | 2 |
| **2020-2050 B2** | 8 | 10 | 10 | 9 | 8 |

As the tables show, according to both scenarios in forecasted precipitations the number of 3-month severe droughts will increase compared to the first observation period when total precipitation is lower and the number of droughts is higher. The extreme shortage of precipitation by B2 scenario always exceeds the one forecasted according to A2 that could be explained in terms of increased precipitation along with this scenario.

### *1.2.2. Khobi Municipality*

#### Ongoing Climate changes

The Territory of Khobi Municipality is included in the sea subtropic humid zone and is featured with warm, humid climate, with mild winters and quite hot summers. Until 1977 the climatic description of the municipality was conducted according to the data of Kheta Meteorological Station (29 m above sea level). Since 1977 it has been described according to Torsa Meteorological Station (10 m above sea level) data.

According to the observations from 1927-1960, the average annual temperature was 14.8$^0$C; average temperature equaled 6.7$^0$C in January and 23.2$^0$C in August. The absolute minimum is 17$^0$C and the absolute maximum is 36$^0$C. The annual sum of active temperatures (above +10$^0$C) is 4,565$^0$C. Annual average relative air humidity reaches 73%. Annual precipitation equals 1.730 mm (the maximum monthly sum in September is 177 mm; minmal in May is 114 mm). Average annual wind speed equals 2.7 m/s, maximum speed is 40 m/s.

In order to observe meteorological elements (air temperature, atmospheric precipitation, and wind) for 1955-2004, the time span was divided into two 25-year periods (1955-1979 and 1980-2004). Average data of meteorological elements were stated exactly for these periods.

While observing meteorological elements on the municipal territory (1955-2004) average annual air temperature was lowered by -0.7$^0$C. Cooling is observed in all seasons. Maximum index of decrease between the two 25-year periods is detected in winter (-1.3$^0$C), and the difference is insignificant in summer. In transitional seasons index of cooling is equalized at 0.5$^0$C. Absolute minimum of temperature is overlapped in all seasons except autumn. In the second period, exceeding of absolute minimum was detected in all seasons except summer. In the second period observed extreme indices are 1-2$^0$C lower than in the first one. **Average maximum temperature** almost repeats the character of average temperature season by season, though by these parameters, intensity of cooling is mitigated. Between the two periods, the difference among values of transitional seasons, as well as annually, changed insignificantly (by -0.1$^0$C). According to this parameter, cooling becomes most intensive in winter, while summers are marked with 0.5$^0$C warming. **Average minimum temperature** almost repeats the character of average temperature season by season. Besides, according to this parameter, cooling is of the same type. The difference between transitional seasons of two periods is negative and reaches 0.5$^0$C. Cooling is maximum in winter, but in summer (between 2 periods) average minimum temperature is unchanged.

**Relative air humidity** between the two abovementioned periods increases in 4% in accordance with an annual value. Increase is maximum in winter and reaches almost 6%, while in summer it equals 3%.

**Values of total atmospheric precipitations** demonstrate a slight increase (7%, 113 mm) in all seasons. The annual increment between two periods is 14%. Variations of precipitation are maximum in autumn, in other seasons it varies between 12-13%.

Compared to the previous 25-year period, **winter** is much cooler (-1.3$^0$C) here mainly because of lowering the minimum parameters. Almost all reviewed parameters are decreased. In the second period the absolute minimum increased by 1$^0$C. Winter freezing increased as was proved by a raised number of freezing nights (around 3.5 days per season). Despite winter cooling, the probability of cold wave occurrence is unchanged. In this season average relative humidity increased by 6%. Besides, all characteristics of precipitation are raised. Total amount of precipitation is also increased (12%, 47mm), as well as average and largest amounts of daily maximum precipitation and extreme indices (R10, R20, R50 and Rx5 day). Tendencies of decreasing average wind speed (except in summer) and increasing maximum wind speed were reported. That is, winter in Khobi Municipality is more severe and rainy in the second 25-year period.

In **spring** the temperature change regime was almost the same as in winter, but the cooling intensity subdued relatively. Between the two observed periods the average and average minimum temperatures were reduced by 0.5$^0$C. Average maximum was also slightly lowered and the risk of spring freezing increased. In the second 25-year period an increase in absolute maximum (+1.6$^0$C) was detected. As a consequence of the cooling, the number of hot days and tropical nights were reduced, and the number of cold days between two periods increased. Total seasonal precipitation, similar to winter, increased (+13%, 39 mm). In relation to precipitation indices, the daily maximum amount of precipitation during 1 and consecutive 5 days exceeded the same index of the previous period. Average values of daily maximum (7%, 2 mm) and the number of heavy rainy days increased.

Precipitation increase between the two periods is proved by other extreme indices (R10, R20, R50) as well, though the tendency of their variation during the whole period is not stable. Maximum indexes of relative humidity and wind speed, similar to winter, increased, while average wind speed was lowered. Consequently, spring became cooler and more humid, with a certain risk of freezing. Regarding spring cooling, the vegetation period (<5$^0$C, >5$^0$C) was shortened by 8 days.

In **summer** average and average minimum temperatures between the 2 periods were almost unchanged, while average maximum and temperature extremes (absolute maximum and minimum) increased. The average maximum increment between two periods reached 0.5$^0$C. Average daily amplitude of temperature increased. In the second period the number of hot days increased by 5.3 days per season. For all precipitation indexes the difference between the two periods was positive. Along with total seasonal precipitation the number of rainy days was also increased. This is proved by an increase of a number of heavy precipitation days (R10, R20, R50, R90; the daily maximum detected in the first period was exceeded by 70 mm in the second period). . Accordingly, strong daily rainfalls presented certain risks for summer seasons. The average wind speed grew between the two periods (+0.1m/s) though the increment is insignificant and therefore, the change tendency is not remarkable. Consequently, summer was more humid, rainy and windy, with intensified extremely hot days.

In **autumn** temperature variation is similar to summer. Average temperature between the 2 periods is slightly lower (by 0.5$^0$C), and average minimum by 0.7$^0$C. The average maximum is slightly lowered. A certain risk of freezing was present as well. Besides, absolute maximum of temperature keeps stable tendency of increase, though in this season relevant extremes were not overlapped. In spite of cooling, in September and October the number of hot and extremely hot days are increased. Most of all, precipitation intensified in autumn. Namely, the seasonal total increased (+20%, 91 mm). The maximum amount of precipitation during 1 and consecutive 5 days was almost doubled. Extreme climate indices related to precipitation (R10, R20, R50 and R90) also increased. Maximum indicators of wind were increased, but average wind speed was lowered. Thus, autumn due to its second half, became more rainy and severe.

According to **mudflow and landslide processes**, the lowland area of Khobi Municipality is in a low-risk zone and the mountainous part is in a risk zone for landslides. In relation to precipitation indices, the maximum amount of precipitation during 1 and consecutive 5 days increased. The duration of consecutively rainy periods was prolonged, while duration of consecutively dry periods was shortened. The number of days when daily precipitation amount exceeds 50 and 90 mm increased. Between the two periods increment in a number of days with more 10-20 mm precipitation was positive. As for the days with more than 50 mm precipitation, it reached 112 in the first[t] period and 116 in the second one (that is 4 more days in the 25-year period). The number of days with more than 90 mm precipitation increased from 20 to 26, which represents a serious hazard for mudflows. This indicates that mudflow risk increased in this municipality. It should be mentioned that the municipality belongs to a quite heavy precipitation zone (100 mm and more precipitation is observed here).

*Table 1.7. The change in the amount of precipitation posing risks of mudflows and landslides (Khobi municipality)*

| Processes involving risks of mudflows and landslides | Total daily precipitation > 50 mm | Total daily precipitation > 90 mm | Increase in total yearly precipitation by 200 mm and more |
|---|---|---|---|
| The change in the number of cases between the scenario and the first period of observation | +4 | +6 | -1 |

Herein should be mentioned that occurrences of total annual 200 mm and more precipitation, that represent a criterion for landslides, are slightly lowered in the second period: in this period there were 4 cases of landslide while 5 landslides occurred in the first period. It indicates that risks of mudflows increased and risks of landslides lowered in the mountainous part of Khobi Municipality.

**Drought.** The tables below present the variation of the average number of severe and extreme droughts between the two periods.

*Table 1.8. Average number of severe droughts in different seasons according to the periods (Khobi municipality)*

| Severe drought (SPI<-1.5) | 1-month | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1956-1980 | 19 | 16 | 24 | 21 | 17 |
| 1981-2005 | 12 | 8 | 4 | 5 | 7 |
| Difference | -7 | -7 | -20 | -16 | -10 |

*Table 1.9. Average number of extreme droughts in different seasons according to the periods (Khobi municipality)*

| Extreme drought (SPI<-2.0) | 1-months | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1956-1980 | 6 | 9 | 3 | 3 | 2 |
| 1981-2005 | 5 | 5 | 8 | 8 | 6 |
| Difference | -1 | -4 | 5 | 5 | 4 |

As is evident from the tables, cases of severe droughts on the territory of the Khobi Municipality are reduced and occurrences of extreme droughts, according to all time-scales are intensified. In terms of the abovementioned increased precipitation, intensification of extreme droughts should be explained by the fact that all cases of precipitation deficiency in the second 25-year period occurred in two drought periods observed in 1986 and 1998-99.

Generally, Khobi Municipality is a heavy precipitation area and no droughts threaten agriculture here.

### Expected Change of Climate Parameters in Years 2020-2050

For Khobi Municipality future climate changes were assessed according to the regional PRECIS model, in which the ECHAM4 global model and two (A2, B2) scenarios of the world socio-economic development were used. Mean values of total average air temperature and total precipitation were calculated by ECHAM4 and HADCM3 models.

Below scenarios of climate parameter changes are reviewed through ECHAM4, A2, B2 and HADCM3 A2 models.

According to both scenarios, **yearly values of average temperature** show an increase in all seasons. Increased temperature is projected especially in summer (2.5$^0$C). In other seasons average temperature rises by 2$^0$C.

Values of **average maximum of atmospheric temperature** also increase according to both scenarios in all seasons and, accordingly, yearly. The minimum increment in spring equals 0.9$^0$C, while in other seasons this parameter is 2$^0$C. According to the B2 scenario, the annual increase of average maximum temperature is 2$^0$C, and by the A2 scenario, maximum temperature increase is greatest in autumn (1.4$^0$C), while it warms up by 1$^0$C in other seasons.

**Average minimum temperature**, except transitional seasons, experiences more warming in all seasons than the maximum maximum temperature. The annual minimum is expected to rise by 1.3-1.9$^0$C. By both scenarios, in winter minimums will warm up by 2-2.4$^0$C. In all other seasons minimum parameters repeat the character of the maximum variations. According to the B2 scenario, this parameter raises more than according to A2 one. In this case winter and summer experience more warming. By the A2 scenario, this warmingis less than 1$^0$C per each season, and annual minimum rises by 1.3$^0$C.

**Total annual precipitation** that increases between two observation periods, according to the B2 scenario and A2 will be increased by 8% and 21% respectively. Precipitation in winter and summer will increase by 30-37%. According to the B2 scenario rainfalls intensify by 4% in autumn and lessen similarly in spring. In winter and summer the value of total seasonal precipitation raises by 21-16%.

In both periods of observation, the **maximum value of daily precipitation** was detected in autumn. According to the future scenario, it is expected to occur in summer. Its absolute maximum value reached 146.6 mm in the first period and equaled 288.5 mm in the second period. According to the future scenario, it will equal 252.4 mm.

The **average value of daily maximum precipitation,** according to the scenario, will increase in all seasons. Most of all average maximums of summer and autumn precipitations are likely to increase, which indicates that intensity of precipitation will enhance in these seasons.

**The average wind speed,** according to the climate scenario, will reach mainly the same value as it was reported in the second observation period, when average wind speed decreased by 0.5 m/s. Its yearly value will not change, but seasonal variation will equal to 0.1 m/s.

Analysis of both scenarios is principally based on the results of A2 scenario, as extreme indexes are also calculated that make variation more precise.

According to both scenarios, **winter** in Khobi Municipality will warm significantly. According to the B2 scenario, all three parameters of temperature will increase by 2.2-2.4$^0$C, and according to A2 they will just slightly rise by 1.1-2$^0$C. The number of days when the minimum day temperature is below 0$^0$C, compared to the observation period, will decrease approximately by 6.1 days (12%), and the number of days when the daily maximum is negative will lessen by 100%. According to the future scenarios, occurrence of hot days is also expected in winter; that was not previously reported in winter in either observation period. By the A2 scenario, total seasonal precipitation will increase by 30% and by 21% according to the B2 scenario. Daily maximum precipitation will increase by 28%, and average daily maximum precipitation will increase by 7mm. As expected, in this season the number of days with 10, 20, 50 mm and more precipitation will increase by 8 times. According to both scenarios, average wind speed may increase by 1.2 m/s. To sum up, in Khobi Municipality winters will become warmer with fewer freezing days and with increased total and intensive precipitation.

In **spring,** variation of average temperature is distinguished by the least increment (0.7-1$^0$C). Average maximum and minimum temperatures will rise similarly. According to the B2 scenario, similar to winters, all three parameters of temperature will warm more intensively than according to A2. The number of freezing nights will be reduced by 36%. Freezing days are not expected. The number of hot days will extend by 4 days (21%). Total seasonal precipitation, compared to the first period, will remain unchanged (A2 scenario) or decrease by 5% according to B2 scenario. In both cases total seasonal precipitation will be lower, compared to the second observation period. Presumably, the average value of daily precipitation and its maximum amount will lower. Similarly, the number of rainy days with 10 and 20 mm precipitation will change. Compared to the first period, their number will decrease by 16% and 2%. The number of days with more than 50 mm precipitation will double. Average wind speed will not change. Consequently, spring in Khobi Municipality is expected to be warmer and moderately dry, with an increased amount of extreme precipitation.

Average **summer** temperature is expected to rise by 1.5-2.5$^0$C. Average minimum will increase more than average maximum. Compared to the first period, the number of hot days will extend by 6.6 days (9%), and the number of tropical nights will increase by 32.9 days. According to the A2 scenario, total seasonal precipitation increases more (437%) than according to the B2 scenario (16%). The number of days with 10 and 20 mm precipitation keep decreasing. The number of days with more than 50 and 90 mm precipitation will increase significantly,; the number of days with more than 90 mmm is expected to double. Amount of maximum precipitation per day may increase by 86%, while the average value of daily precipitation may increase approximately by 14%. According to both scenarios, average wind speed is almost unchanged. Thus, summer in Khobi Municipality will be much hotter and extremely rainy.

In accordance with both the A2 and B2 scenarios, the average **autumn** temperature will rise by 1.3-1.9$^0$C. This season will be marked by a perceptible increase of maximum, rather than minimum temperatures. Presumably, the number of hot days will extend by approximately 9 days (32%) and occurrence of tropical nights will increase by 3.8 cases (3.5 times greater than the first period). The number of freezing nights will decrease by 0.4 cases. Total seasonal precipitation will increase by 8% in reference to the A2 scenario and by 4% in reference to the B2 scenario. In both cases it decreases compared to the last 25-year period. The maximum amount of daily precipitation (that increased significantly during the 2 observed periods) will lower by the scenarios; though it will still be higher by 40% compared to the first period. The average index of this parameter keeps increasing (it will be 9 mm more than in the first period). The number of the days when daily precipitation exceeds 50 and 90 mm will also extend. In return, the number of days when daily precipitation is less than 10 and 20 mm will lessen. Therefore, according to all precipitation data, autumn is expected to have considerable risk of heavy precipitation; though it will be warm with less risk of freezing.

### Extreme Occurrences

As precipitation indices show, in 2020-2050 the maximum amount of precipitation during 1 and consecutive 5 days may increase in Khobi Municipality. Also, duration of enduringly rainy and consecutively rainy days as well as the number of days with 50 and 90 mm precipitation is expected to increase.In precipitation indices a number of days when total daily precipitation is more than 10 and 20 mm is decreased. Average amount of precipitation per day will also increase. This region is featured with excessive precipitation. In the basic period 90 mm and more precipitation was observed daily in summer and autumn, while according to the future scenario, this may occur in every season. The number of similar days will extend by 35 days and the number of mudflow-risk days with 50 mm and more precipitation will increase by 42 days.

***Table 1.10. The change in the amount of precipitation posing risks of mudflows and landslides in the period between 2020 and 2050 (Khobi municipality)***

| Processes involving risks of mudflows and landslides | Total daily precipitation > 50 mm | Total daily precipitation > 90 mm | Increase in total yearly precipitation by 200 mm and more |
|---|---|---|---|
| The change in the number of cases between the scenario and the first period of observation | 42 | 35 | 6 |

The table above shows that mudflow risks will grow dramatically in Khobi municipality. Besides, it should be mentioned that increases in total yearly precipitation by 200 mm and more, which is a criterion for mudflow risks, increased by 6 occurrences in the second period.

**Droughts**. The tables below demonstrate the average number of severe and extreme droughts for all three periods.

***Table 1.11. Average number of severe droughts (different durations) in discussed period (Khobi municipality)***

| Severe Drought (SPI<-1.5) | 1-month | 3-months | 6-months | 9-months | 12-months |
|---|---|---|---|---|---|
| 1961-1985 | 19 | 15 | 24 | 21 | 17 |
| 1986-2010 | 12 | 8 | 4 | 5 | 7 |
| 2020-2050 A2 | 11 | 12 | 6 | 3 | 8 |
| 2020-2050 B2 | 22 | 21 | 16 | 15 | 16 |

***Table 1.12. Average number of extreme droughts (different duration) in discussed periods(Khobi municipality)***

| Extreme drought (SPI<-1.5) | 1-month | 3-month | 6-month | 9-month | 12-month |
|---|---|---|---|---|---|
| **1961-1985** | 6 | 9 | 3 | 3 | 2 |
| **1986-2010** | 5 | 5 | 8 | 8 | 6 |
| **2020-2050 A2** | 9 | 8 | 6 | 0 | 0 |
| **2020-2050 B2** | 8 | 7 | 7 | 5 | 8 |

As the tables show, according to both scenarios the number of 3-month severe droughts will increase. Extreme shortage of precipitation by B2 scenario always exceeds the A2 forecast, which could be explained in terms of the increased precipitation with this scenario.

### *1.3 Soil*

A classification of the main types of soils present on the lower course of the Rioni River is provided based on the FAO classification. The following main soil types are present on the territory:

- RED PODZOLISED SOILS
- YELLOW PODZOLISED SOILS
- YELLOW SOILS
- SUBTROPICAL PODZOLS
- SUBTROPICAL GLEY PODZOLS
- SILTY BOG
- RAW HUMUS CALCAREOUS BOG B G
- ALLUVIAL

**Red Podzolised soils** are developed on the hilly belt of Senaki Municipality. These soils are featured with loamy mechanical composition, high dispersion, low amount of humus and nutrient elements and low fertility. Due to frequent heavy rains this type of soil experiences erosion and degradation, and absence of natural vegetation and incorrect cultivation of the soil promote these processes.

In the targeted area **yellow soils** are common to the relief of slight and medium inclination. The mechanical composition of these soils consists of heavy loam and clay, with a low dispersion coefficient, and unprofitable physical features. Yellow soils are quite sensitive to erosion, especially if the territory is void of vegetation.

Yellow podzolised soils are common to slightly inclined and wavy reliefs. Signs of podzolisation are easily notable at the lower horizon of these soils. They are of light and medium mechanical composition and have unprofitable physical features, lack nutrient elements and are not stable to erosion.

**Sub-tropical podzol and sub-tropical gley podzols.** These types of soils are common to the transitional zone from Colcheti Lowland to its higher part. Here and there the profile of this soil is marked with podzolisation, namely, rust spots and soft forms of concretion, as well as signs of gleying. This type of soil is of very heavy mechanical composition and has a low water permeability that creates conditions for soil bogging and gleying.

**Gley podzols** are characterized with low absorption and acid reactions. These soils are profitable for agro-industry. The degree of podzolisation is high in subtropical soils as the lower horizon of the soil contains a great amount of iron rust and concretion, which in composition forms waterproof layers.

**Silty bogs** are met on the low and depressed relief of the lower Rioni River, as well as in the western part (seaside) of the Odishi Lowland. Because of excessive surface water and intensive hydromorphic plants, the upper layers of the soil have marks of podzolisation and bogging. The upper layers are grey and dovelike colors. Due to the heavy mechanical composition of the middle and lower layers and little water permeability, the territory is usually bogged.

**Raw humus calcareous bog** is developed on calcareous ground, mostly on limestone and marls. Primarily these soils are met in an area rich with limestone. If met on the inclined slopes, raw humus calcareous bog soils are characterized with great and medium thickness, lime alkalizing from the carbonic acid and heavier loamy mechanical composition. These soils are featured with high level of humus (8-9%) in upper layers; carbonic acid lime in lower layer reaches 70-80%. If encountered on inclined and steep slopes, raw humus calcareous bogs are subject to erosion processes.

**Alluvial calcareous** are developed on the banks of the Rioni, Tsivi and Tekhura Rivers. These soils are characterized by a less differentiated profile and moderately low-humus horizon. By mechanical composition they are light and medium loamy soils. In the upper 20 cm layer, the index of humus does not exceed 2.5-3.0% and, consequently, it is poor in plant supplements.

Anthropogenic soils are developed along the lower Rioni course as a result of colmatage / clogging due to silting with river sediments (that is how anthropogenic soils were formed on the territories of Patara Poti, citrus farms, etc.).

Within the borders of the targeted territory, soil degradation and defertilization are detected. Along the banks of the Rioni, Tekhyra and Tsivi rivers erosive processes are activated intensively due to bank washing by floods and freshets, and agricultural land degradation is expressed in flooding and soil erosion of river-adjacent territories. Thus, the soil layers are washed; its physical-mechanical and physical-chemical features get changed; and soil podzolisation and bogging processes intensify dramatically.

### *1.4 Natural Vegetation*

The lower course of the Rioni River is included in the western part of the Colcheti botanical-geographic province. It is distinguished with one-floor landscape with plain relief, humid subtropical climate, wetlands, with swamp, and mesophilic and hydrophilic plants. Nowadays, secondary (anthropogenic) mesophilic Colchis landscape prevails on the municipal territory. Here 2 types of phyto-landscapes are differentiated: swamps and boggy forests (30-50 m above sea level), and Colchis lianian humid relict forests (up to 500 m above sea level).

As mentioned above, vegetation of the targeted area is strongly transformed. Near--natural vegetation is preserved in the forms of certain plots and massifs (on both slopes of Unagira Mount, in Sagabeskirio, Shromiskhevi, Shuakhorshi, Zedakhorshi, Bethlem and in other localities), which are mostly covered with beech and hornbeam forests. A large part of post forest areas is used as agricultural lands (agricultural lands, gardens, grasslands and pastures). In the recent past, tea plantations were cultivated in some places. Also, near-natural vegetation with less distressed structure and abundant relict species is met in difficult areas of the Black Sea coastline. In similar areas mainly separate sections of peat bogs, swamp forest and wetland alder thickets are preserved. Along the coastline rare plants of sandy ricks are found in small sections.

In the western and southern parts of the targeted area of Senaki Municipality, swamps with grasses (*Juncus effusus, J. learsii, Carex gracilis, Butomus umbellatus, Phragmites australis, Polygonum hydropiper, Tipha latifolia, Rhamphicarpa medwedewii, Iris pseudocorus*), Common reed (*Phragmites australis*), Common Bulrush *(Typha latifolia),* Irisis *(Iris pseudocorus),* Jancus (Juncus effusus) are common. Also, bi-dominant common reed-bulrush, bulrush-iris, Juncus-Rush swamps and fragmentarily, peat swamps (Sphagnum imbricatum, S. cymbifolium, S. acutifolium) are present. It is noteworthy that these peat swamps are inhabited by rare elements (for Caucasus) of boreal flora – *Drosera rotundifolia, Carex lasiocarpa, Rhynchospora Alba* – as well as by relict species of *Osmunda regalis, Rhynchospora caucasica, Rhampicarpa medwedewii, Trapa colchica.*

In the targeted area of Khobi Municipality, peat swamps are presented by Juncus-Rush massifs of the Nabada and Tchuria Rivers that are located along the coastline of Odishi Lowland between the confluences of the Rioni and Tcuria rivers. Generations of these peat swamps were conditioned by intensive atmospheric precipitation (1500-1600 mm per year); the flat, weakly fragmented and slightly inclined surface of the coastline plain; and a horizon of water-resistant or hardly water-permeable sediments (mostly loams).

In similar conditions, drainage of superficial waters is considerably slowed down, and waters almost do not drain deep down. This results in delaying surface waters on coastline plains and, consequently, their saturation with moisture. Due to the abovementioned, soil and ground layers are dispersed with water that causes decreased viability of anaerobic bacteria and other micro-organisms, , weakening of oxidation, and rotting. In terms of warm and humid climate the Black Sea coast is characterized by high biological productivity, and every year a large amount of dead organic mass is regenerated as a result of partial oxidation and rotting. This mass of peat emerges and accumulates on the coastal plains.

Peat arrays of Nabada and Churia Mountains are swamps of a lower type, where a major edificatory role belongs to the following plant associations: thick turf sedges (*Carex acutiformis, C. Vesicaria*), rush plants (*Juncus Effusus),* (*Phragmitis australia*), and Typha (*Tupha*) as well as *Drosera rotundifolia, Rhynchospora alba* and relict plants like – *Osmunda regalis, Rhynchospora caucasica, Rhampicarpa medwedewii, Trapa colchica* and others. Other representatives of sedge-rush plants are Calamus (*Acorus calamus*), *Kosteletzkya,* arrowhead (*Sagittaria sagittifolia*), etc.

In the target area swampy forests of Colchis, alder thickets *(Alnus barbata)* occupy a dominant role. In these forests alder creates various options - alder thickets occupying sage *(Carex gracilis),* alder thickets occupying rush (Juncus effusus), alder thickets with reeds *(Phragmites australis),* alder thickets with Typha *(Typha latifolia),* alder thickets with grasses. In these options the units of poplar *(Populus hybrida),* willow *(Salix australior S. Alba*), wingnuts (Pterocarya pterocarpa) and others can also be found.

Fragments of wetland forest are constituted with smilax (*Smilax exelsa),* clematis (*Clematis vitalba*), periploca (*Periploca graeca*), species of rubus (*Rubus sanguineus, R. candicans*), black bryony (*Tamus communis*), and common and Colchis Ivy (*Hedera helix, H. colchica*). Rarely, *Vitis silvestris,* Fox grape (*Vitis labrusca*), common hop (*Humulus lupulus*), *Ruscus aculeatus* and others are also found.

Within the area of up to 500 m above sea level, relict small thickets of Colchis arrays with beeches, hornbeams and oaks are preserved. Rarely or almost never occur wingnuts *(Pterocarya pterocarpa),* elms *(Ulmus foliacea, Ulmus elliptica),* linden *(Tilia begoniifolia),* common persimmon *(Diospyros lotus),* maple *(Acer campestre),* ash *(Fraxinus exelsior),* poplar *(Populus hybrida),* and Colchis fig *(Ficus colchica).* In this forest, subforest is created by evergreen and perennial shrubs including laurel *(Laurocerasus officinalis),* rhododendron *(Rhododendron ponticum),* ruscus *(Ruscus hypophyllum),* ilex *(Ilex colchica),* Caucasian bilberry *(Vaccinium arctostaphyllos),* yale *(Azalea pontica Rhododendron ponticum),* staphylea *(Stapylea colchica)* and others.

In swamp ex-forests, especially in wetland habitats (brooks, canals, flooded depressions), amorpha (Amorpha fruticosa) is widely expanded. It is a progressive weed shrub here, and creates serious invasive thickets not only in agricultural land, but in relict Colchis forests as well.

Coastal vegetation of the lower Rioni River basin is very particular. Sandy coastline embankments, located between the confluence of the Rioni and Churia rivers with average width of 150-250 m, are featured with great biodiversity despite the limited area of their distribution. In the peculiar dry, well heated, here and there salty areas of meadow cord of coastline embankment, distinguished from other floristic compositions of Colchis lowland, littoral psammophytes including spurges (Euphorbia), blue thistles (*Cirsium*) and more are widespread. Species grown from bulbs include sea lily, *Imeretian Goebelia alopecuroides*, and dubo (*Cynodon dactylon),* also many perennial xerophytes and ephemera including seaside stachys, *Silene*, and *Verbascum*; Xerophytic vegetation including paliurus, sea-buckthorn, and hawthorn; Mediterranean species such as yellow curt *(Glaucium corniculatum)* and more are found here.

A number of plant species – drosera, water nuts, sea lily, yellow curt *(Glaucium corniculatum) etc*. – from coastal wetlands and sandy coastline embankments are rare, and are on the Red List of endangered species.

The natural vegetation of lower Rioni River may experience the following dangers: agricultural land development, livestock rearing and grazing, timber extraction, accidental fires, and so on.

### *1.5 Direction of Agriculture*

Low areas of the downstream Rioni River (30 meters above sea level) are used for subtropical (tea, citrus fruits), annual (corn, beans, vegetables) and perennial (vineyards, fruit trees, laurel, etc.) production.

According to 2011 data, the area of Senaki Municipality (which includes the majority of the target area) is 50,092 ha, of which agricultural lands occupy 22,155 ha (including 11,229 ha of arable lands, 3,946 ha of perennial plants, 18 ha of meadows, and 6,962 ha of pastures).

Corn is the main annual crop in the target area. Average corn yield is low and ranges from 0.8 to 3.3 t (corn is produced on average 7,000-7,600 ha in the target area within the Senaki district. Approx. 26 t were produced according to 2011 data). One of the reasons for the low corn harvest is low levels of seed-farming, crop rotation, and obsolete agro-techniques.

Beans are primarily grown in residential plots of the target area. This culture is largely co-cultivated with corn. The common culture here is soya, which occupies a relatively small area. The average yield per 1 ha ranges between 0.5-1.5 t. Vegetables (tomatoes, peppers, early cabbage, onion, garlic, potatoes and root crops) occupy an area of approximately 240-270 ha and the average yield per ha ranges from 3.4 to 5.8 t. Cucurbits (mostly melon, cucumber, watermelon) occupy 40-50 ha and on average 90 to 400 t are produced per year, and the yield per ha equals 4.1-8 t. Potatoes are harvested on 25-35 ha that produces 30-40 t (mostly early potatoes). The yield per ha of 0.7-4.4 t (which is a very low figure) is caused by the lack of high-quality seeds and outdated agriculture techniques.

The population of the target area produces 5-10 thousand t of fruit. Pome productionamounts to 250-450 t; stone-fruits production is 99-170 t (plums range from 42-70 t); nut production is 12-13, t hazel nuts amount to 26-40 t; and subtropical crop are 54-81 t. Average fruit and citrus production in 2011 amounted to 10.28 t per ha.

The most popular pomes are pears (600-650 t), apples (200-250 t) and quinces (15-20 t); 600-700 t of grapes are produced mainly for local/familial consumption.

Analysis of the results of agricultural development on the target area indicates that large fluctuations in harvests can be explained by the fact that agriculture is profoundly dependent on climatic conditions. It should also be noted that most of agricultural machinery is heavily damaged. In addition, there is a quite high imbalance between rural agricultural production and energy prices, which increases production expenses and costs and reduces competitiveness in the market. Besides, it should be noted that the windproof strips along agricultural lands are devastated and drains, catchments and bilateral collectors are heavily damaged. Due to frequent flooding and erosion the soil continues to degrade.

### *1.6 Assessment of Population’s Health*

It is proved that global climate change significantly impacts human health.

During the last decades, numerous studies have been conducted by various countries, authoritative international organizations and regional programs dedicated to the human body's sensitivity to climate changes and its impact on health.

Climate change can significantly aggravate diseases sensitive to climate changes; that's why it is very important to ensure timely and effective interventions on global as well as regional and country levels.

In order to realistically assess the consequences of climate change and variability, we should understand what kind of sensitivity local residents have for new conditions and how adequately they react. Connections among sensitivity, adaptation capability and potential consequences are defined by standardized schemes to a certain extent. Humans’ health sensitivity to climate changes is determined by:

- Perception that includes degree of sensitivity of health, natural and social systems (which is important in terms of influence on the results of the human population health) to weather and climate changes
- Characteristics of the population, such as the level of development and demographic structure;
- Impacts of hazardous weather and climatic factors (climate-related variations, including level and frequency);
- Measures and activities taken for adaptation, which aim at reducing the burden of unreasonable and undesirable impacts on human health (initial level of adaptation) and the efficiency of which slightly determines the attitude of "exposure- response".

The groups and subgroups of the population and systems that are not capable or do not want to adapt, are particularly susceptible, as well as those with high perceptibility toward weather and climate changes. Overall, population sensitivity to any kind of threats depends on local environment, level of material resources, effective management (both local and higher levels), quality of public health infrastructure, and access to information.

For the purposes of this report, rates of population morbidity (incidence) and prevalence of both contagious and non-contagious diseases and the applicability to medical institutions were researched along the lower course of the Rioni River (Senaki and Khobi municipalities).

In order to study the structure of population morbidity and the trends of disease prevalence in these municipalities, official statistical information on the spread of disease in Senaki and Khobi municipalities, in Segrelo-Zemo Svaneti region and all over Georgia in 2000-2010 was examined. Rates of morbidity (incidence) and disease prevalence were analyzed in support of the abovementioned reasons.

***The total increase in morbidity and prevalence of the disease.*** Analysis of the total number of ward and poly-clinic referral rates, ambulance calls and per capita rates of referral data showed that in 2000-2010 the average referral rate amounted to 1.3 in the target area, which is 1.4 less than the average index for the entire country (1.83). Physician referral rates were highest in 2005-2006 (respectively, 1.64 and 1.93.) However, even in these years, medical institution referral rates were lower (2.1) than the average country rate of 2.2.

Trend analysis of general morbidity rates (incidence) and prevalence demonstrates that from 2004 an increasing trend of these indexes was observed in the target municipalities, which reached its peak in 2006.

Respectively, these years were marked with morbidity rates higher than the overall regional and national levels. This fact is also consistent with the high rates of physician referral which were observed in 2005-2006.

***Transmitted diseases*****.** Increasing trends of transmitted diseases were observed in 2000-2006, and in 2007 prevalence of transmitted diseases decreased. From 2000-2006 the incidence of this group of pathologies was higher than the regional rates.

Increasing rates of transmitted diseases reported across the whole country are conditioned by poor sanitary and hygienic conditions, increases in upper respiratory tract infections and diarrheal diseases, better medical facilities and higher physician references, and with registration improvements. However, this trend was evident in the target municipalities in 2000-2006, when prevalence of this group of pathologies exceeded regional and in 2006 the country's overall rates.

***Cancers***. Data analysis of cancer prevalence rates in 2000-2010 in medical facilities showed a growth trend in 2006-2010. Rates reported in 2002-2010 were considerably higher than the overall regional rates, and approached country rates, which indicate a high level of this group of pathologies in the target area.

***Diseases of the blood and blood-forming organs***. Diseases of the blood and blood-forming organs in the performance analysis showed that in 2000-2010 low indicators of this group of pathology were observed, and were significantly lower than the same regional and national indicators.

***Endocrine, nutrition and metabolic disorders.*** Analysis of the prevalence of endocrine diseases in 2000-2010 shows that these figures were significantly lower than regional and national figures. In addition, this group of diseases did not demonstrate a marked tendency of increase or decrease.

Diabetes prevalence rates were significantly higher than general regional indicators. Growth in the rates is observed in 2000-2006, but in 2007-2010 rates of Senaki Municipality were considerably lower than general regional indicators. In 2006 the disease reached its peak, which is consistent with the high rates of physician referral.

***Diseases of the nervous system.*** The ten-year trend analysis indicates that the spread of the diseases of the nervous system in the target municipalities lagged behind the general country rates, while in 2005-2010 it was ahead of the regional level, which indicates a relatively high prevalence of this group of pathologies.

***Diseases of the circulatory system.*** Incidences of circulatory diseases at the level of the target area are quite high. In many cases (in 2005-2007 and 2009-2010) it exceeded Samegrelo-Zemo Svaenti regional and national levels, which indicates the high sensitivity of this group of diseases and pathologies.

High prevalence of hypertension and ischemic heart diseases were observed in Senaki district. In 2008 indicators of prevalence of these pathologies reached a peak, when the municipal and national rates exceeded 1.7 and 2.8 times respectively.

***Diseases of the respiratory system.*** Analysis of ten-year dynamics of respiratory system diseases shows that in Senaki and Khobi municipalities respiratory diseases reached a high level compared with regional rates. The prevalence reached its peak in 2006, when the municipal indicators surpassed the regional and country levels. Bronchial asthma prevalence is also high in these districts, but significantly lower than the regional indicators.

***Diseases of the digestive system.*** Statistical analysis of 2000-2010 data showed a relatively low level of morbidity from digestive system diseases in the municipalities compared to overall level in the country. But in 2004-2008, municipal rates for prevalence of this group of pathologies were higher than the regional level.

***Diseases of the genitourinary system.*** Prevalence of genitourinary system diseases shows (2000-2010 trends) that prevalence rates for this group of pathologies are high, and in 2004-2007 were significantly higher than the regional and national rates. In addition, the prevalence peak was observed in 2008, when municipal indicators exceeded regional levels by 2.3 times. Generally, the trend indicates a high level of incidences of this group of pathologies.

***Musculoskeletal and connective tissue diseases.*** The 2000-2007 analysis of prevalence indicators of musculoskeletal system and connective tissue pathologies shows that the tendency for this group of diseases increased greatly in Senaki and Khobi municipalities. The peak was observed in 2007, and in 2000-2008 local municipal rates were higher than regional and national rates. Therefore, we can conclude that there will be an increased growth trend in the spread of these diseases***.***

***Accidents and injuries.*** In the target area extremely high level of incidences are caused by traumas and accidents. It should be noted that these figures are significantly higher than both the regional and the country's overall figures for the years 2001-2008.

***Congenital malformations and developmental abnormalities***. Prevalence of this group of diseases was significantly lower in both Senaki and Khobi municipalities as compared to national or regional rates.

## 2. Vulnerability to Climate Change and Natural Disasters in Lower Alazani-Iori Pilot Watershed Area

The character of expected processes on the target municipal territories was defined based on analysis of the observation data on meteorological elements of the target territory in years 1956-2005, also by comparing and accumulating the data of regional PRECIS, ECHAM4, and HadCM3 climate models and A2 and B2 scenarios of world socio-economic development.

In 2020-2050 on the lower Rioni River, municipalities should expect the following:

**Senaki Municipality.** Increase in average air temperature and average maximum temperature by about 1.7-2.5$^0$C; increase in the absolute maximum by 2$^0$C (45$^0$C instead of 43$^0$C); warming of absolute minimum by 1.8-2.0$^0$C (-7.5-7.8$^0$C instead of -9.8$^0$C); increased total annual atmospheric precipitation (1,800-2,000 mm instead of 1,785 mm); sharp enhancement of daily atmospheric precipitation (237 mm instead of 182 mm); increased number of days with heavy rainfall (≥ 50; ≥ 90) compared to the baseline period of 2-25 days; rise in the number of tropical days and nights respectively by 20-25 and 15-20 occurrences; slight increase of freezing nights as well as slight decrease of freezing days.

**Khobi Municipality.** Increase in average annual air temperature and average maximum temperature by about 2$^0$C; warming of absolute minimum; increased total annual atmospheric precipitation by 8-21%; sharp enhancement of average daily atmospheric precipitation (intensified rainfalls); insignificant change in average and maximum wind speeds. It should be noted that Khobi municipality is distinguished by a rainy climate, where total annual precipitation equals 1,700-1,750 mm, the monthly average maximum ranges from 114 to 177 mm, and the daily maximum reaches 250-270 mm. The indices of atmospheric precipitation are expected to increase in coming decades.

The results of described changes in the lower Rioni River Basin are explained below:

### *2.1 Flood and Freshet Risk Assessment in General Terms of Expected Climate Changes in Lower Rioni Basin*

Flood and freshet risk is the likelihood of their occurrence and their environmental and economic impacts. Flood and freshet risks imply the danger and impact of their generation. Risk can be estimated with frequency probability methods, and the impact risk can be estimated by assessing damage and feedback. The frequency is observed values in the past, the probability is the possibility of a future occurrence. Frequency is the result of what has already happened, and probability is a forecast of what may occur.

In order to explore and analyze flood and freshet risks in the lower Rioni River basin, the following materials were used:

- Sakochakidze village hydrological data gained through exploration
- The climate change scenarios developed for Khobi and Senaki municipalities for the years 2020-2050.

The discharge mode of the Rioni River is characterized by spring and summer floods, which are caused by snowmelt, rainfall, and freshets throughout the year. Great intensity of precipitation is observed in this watershed basin, and therefore catastrophic freshets occur periodically in the lower course of the basin. For example, on February 1, 1987, when the Rioni River flooded, its discharge reached 5,000 $m^3$. It was later joined by the currents from Vartsikhe reservoir that emptied 1,600 $m^3$ and caused flooding of both banks of the lower

Rioni River within the boundaries of Senaki and Khobi municipalities. Other extensive floods took place on December 30, 1996 and in September and October, 2008.

In order to determine flood and freshet risk periods on the Rioni River, observation data from 1947-1986 at the Sakochakidze village hydrological station were used. The observations were carried out on water discharges in the years 1938-1946, with the exception of some years; from 1947-1986 the data is continuous. For estimation of flood and freshet risk periods, average monthly, average of instantaneous maximum, observed instantaneous maximum and observed daily maximum discharges were evaluated. The values are given in Table 2.1 and Figures 2.1 and 2.2.

***Table 2.1. River discharges. Observation data, hydrostation Sakochakidze on the Rioni River***

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | $Q_{av.}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average monthly | 295 | 365 | 458 | 646 | 660 | 539 | 394 | 297 | 242 | 301 | 327 | 352 | 406 |
| Average of instantaneous maximum | 773 | 916 | 1086 | 1399 | 1267 | 1292 | 994 | 927 | 631 | 932 | 1080 | 1198 | 1041 |
| Average of daily maximum | 696 | 834 | 982 | 1261 | 1206 | 1151 | 909 | 814 | 570 | 862 | 947 | 1055 | 941 |
| Observed instantaneous maximum | 1840 | 2280 | 2520 | 4650 | 2280 | 3000 | 2580 | 3520 | 1590 | 2140 | 3330 | 2780 | |
| Observed daily maximum | 1840 | 2210 | 2390 | 3430 | 2280 | 2580 | 2340 | 3310 | 1360 | 2040 | 3160 | 2480 | |

***Diagram 2.1. Average Multiannual discharge (Rioni River – Sakochakidze Village)***

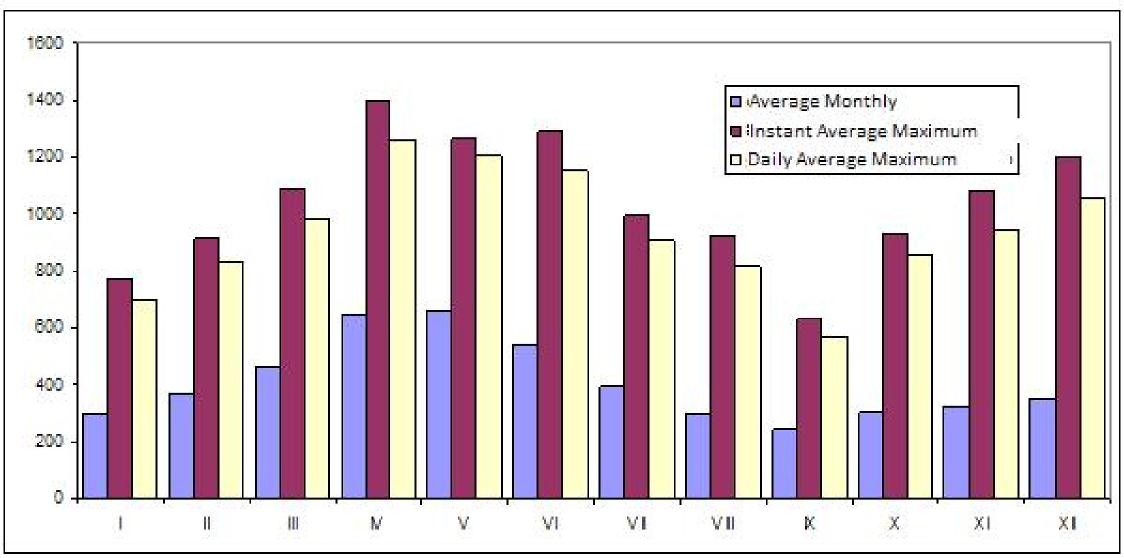
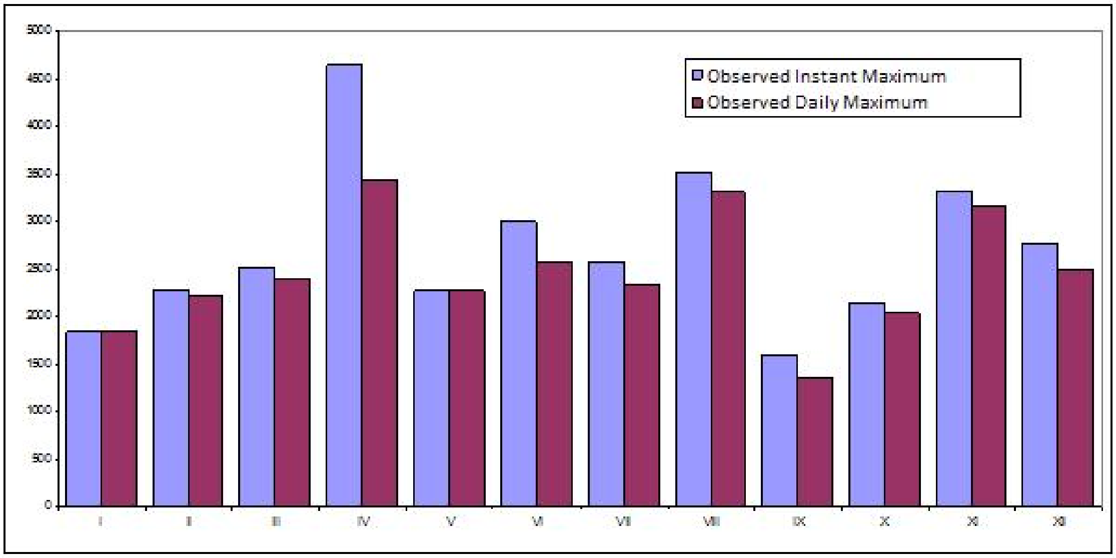


***Diagram 2.2. Observed maximum discharges (Rioni River – Sakochakidze Village)***




The maximum annual discharges per year during the observation period are illustrated in Table 2.2:

***Table 2.2. Amount of maximum annual discharges per year in observation period***

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Number of days (1947-86)** | 0 | 6 | 5 | 7 | 2 | 4 | 2 | 2 | 0 | 4 | 3 | 5 | 40 |
| **% (1947-86)** | 0 | 15 | 13 | 18 | 5 | 10 | 5 | 5 | 0 | 10 | 8 | 13 | 100 |
| **Number of days (1967-86)** | 0 | 4 | 1 | 2 | 1 | 3 | 1 | 2 | 0 | 0 | 2 | 4 | 20 |
| **% (1967-86)** | 0 | 20 | 5 | 10 | 5 | 15 | 5 | 10 | 0 | 0 | 10 | 20 | 100 |

For reference, intervals of water discharges were selected as 800 $m^3/s$ to 3,600 $m^3/s$, with increments of 400 $m^3/s$. The continuous span of years 1947-1986 was applied as a reporting period.

***Table 2.3. Number of days when maximum discharges ($m^3/s$) occurred in different intervals (observation period 1947-1986)***

| | I | | II | | III | | IV | | V | | VI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | | Number | | Number | | Number | | Number | | Number | |
| **3,200-3,600** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| **2,800-3.199** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| **2,400-2,799** | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 1 | 1 |
| **2,000-2,399** | 0 | 0 | 2 | 2 | 2 | 2 | 0 | 4 | 1 | 1 | 6 | 7 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,600-1,999 | 1 | 1 | 3 | 5 | 4 | 6 | 11 | 15 | 14 | 15 | 8 | 15 |
| 1,200-1,599 | 3 | 4 | 17 | 22 | 21 | 27 | 53 | 68 | 32 | 47 | 15 | 30 |
| 800-1,199 | 23 | 27 | 42 | 64 | 73 | 100 | 218 | 286 | 198 | 245 | 81 | 111 |

| | VII | | VIII | | XI | | X | | XI | | XII | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | | Number | | Number | | Number | | Number | | Number | |
| 3,200-3,600 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2,800-3.199 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 2,400-2,799 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 |
| 2,000-2,399 | 3 | 3 | 1 | 3 | 0 | 0 | 1 | 1 | 5 | 7 | 5 | 5 |
| 1,600-1,999 | 2 | 5 | 3 | 6 | 0 | 0 | 7 | 8 | 5 | 12 | 7 | 12 |
| 1,200-1,599 | 4 | 9 | 4 | 10 | 3 | 3 | 14 | 22 | 20 | 32 | 15 | 27 |
| 800-1,199 | 39 | 48 | 21 | 31 | 7 | 10 | 32 | 54 | 36 | 68 | 54 | 81 |

Table 2.3 illustrates the duration of discharge standing, or a number of days in the reporting period when more or equal discharges to a given value are observed (i.e., the number of days between a given interval and its upper interval).

As illustrated in Tables 2.2 and 2.3, flood and freshet risk is small in I and IX months, but in the rest of the months, these risks are significant and are characterized approximately by similar frequency. Aprils are often distinguished by their frequency.

***Table 2.4. Decreasing row of maximum instantaneous discharges (monthly, yearly), Rioni River –Sakochakidze Hydrostation***

| N | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual | P% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1840 | 2280 | 2520 | 4650 | 2280 | 3000 | 2580 | 3520 | 1590 | 2140 | 3330 | 2780 | 4650 | 2.4 |
| 2 | 1530 | 2190 | 2200 | 3510 | 2210 | 2630 | 2380 | 2480 | 1440 | 2060 | 2850 | 2670 | 3510 | 4.9 |
| 3 | 1360 | 1850 | 2080 | 2280 | 2170 | 2540 | 2330 | 2040 | 1240 | 1930 | 2810 | 2450 | 2810 | 7.3 |
| 4 | 1320 | 1790 | 1780 | 1940 | 2040 | 2020 | 2110 | 1830 | 1140 | 1740 | 2720 | 2260 | 2720 | 9.8 |
| 5 | 1160 | 1750 | 1720 | 1930 | 2020 | 1990 | 1850 | 1440 | 994 | 1740 | 2000 | 2250 | 2250 | 12.2 |
| 6 | 1130 | 1590 | 1690 | 1920 | 1920 | 1930 | 1610 | 1430 | 987 | 1720 | 1680 | 2240 | 2240 | 14.6 |
| 7 | 1100 | 1560 | 1640 | 1820 | 1860 | 1780 | 1460 | 1360 | 880 | 1590 | 1670 | 2030 | 2030 | 17.1 |
| 8 | 1090 | 1500 | 1520 | 1720 | 1850 | 1770 | 1340 | 1350 | 877 | 1570 | 1610 | 1650 | 1850 | 19.5 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 1080 | 1440 | 1500 | 1650 | 1710 | 1630 | 1320 | 1330 | 813 | 1420 | 1590 | 1510 | 1710 | 22.0 |
| 10 | 1080 | 1300 | 1410 | 1630 | 1670 | 1600 | 1290 | 1220 | 804 | 1400 | 1500 | 1480 | 1670 | 24.4 |
| 11 | 1060 | 1250 | 1370 | 1530 | 1570 | 1590 | 1230 | 1160 | 761 | 1400 | 1500 | 1480 | 1590 | 26.8 |
| 12 | 1010 | 1100 | 1290 | 1520 | 1560 | 1580 | 1230 | 1080 | 748 | 1250 | 1300 | 1430 | 1580 | 29.3 |
| 13 | 923 | 1080 | 1270 | 1500 | 1560 | 1580 | 1220 | 1060 | 724 | 1190 | 1200 | 1420 | 1580 | 31.7 |
| 14 | 903 | 1040 | 1160 | 1490 | 1540 | 1430 | 1060 | 1040 | 716 | 1140 | 1120 | 1380 | 1540 | 34.1 |
| 15 | 899 | 875 | 1150 | 1400 | 1460 | 1400 | 1040 | 970 | 670 | 1080 | 1100 | 1270 | 1460 | 36.6 |
| 16 | 844 | 828 | 1130 | 1380 | 1460 | 1360 | 1040 | 934 | 665 | 1072 | 1060 | 1270 | 1460 | 39.0 |
| 17 | 841 | 798 | 1080 | 1350 | 1360 | 1310 | 1030 | 896 | 654 | 1060 | 1040 | 1200 | 1360 | 41.5 |
| 18 | 830 | 784 | 1010 | 1320 | 1290 | 1230 | 934 | 839 | 654 | 969 | 984 | 1190 | 1320 | 43.9 |
| 19 | 817 | 774 | 1010 | 1300 | 1180 | 1210 | 785 | 837 | 652 | 884 | 895 | 1170 | 1300 | 46.3 |
| 20 | 785 | 760 | 976 | 1300 | 1170 | 1140 | 760 | 797 | 604 | 870 | 872 | 1170 | 1300 | 48.8 |
| 21 | 765 | 720 | 907 | 1290 | 1160 | 1140 | 742 | 795 | 578 | 815 | 810 | 1160 | 1290 | 51.2 |
| 22 | 760 | 676 | 871 | 1160 | 1120 | 1120 | 734 | 788 | 578 | 799 | 779 | 1060 | 1160 | 53.7 |
| 23 | 745 | 667 | 866 | 1110 | 1060 | 1040 | 715 | 706 | 544 | 779 | 779 | 1050 | 1110 | 56.1 |
| 24 | 586 | 643 | 861 | 1090 | 1010 | 1030 | 667 | 607 | 525 | 698 | 772 | 983 | 1090 | 58.5 |
| 25 | 584 | 611 | 851 | 1060 | 994 | 990 | 631 | 585 | 515 | 619 | 737 | 831 | 1060 | 61.0 |
| 26 | 532 | 596 | 803 | 1050 | 960 | 967 | 599 | 580 | 496 | 530 | 720 | 820 | 1050 | 63.4 |
| 27 | 530 | 589 | 795 | 1020 | 924 | 958 | 575 | 574 | 479 | 465 | 716 | 811 | 1020 | 65.9 |
| 28 | 495 | 587 | 762 | 1000 | 911 | 920 | 567 | 486 | 427 | 453 | 575 | 780 | 1000 | 68.3 |
| 29 | 492 | 568 | 750 | 990 | 892 | 885 | 562 | 452 | 421 | 447 | 568 | 768 | 990 | 70.7 |
| 30 | 479 | 550 | 731 | 963 | 797 | 880 | 550 | 427 | 367 | 443 | 512 | 701 | 963 | 73.2 |
| 31 | 440 | 532 | 692 | 954 | 773 | 875 | 541 | 425 | 364 | 409 | 502 | 684 | 954 | 75.6 |
| 32 | 423 | 492 | 686 | 954 | 744 | 785 | 532 | 400 | 363 | 392 | 471 | 631 | 954 | 78.0 |
| 33 | 401 | 473 | 642 | 916 | 744 | 776 | 530 | 388 | 315 | 390 | 443 | 614 | 916 | 80.5 |
| 34 | 382 | 411 | 638 | 886 | 738 | 755 | 526 | 376 | 292 | 328 | 434 | 522 | 886 | 82.9 |
| 35 | 372 | 408 | 615 | 868 | 720 | 747 | 522 | 348 | 282 | 326 | 370 | 514 | 868 | 85.4 |
| 36 | 315 | 380 | 585 | 842 | 706 | 734 | 500 | 342 | 278 | 307 | 335 | 476 | 842 | 87.8 |
| 37 | 315 | 368 | 509 | 765 | 702 | 720 | 496 | 315 | 268 | 298 | 305 | 472 | 765 | 90.2 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | 267 | 324 | 465 | 710 | 659 | 687 | 418 | 309 | 231 | 248 | 298 | 392 | 710 | 92.7 |
| 39 | 234 | 269 | 454 | 646 | 615 | 568 | 416 | 285 | 168 | 168 | 154 | 302 | 646 | 95.1 |
| 40 | 195 | 253 | 436 | 534 | 568 | 396 | 349 | 280 | 155 | 143 | 100 | 53.2 | 568 | 97.6 |

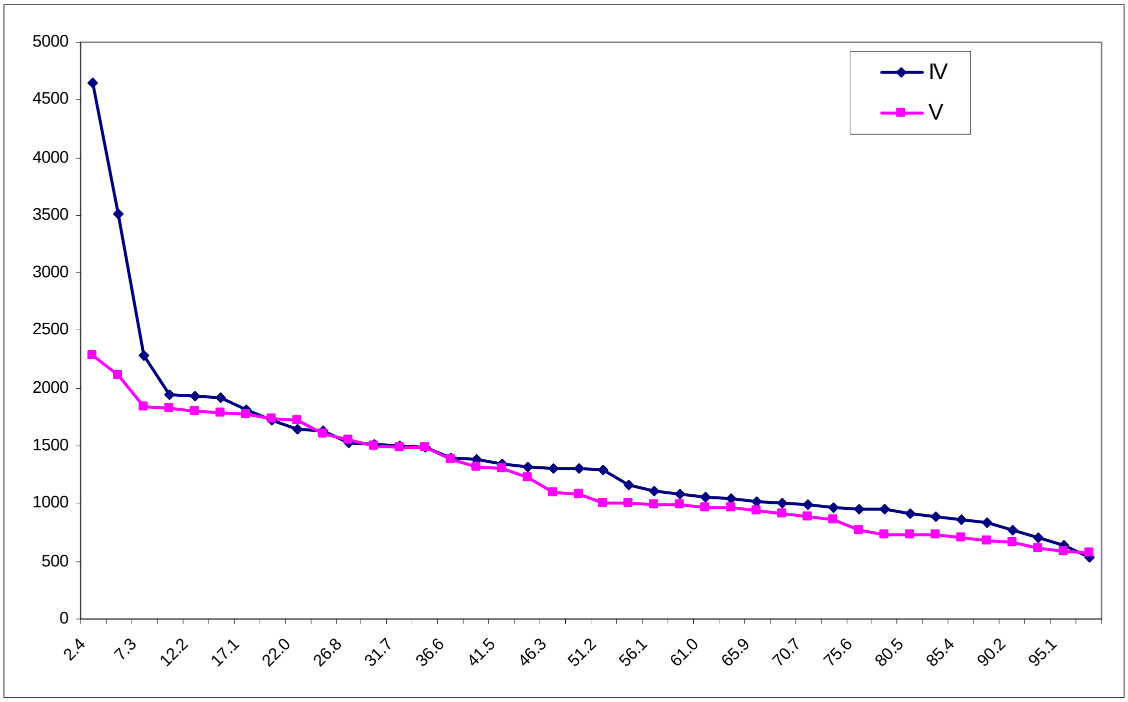
***Table 2.5. Decreasing row of maximum daily discharges (montly, yearly)***

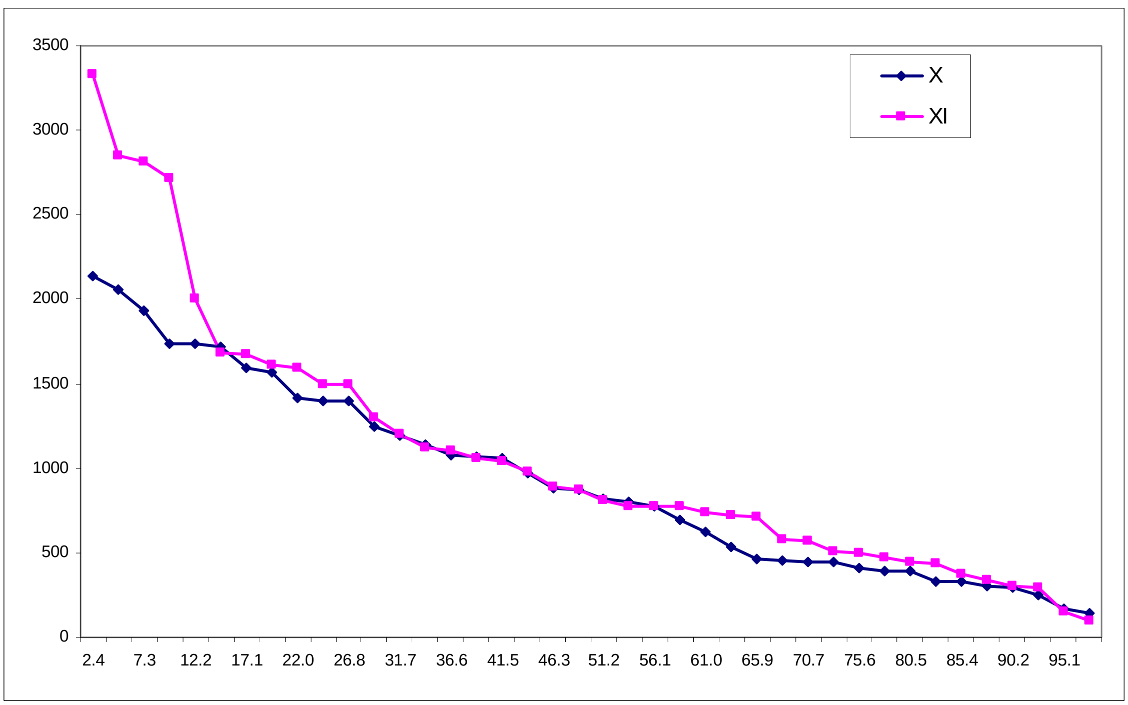
| N | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual | P% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1840 | 2210 | 2390 | 3430 | 2280 | 2580 | 2340 | 3310 | 1360 | 2040 | 3160 | 2480 | 3430 | 2.4 |
| 2 | 1350 | 2110 | 2170 | 2890 | 2110 | 2270 | 2220 | 2160 | 1350 | 1940 | 2650 | 2380 | 2890 | 4.9 |
| 3 | 1330 | 1690 | 1670 | 1950 | 1840 | 1980 | 2120 | 1760 | 1220 | 1850 | 1940 | 2080 | 2120 | 7.3 |
| 4 | 1130 | 1660 | 1620 | 1840 | 1830 | 1900 | 1960 | 1690 | 1080 | 1710 | 1800 | 2000 | 1960 | 9.8 |
| 5 | 1080 | 1630 | 1600 | 1750 | 1800 | 1670 | 1590 | 1320 | 920 | 1700 | 1750 | 1960 | 1800 | 12.2 |
| 6 | 1050 | 1550 | 1570 | 1680 | 1790 | 1620 | 1270 | 1210 | 832 | 1690 | 1590 | 1930 | 1790 | 14.6 |
| 7 | 1040 | 1320 | 1540 | 1660 | 1780 | 1610 | 1240 | 1150 | 728 | 1500 | 1480 | 1640 | 1780 | 17.1 |
| 8 | 914 | 1320 | 1420 | 1570 | 1730 | 1550 | 1230 | 1130 | 717 | 1330 | 1460 | 1580 | 1730 | 19.5 |
| 9 | 904 | 1310 | 1280 | 1560 | 1720 | 1550 | 1180 | 1060 | 703 | 1260 | 1390 | 1380 | 1720 | 22.0 |
| 10 | 900 | 1060 | 1250 | 1490 | 1600 | 1540 | 1168 | 978 | 701 | 1260 | 1380 | 1360 | 1600 | 24.4 |
| 11 | 894 | 1040 | 1210 | 1380 | 1550 | 1540 | 1150 | 970 | 671 | 1240 | 1370 | 1200 | 1550 | 26.8 |
| 12 | 848 | 1010 | 1170 | 1370 | 1500 | 1460 | 1140 | 950 | 664 | 1090 | 1100 | 1190 | 1500 | 29.3 |
| 13 | 822 | 950 | 1130 | 1360 | 1490 | 1320 | 1130 | 862 | 654 | 1060 | 1060 | 1160 | 1490 | 31.7 |
| 14 | 769 | 908 | 1110 | 1360 | 1490 | 1260 | 1000 | 842 | 649 | 1030 | 1060 | 1120 | 1490 | 34.1 |
| 15 | 756 | 860 | 1110 | 1310 | 1380 | 1230 | 960 | 838 | 622 | 1020 | 1030 | 1120 | 1380 | 36.6 |
| 16 | 750 | 785 | 1020 | 1300 | 1320 | 1200 | 955 | 809 | 605 | 1010 | 1030 | 1100 | 1320 | 39.0 |
| 17 | 741 | 763 | 870 | 1290 | 1300 | 1190 | 870 | 769 | 597 | 905 | 965 | 1070 | 1300 | 41.5 |
| 18 | 712 | 713 | 848 | 1270 | 1230 | 1160 | 835 | 707 | 547 | 828 | 818 | 1060 | 1270 | 43.9 |
| 19 | 706 | 707 | 844 | 1250 | 1100 | 1080 | 828 | 702 | 528 | 786 | 771 | 1040 | 1250 | 46.3 |
| 20 | 705 | 671 | 835 | 1220 | 1080 | 1070 | 726 | 697 | 523 | 760 | 748 | 1010 | 1220 | 48.8 |
| 21 | 675 | 636 | 833 | 1110 | 1010 | 1040 | 693 | 683 | 515 | 741 | 694 | 991 | 1110 | 51.2 |
| 22 | 655 | 589 | 795 | 1070 | 1010 | 992 | 684 | 659 | 491 | 718 | 684 | 970 | 1070 | 53.7 |
| 23 | 651 | 575 | 790 | 1060 | 994 | 926 | 666 | 632 | 484 | 688 | 667 | 846 | 1060 | 56.1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 566 | 574 | 781 | 1000 | 988 | 925 | 651 | 592 | 484 | 664 | 663 | 827 | 1000 | 58.5 |
| 25 | 528 | 563 | 767 | 984 | 970 | 902 | 624 | 557 | 480 | 570 | 655 | 822 | 984 | 61.0 |
| 26 | 504 | 555 | 754 | 966 | 964 | 885 | 616 | 535 | 474 | 520 | 638 | 763 | 966 | 63.4 |
| 27 | 504 | 545 | 715 | 965 | 934 | 865 | 560 | 508 | 473 | 491 | 568 | 738 | 965 | 65.9 |
| 28 | 484 | 517 | 695 | 964 | 911 | 856 | 535 | 450 | 397 | 438 | 566 | 690 | 964 | 68.3 |
| 29 | 464 | 510 | 673 | 911 | 892 | 840 | 522 | 412 | 385 | 433 | 517 | 675 | 911 | 70.7 |
| 30 | 448 | 458 | 650 | 906 | 856 | 768 | 503 | 379 | 364 | 419 | 507 | 669 | 906 | 73.2 |
| 31 | 390 | 442 | 632 | 890 | 765 | 765 | 484 | 378 | 358 | 396 | 466 | 611 | 890 | 75.6 |
| 32 | 388 | 439 | 611 | 875 | 733 | 717 | 482 | 376 | 334 | 395 | 435 | 607 | 875 | 78.0 |
| 33 | 374 | 399 | 582 | 846 | 729 | 711 | 472 | 370 | 302 | 310 | 420 | 586 | 846 | 80.5 |
| 34 | 360 | 396 | 568 | 820 | 728 | 698 | 471 | 342 | 292 | 296 | 397 | 499 | 820 | 82.9 |
| 35 | 359 | 388 | 565 | 820 | 711 | 643 | 469 | 326 | 270 | 292 | 350 | 495 | 820 | 85.4 |
| 36 | 310 | 367 | 484 | 804 | 674 | 640 | 464 | 308 | 257 | 291 | 310 | 453 | 804 | 87.8 |
| 37 | 302 | 355 | 453 | 706 | 663 | 574 | 460 | 298 | 256 | 260 | 295 | 423 | 706 | 90.2 |
| 38 | 251 | 314 | 451 | 683 | 619 | 562 | 397 | 283 | 190 | 246 | 276 | 354 | 683 | 92.7 |
| 39 | 212 | 233 | 433 | 628 | 591 | 541 | 380 | 271 | 166 | 162 | 153 | 276 | 628 | 95.1 |
| 40 | 193 | 230 | 405 | 485 | 568 | 391 | 334 | 268 | 150 | 134 | 85 | 51 | 568 | 97.6 |

Tables 2.4 and 2.5 illustrate I-XII months and decreasing rows of annual instantaneous and observed daily discharges and corresponding empirical values in percentage in sequence with row numbers. $P = \frac{m}{n+1}100\%$, where $m$ is a row number, and $n$ - observed number ( $n$ = 40). Tables allow us to compare variance ranges of maximum discharges in certain months, and values of empirical provision for annual and monthly discharges.

***Diagram 2.3. Empirical provision curves for IV-V, X-XI months and yearly Instantaneous maximum discharges (Rioni River – Sakochakidze Village)***


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2.4
7.3
12.2
17.1
22.0
26.8
31.7
36.6
41.5
46.3
51.2
56.1
61.0
65.9
70.7
75.6
80.5
85.4
90.2
95.1
IV
V


3500
3000
2500
2000
1500
1000
500
0
2.4
7.3
12.2
17.1
22.0
26.8
31.7
36.6
41.5
46.3
51.2
56.1
61.0
65.9
70.7
75.6
80.5
85.4
90.2
95.1
X
XI

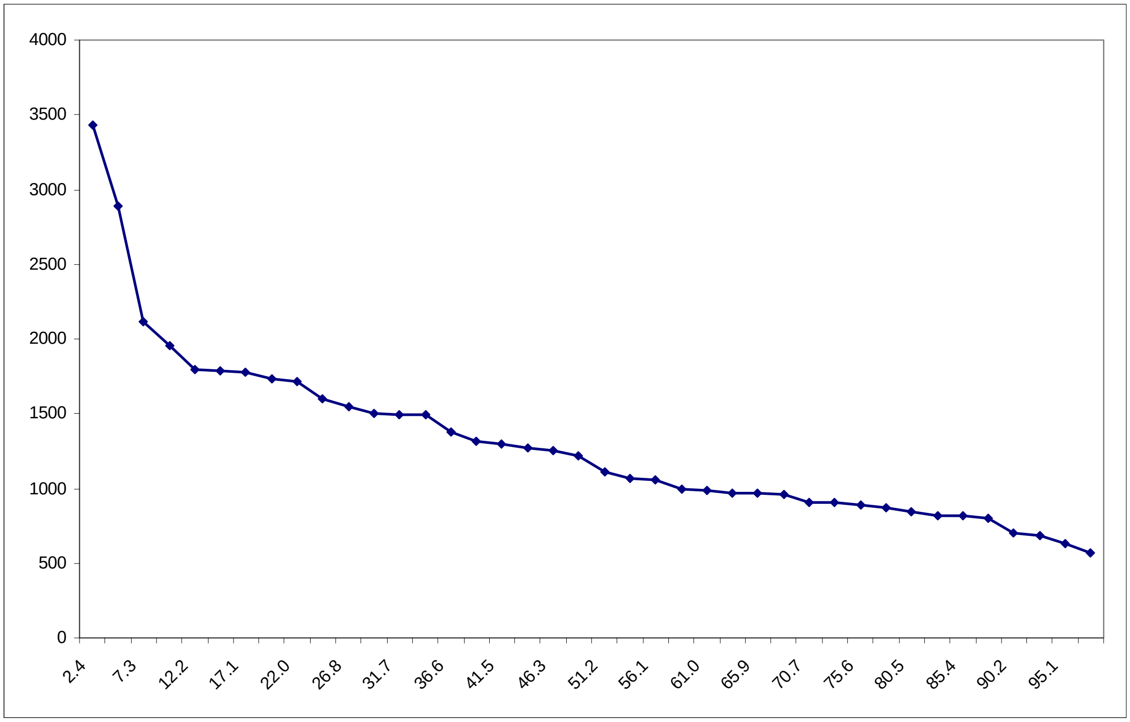


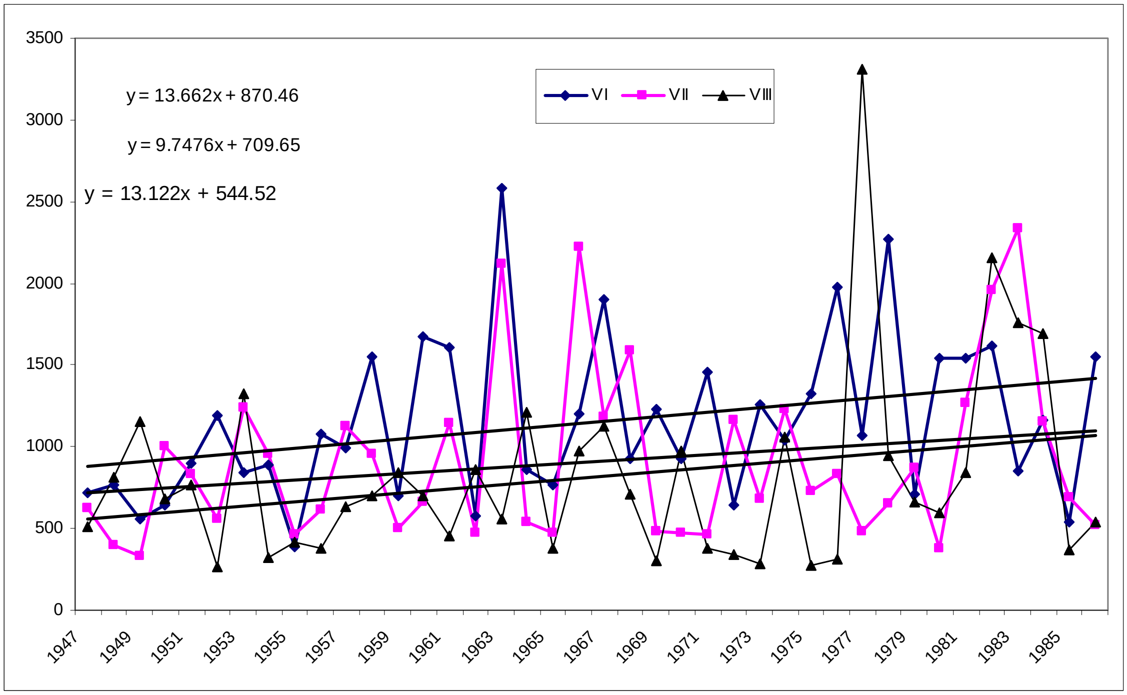

Figure 2.3. illustrates curves for empirical provision of IV-V, X-XI months and for a whole year.

In order to determine flood and freshet dynamics, correlation coefficients (of separate monthly trends) between the maximum discharges and a sequential number for 1947-1986 continuous period (which is given in Table 2.6) were estimated, which shows that the trend is observed only in VI, VII, VIII months and especially, for maximum yearly discharges (r = 0.45).

***Table 2.6. Correlation Coefficients for maximum discharge trends (Rioni River –Sakochakidze Hydrostation)***

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annula |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1947 - 1986** | -0.12 | -0.05 | -0.12 | 0.19 | 0.08 | 0.32 | 0.22 | 0.26 | -0.14 | -0.15 | 0.17 | 0.16 | 0.45 |

***Diagram 2.4. Variance curves of maximum discharges for VI-VII-VIII months and for the whole year (1947-1986, Rioni River –Sakochakidze Hydrostation)***



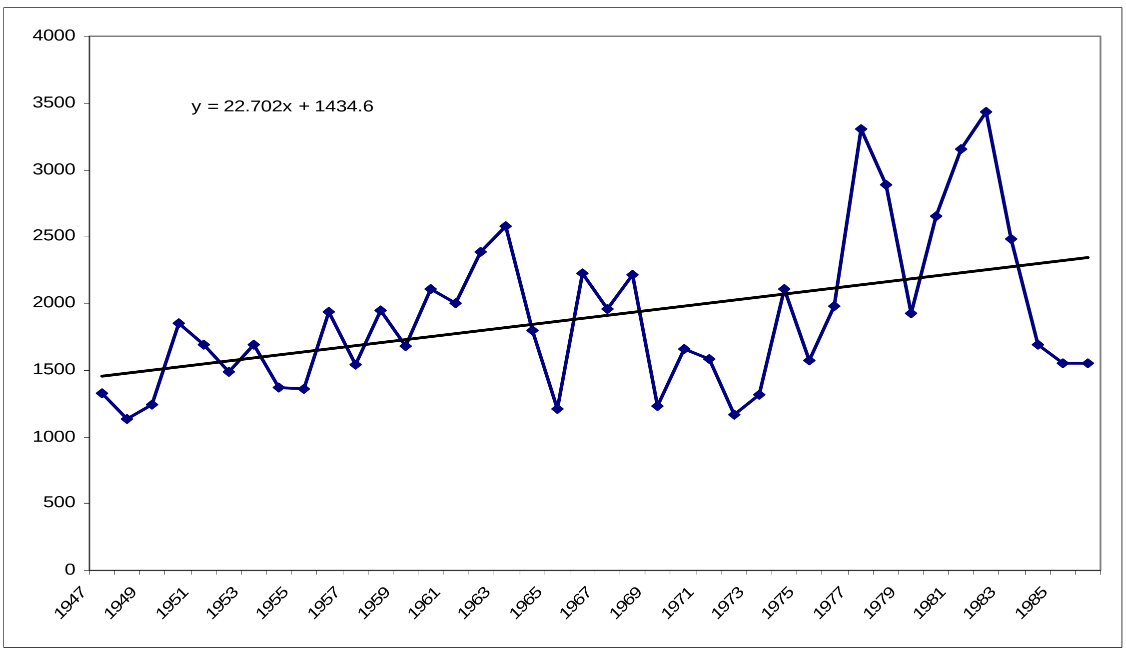




***Table 2.7. Correlation coefficients of daily maximum precipitation and maximum discharge on the same day (1), and maximum daily discharges and precipitation of the same day (2)***

| *r* | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.32 | 0.39 | 0.23 | 0.30 | 0.12 | 0.02 | 0.52 | 0.11 | 0.48 | 0.33 | 0.38 | 0.51 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0.38 | 0.55 | 0.13 | 0.45 | 0.12 | 0.25 | 0.65 | 0.25 | 0.46 | 0.58 | 0.36 | 0.17 |

1 d $Q_{day} = f\left(X_{day}^{max}\right)$; 2 d $Q_{day}^{max} = f\left(X_{day}\right)$

Correlation coefficient values were assessed for I-XII months, between daily maximum precipitation and maximum discharge on the same day, and the maximum daily discharges and precipitation of the same day, which is illustrated in Table 2.7. From the values given in the Table, VII month rainfall influence on maximum discharges is quite significant, and is less in V-VI months, which indicates that the major determinant factor of maximum discharges is snowmelt.

Regarding the abovementioned information and according to the climate scenarios, in 2020-2050 total annual atmospheric precipitation in the target area, compared with the baseline period (1956-2006), may increase by 9-22%.

In addition, an increase in maximum daily precipitation is expected (237 mm instead of 183 mm in baseline period) and a significant increase in average daily precipitation maximums. Therefore, we can assume that in 2020-2050, in the lower Rioni River basin, willmaintain or increase the high risk of strong, frequently catastrophic floods and freshets on the Rioni River (and partly in the Tekhura River). Relevant statistical evidence confirms that the part of Odishi Plain surface, which is the target area within the boundaries of INRMW program, has been flooded several times with powerful torrents of the Rioni, as well as partly by the Tekhura River during the last 100-120 years (1895, 1922, 1983, 1987, 1996.). Consequences of the Rioni River flood in January 30-31, 1987 are especially noteworthy. Due to this flood approximately 10-12 thousand ha of agricultural land located in Khobi and Senaki municipalities on both sides of the Rioni, was flooded by torrents 1-3 m deep. It damaged or completely destroyed more than 1,600 buildings. Infrastructure facilities (roads, irrigation canals, water facilities, etc.) were badly damaged or completely malfunctioned. More than 6,000 cattle were killed. Also, flooding of agricultural lands and crofts in Mukhuri, Siriachkonis, Teklati, Akhalsopeli villages is noteworthy. It should be specially noted that torrents 2-3 m deep flooded the area at the confluence of the Rioni and Tekhura rivers, resulting in damaged or completely destroyed roads, buildings, bridges and agricultural crops.

Analysis of causes for severe floods within the boundaries of the target area shows that occurrence of natural disasters has intensified: strength of freshets and the accompanying damage has increased during last 100-120 years.

This fact, in conjunction with natural geo-morphological and hydro-climatic features of the Rioni and Tekhura drainage basins, was conditioned by the progressively increasing impact of anthropogenic interventions.

Out of these factors utmost attention should be given to the process of forest cutting. A significant part of the natural rainforests in the river drainage basins was clear-cut. The forest cover, together with the climate, plays an important role in determining the river's hydrological regime. In the forested drainage basins, volume of surface runoff and maximum discharges are considerably less compared to the capacity of the deforested drainage basins of the same area and climatic conditions. Accordingly, runoff volume and maximum discharges of the deforested (or strongly degraded forest cover) rivers are bigger and thus, the probability of stronger (catastrophic) freshets in such basins is higher. In the Rioni drainage basin (especially themiddle and upper courses of the basin), forest cover is heavily degraded due to unsystematic cutting. Consequently, the drainage and water regulation function of this basin is substantially disrupted. This is one of the main reasons for the destructive and catastrophic flood occurrences in the lower course of the basin.

In the target area, one of the reasons for increased floods and freshets in 2020-2050 could be the rise of the average multiannual level of the Black Sea by at least several dozen centimeters. It is known that rise of sea level is caused by global warming. In this case, rivers (Rioni, Khobistskali) will flood at their conjunction. This will cause the water level to rise in the river beds during the floods and the overflowing torrent will cause intensified flooding of the surrounding areas.

### *2.2 Coastal Erosion*

The sea level rise caused by global warming will contribute to washing off the land directly adjacent to the coastline (marine and terrestrial touchline) of the target area and will enhance the retreat process. This process has been going on for several decades, and it was caused by negative impact of anthropogenic factors on the surface of the seashore (various engineering measures including modernization of the old port, construction of a new port, construction of wave barriers and dams for protecting their domestic waters, removal of bank feeding inert materials from the beaches, etc.).

### *2.3 Soil Degradation*

In 2020-2050, a forecasted increase in air temperature and atmospheric precipitation compared to the baseline period (1956-2004) as well as negative impacts of anthropogenic factors will create more favorable conditions for soil degradation and deterioration of fertility around the lower Rioni basin.

Modification of the main characteristics of the soil with respect to possible climate change should be expected. Namely, within the target area and along the river beds, floodplain area washing and swamping due to the influence of climatic and anthropogenic factors are projected, which will further contribute to soil degradation, bogging, and to changes in physical and chemical properties.

### *2.4 Natural Vegetation*

As a respective chapter of the report demonstrated, across the target area meteorological changes are forecasted in the years 2020-2050. In particular, temperature warming by 1.4-2.8$^{0}$C and an increase in total seasonal precipitation (from 21% to 32%) are projected. Similar climatic changes cannot have significant effects on geo-botanical environment, and will not hamper the forest regeneration and renewal processes; there will be no replacement for mezophytes by xerophytes. Droughts will not threaten natural vegetation. Climate changes may lead to a prolongation of the vegetation period of plants. This is especially true for the early spring flora plants. Their vegetation period will also be prolonged.

### *2.5 Agriculture*

Because of expected climate changes, compared to the current situation, agricultural fields may experience the following impacts in the years 2020-2050:

Due to intensive melting and heavy rains enhancement of river (Rioni, Tekhuri, Tsivi) floods, intensification of floodplain and agricultural land flooding caused by torrent overflows, and strengthening of water erosion will result in degradation of agricultural lands, crops, gardens, hayfields and pasture.

Also, risks of spring and autumn freezing, characteristic to the baseline period, will still threaten tropical and subtropical crops.

### *2.6 Future climate impacts on the health status of the population*

Within the boundaries of lower Rioni River basin, especially in Odishi Lowland, the impact of discomfort temperatures on the population is quite significant. 'Discomfort temperatures" mean those indicators of ground level air temperature that have harmful effects, first of all, on human health. Similar temperatures also adversely affect the functioning of infrastructure in various fields. If the air temperature approaches the temperature of the human body, normal physiological processes are impeded. Low temperatures negatively impact human health as well. At temperatures below 5-10$^0$C, people suffer from discomfort and their open-air presence is partly limited. At lower temperature, tissues experience abrupt disruption of blood flow so that they may develop hypothermia.

The negative impact of discomfort temperatures on the human body enhances in windy and relatively humid conditions. The target area is characterized by high exposure to both of these meteorological processes. Strong winds (speed of more than 15 m/s) are quite frequent here. At least once per year wind blows with a speed higher than 20 m/s. In addition, it should be pointed out that negative impact of sustained duration of strong winds on the human body is of great importance. Within the lower Rioni River basin (especially in Odishi Lowland) sustained duration of strong winds reaches 4-8 hours, which is a very high index. The number of days with strong winds exceeds 40 days per year.

The target area is characterized by high air humidity, especially during the warm season, when the air temperature is high. The high-humidity is conditioned by moist saturated air masses from the sea. Under the influence of these masses, relative air humidity ranges from 75% to 82% for most of the year. Therefore, physiological humidity is respectively high, or relative humidity equals the temperature of the human body, which adversely affects the human body.

According to the climate forecasting scenario, in 2020-2050 parameters of the above-mentioned meteorological index will increase to some extent within the boundaries of the target area. Consequently, the natural environment will become more aggressive to human body, compared to the baseline period.

### *2.7 Vulnerability and Disaster Risk Assessment by the communities*

This subchapter analyzes outcomes of field studies implemented through the program Integrated Natural Resources Management in Watersheds of Georgia (INRMW). The vulnerability of the lower Rioni basin communities (INRMW program includes communities of Senaki and Khobi municipalities on the Rioni River) to climate changes and natural disasters were analyzed and delineated. Community risks were measured in reference to natural disasters. The target area maps of hazards, vulnerabilities and risks were prepared based on information given in this subchapter.

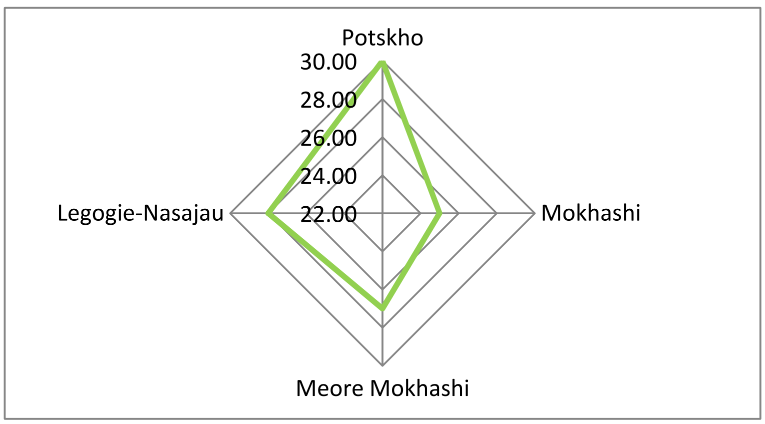
Detailed descriptions of the communities included in the lower Rioni basin are given below. They rely on analysis of the field research data implemented by CENN. Also, data represented in annual bulletins (2006, 2007, 2008, 2009, 2010[1]) prepared by the National Environmental Agency are extensively applied.

### *2.7.1. Potskho Community*

Potskho community is located in the northeasternmost part of Senaki Municipality. The community borders the territories of Chkhorotsku and Martvili municipalities. The Potskho community comprises the basins of Materiati, the left tributary of the Tsivi River (right tributary of the Rioni River), and Gurdzemi (right tributary of the Tekhura River). Besides, the community territory is represented by the somewhat large and small channels of the tributaries of the mentioned rivers.

The Potskho community consists of four villages: Potskho, Mokhashi, Meore Mokhashi, Legogie-Nasajau. The villages of Potskho and Legogie-Nasajau belong to the Tsivi River basin,while the villages of Mokhashi and Meore Mokhashi are located near the Gurdzemi River.

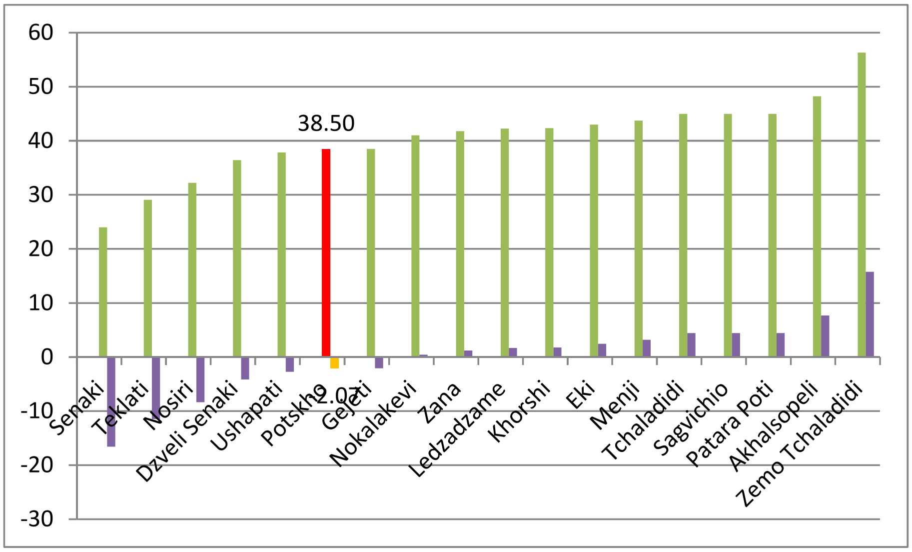
The average distance of the villages from the municipal center is 28 km.



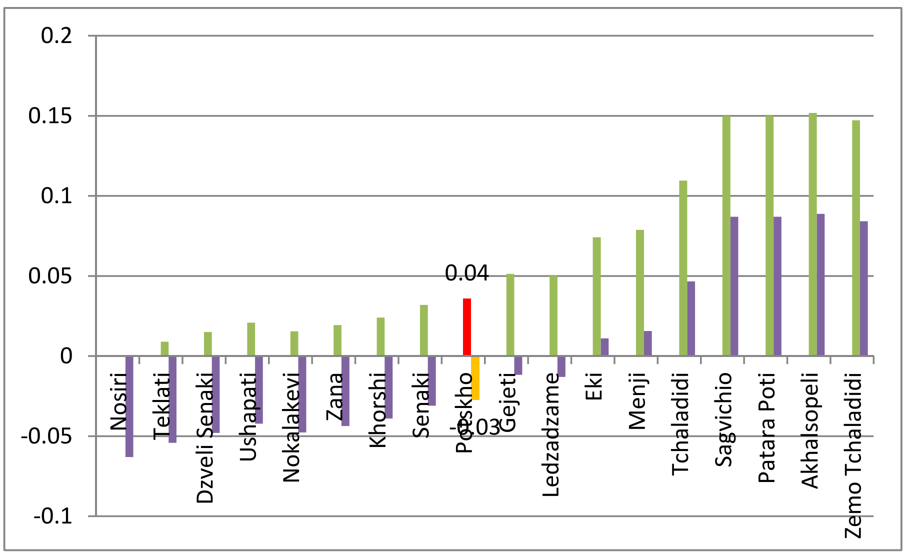

Field research has revealed that the main problems of the community in regards to hazardous natural events are landslide processes and floods.

As a result of the research conducted within the framework of the program, the vulnerability of the Potskho community towards natural disasters and climate changes was assessed at 38.50 points. This indicator is less than the average of the communities located in the lower stream of the Rioni River basin comprising 40.57 points. The difference from the average is 2.07 points (see the diagram). Thus, the Potskho community is distinguished by a relatively low level of vulnerability among the communities of the lower stream of the Rioni River basin. In general, on the scale of the target area of the program, the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).

[1] Ministry of Environment Protection of Georgia. National Environmental Agency. Department for Management of Geological Hazards and Geological Environment. Division for Natural Processes, Engineering Geology and Geo-ecology. Information Bulletin – Results and Development Forecasts of natural Geological Processes in Georgia.




The risk level for the Potskho community comprised 0.04 points. This indicator is also less than that of the average of the communities of the lower stream of the Rioni River basin, that comprises 0.05 points. The difference from the average is 0.02 points (see the diagram). In general, on the scale of the target area of the program, the risk level of the community was assessed as lower than the average (see the map – Assessment of Disaster Risks of Senaki Municipality).




In details, the situation in each village of the Potskho community in regards to the hazardous natural events is as follows:

### Potskho Village

The main problem for the village of Potskho is a ***landslide*** body represented on two points on the village territory. The landslide is developed on the so-called Lejologue-Lesanie district where the physical-mechanical features of the clay grounds of the local watershed slope are deteriorated by waterlogging. As a result of this process, houses and plots of three local families are damaged (about 5 ha). The experts of the National

Environmental Agency evaluated the mentioned territory as the one highly vulnerable to the activation of the landslide processes.




The landslide is also observed on the road connecting the Potskho community with the town of Senaki; here, the Meteria River washes the river bank, damages the supporting area of the slope and causes the development of a coastal landslide. As a result of this process, a 150 meter road section, connecting the community with the town of Senaki, is damaged. On the same section, the Meteria River ***washes the banks,*** and in case of abundant precipitation, it overflows the banks and floods the agricultural lands and houses of the local population. In all, the ***flood*** harms about 30 inhabitants and 10 ha of the agricultural lands.

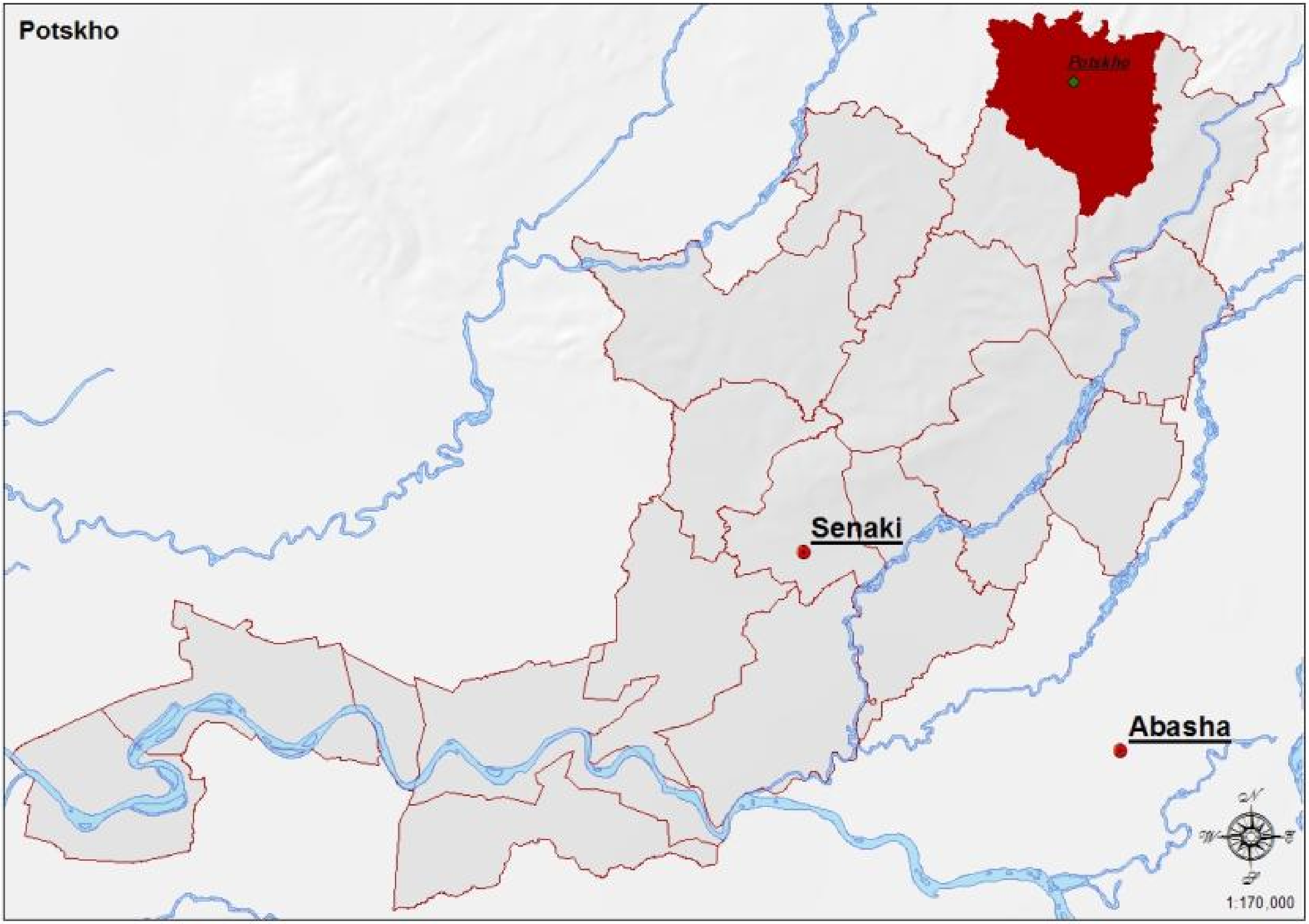
**Mokhashi Village**

The village of Mokhashi is located in the eastern part of the community, near the Gurdzeni River. In the village, in the so-called Letkebuchava district, a landslide threatens the houses and plots of 5 households (about 5 ha in total). The landslide also damaged a road section of about 200 meters connecting Mokhashi and Potskho.

In the eastern part of the village, around the Gurdzeme River, because of river activitythe right bank is intensively being washed. As a result of the process the main bridge connecting the community with the rest of the territory is significantly damaged; also, about 7 ha of agricultural lands are washed. In spring, because of intensive snowmelt and abundant precipitation, the river overflows the banks and floods the agricultural lands located nearby. In all, an area of about 20-30 ha is being flooded and damaged.

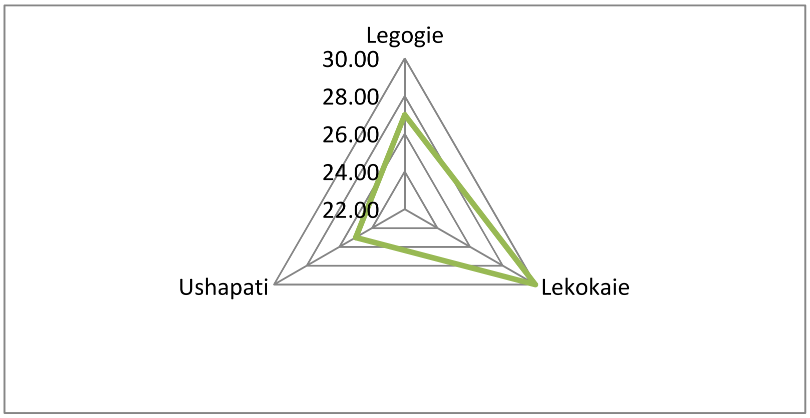




Potskho
Potskho
Senaki
Abasha
1:170,000

### *2.7.2. Ushapati Community*

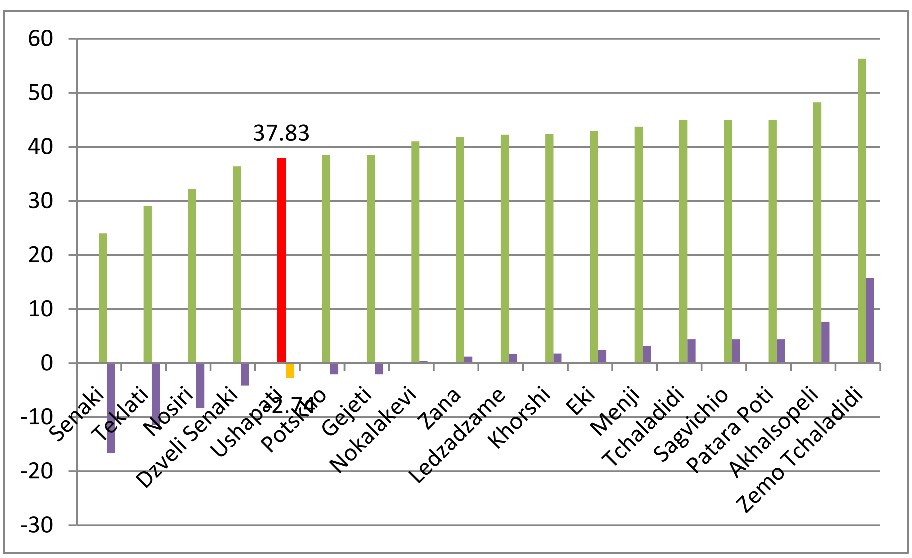
Ushapati community is located in the northern part of Senaki Municipality, on the left bank of the Meteria River and comprises the confluence of the Tsivi and Meteria rivers. Besides the Meteria River, the community territory is crossed by the channels of temporary and constant water flows.

The Ushapati community consists of three villages: Ushapati, Legogie, Lekokaie. The average distance of the villages from the municipal center is 28 km.

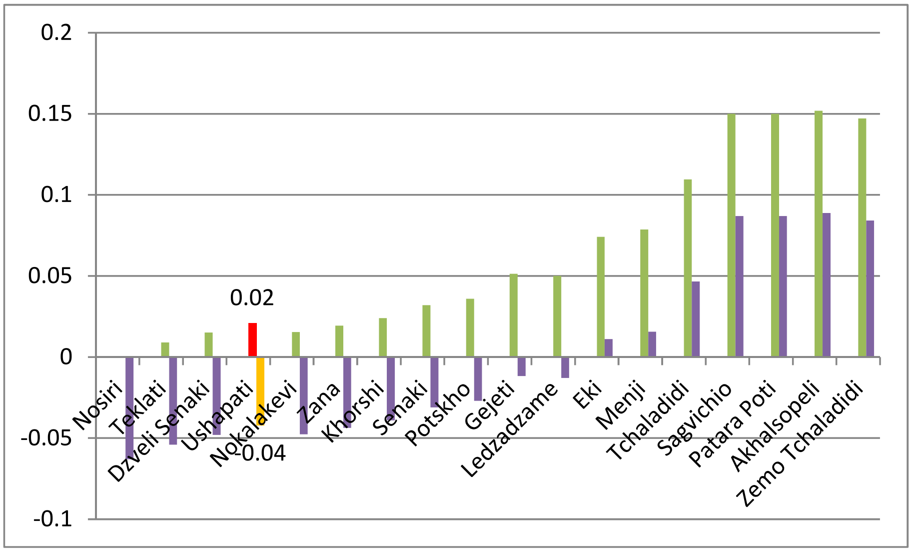



The main problem of the community in regards to the hazardous natural events revealed during the field research is landslide process.

As a result of the research conducted within the framework of the program, the vulnerability indicator of the Ushapati community was assessed at 37.83 points. This indicator is less than the average of the communities located in the lower stream of the Rioni River basin. The difference from the average is 2.74 points. Therefore, the vulnerability of the Ushapati community is relatively low. In general, on the scale of the target area of the program, the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).




The risk level for the Ushapati community, based on the same research, comprised 0.02 points. This indicator is lower than the average of the communities of the lower stream of the Rioni River basin. The difference from the average is 0.04 points (see the diagram). Within the lower stream of the Rioni River basin, the indicator of the Ushapati community is one of the lowest. In general, on the scale of the target scope of the program, the risk level of the community was assessed as lower than average (see the map – Assessment of Disaster Risks of Senaki Municipality).



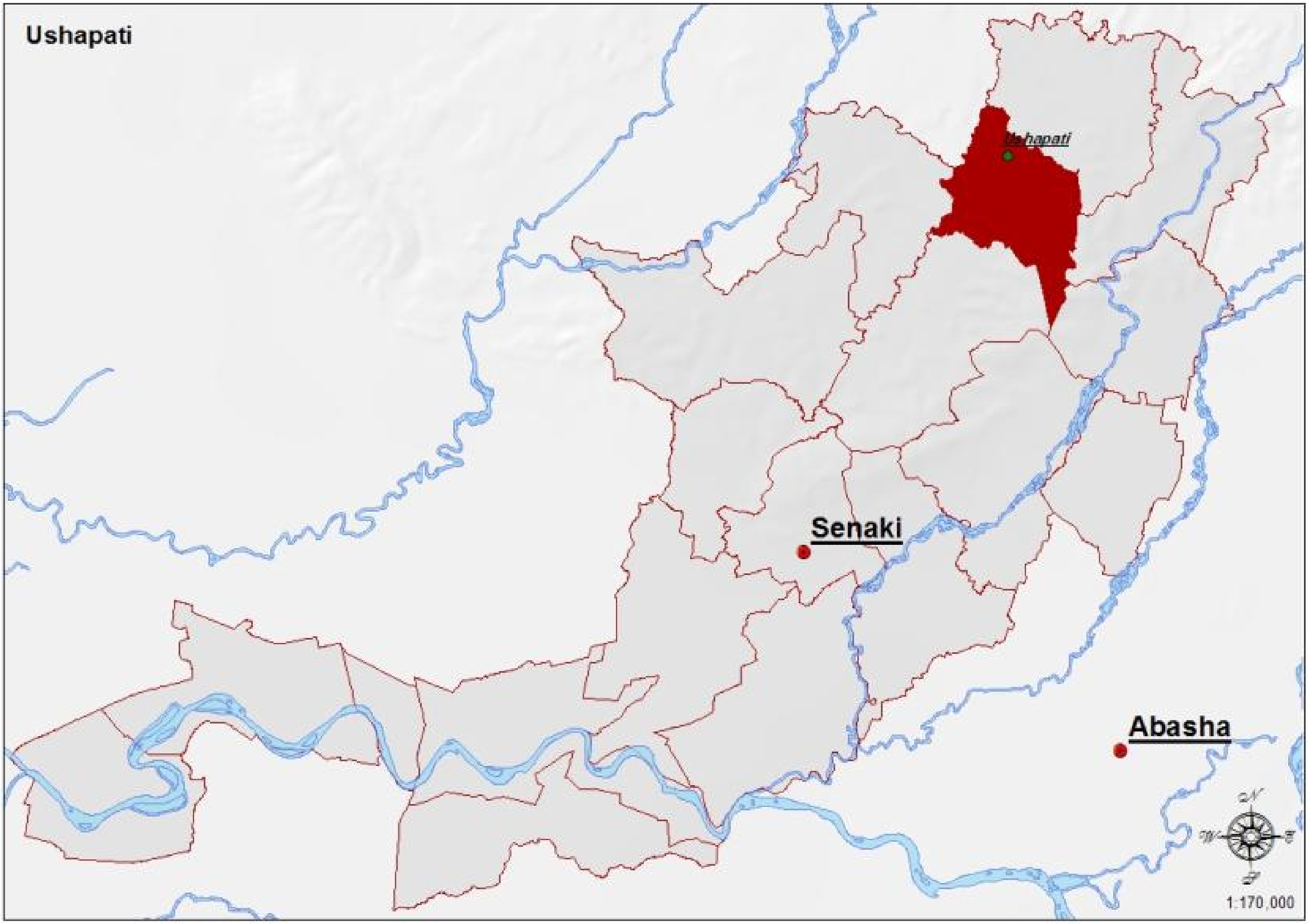

In detail, the situation in the villages of the Ushapati community in regards to the hazardous natural events is as follows:

### Ushapati Village

The main problem for the village of Ushapati is a ***landslide*** process developed on the village territory on the road connecting the villages of Ushapati and Lekokaie. On the slopes near the road a landslide process developed that is mainly connected with the activities of underground waters. As a result of the process, a 20-meter section of the road is damaged. The house of one inhabitant (Aza Kuprava), as well as the ancillary buildings and plots are also damaged (in particular, 1000m$^2$ of nut plants ). In case of the further development of the process, the former municipal building of the village, which is now occupied by the local police department, will also be endangered.


**Lekokaie Village**

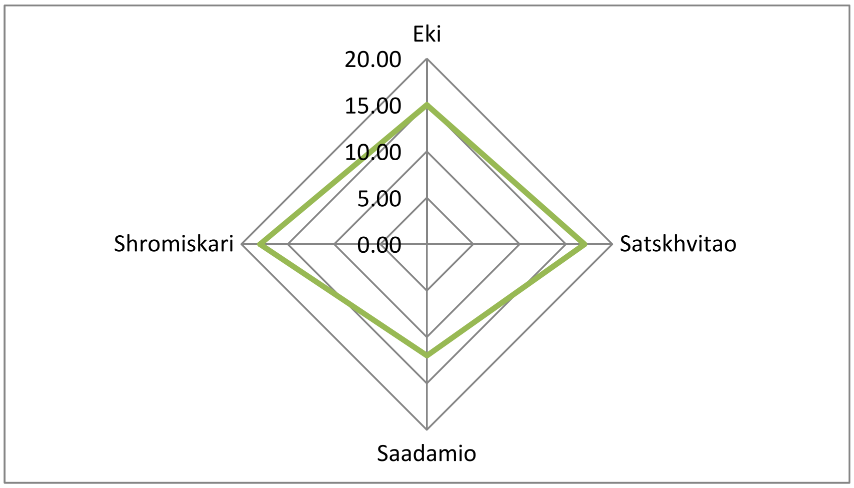
The village of Lekokaie is located in the southern part of the Ushapati community. Field researchrevealed that out of the hazardous natural events, the ***landslide*** has been observed on this area. The landslide body developed in the northern part of the village damaged the houses of two inhabitants (Korshia, Malania), as well as their ancillary buildings and plots (in total about 2000 $m^2$). The landslide process is determined by the activities of the underground waters and the weak physical-mechanical features of the rocks that form the slope. It was observed that the landslide processes have a significant impact on the houses. In case of process development, the owners of these houses will be highly endangered. Herewith, it should be noted that these problems are not mentioned in the reports of the National Environmental Agency which indicate that the specialists of the agency have not conducted an expert research of this issue. To secure the inhabitants and determine whether the houses are appropriate for living, research is necessary.



Ushapati
Ushapati
Senaki
Abasha
1:170,000

### *2.7.3. Eki Community*

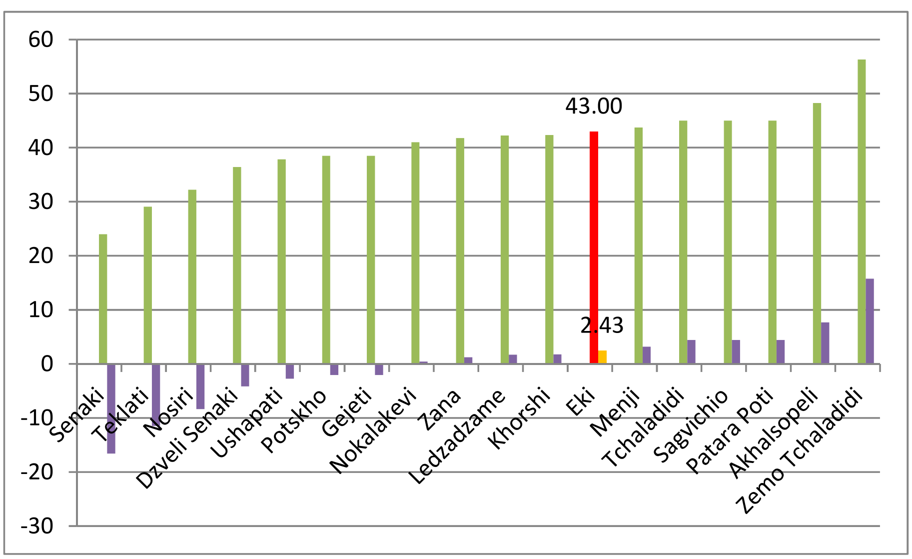
The Eki Community is located in the northern part of the Senaki Municipality in the Tsivi River gorge. The left tributary of the Tsivi River also runs on the community territory. The Tsivi and Ekiskuri Rivers practically cross the whole territory of the community. The community villages are mainly located along these rivers.

The Eki community consists of four villages – Eki, Satskhvitao, Saadamio and Shromiskari. The average distance of the villages from the municipal center is 16 km.

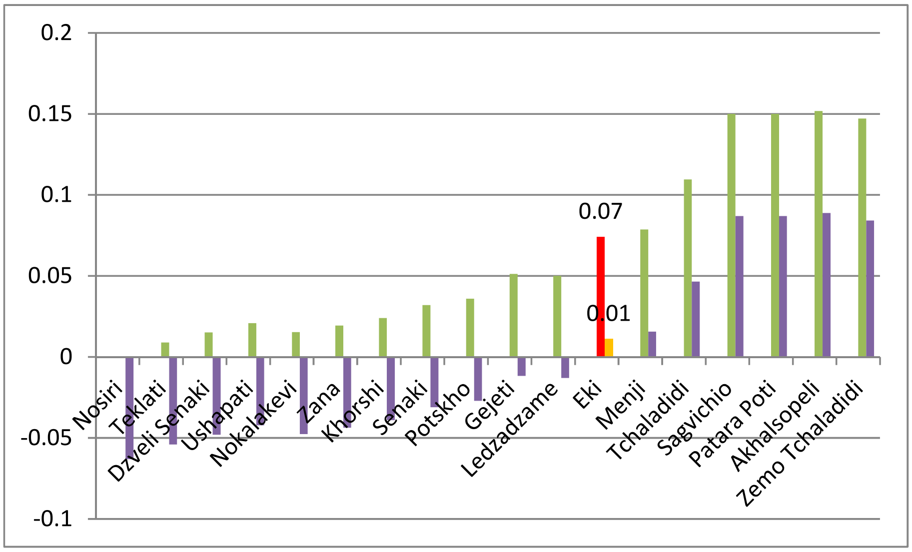



The main problem of the community in regards to the hazardous natural events revealed during the field research is mainly connected with landslide processes. The population also mentioned the problem of floods.

As a result of the vulnerability assessment, the Eki community vulnerability was assessed at 43 points. This indicator exceeds the average of the communities located in the lower stream of the Rioni River basin. However, the difference from the average is not big and comprises 2.43 points (see the diagram). On the scale of the target area of the program, the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).



Based on the results of the same research the risk level for the Eki community was determined to be 0.07 points. As in case of the vulnerability index, this index also exceeds the average of the communities located in the lower stream of the Rioni River basin. However, in this case, the difference is slight and comprises only 0.01 points (see the diagram). On the scale of the target scope of the program, the risk level of the community was assessed as lower than average (see the map – Assessment of Disaster Risks of Senaki Municipality).




In details, the situation in the villages of the Eki community in regards to the hazardous natural events is as follows.

**Saadamio Village**

The village of Saadamio is located in the southern part of Eki community. The main problem for the village is a ***landslide*** process developed on several areas of the village territory. The field research also revealed the problem of ***bank washing.***

In the western part of the village, as a result of landslide processes the road connecting the village with the agricultural lands of the inhabitants and six households have been damaged (fallen down). A 30-meter section of the road is damaged. According to the population, the development of the process has been determined by the intensive logging of the forests on the nearby slopes.

Near the mentioned section (a bit to the east) a second landslide body is represented; as a result of its activity, the house of one inhabitant (Gigla Goginava) was already destroyed. The plots are also damaged (0.5 ha).




In the westernmost part of the village, by the border of the Menji Community, on the territory of the so-called Sapachkorio, the Chkhari stream is running. During floods (in case of abundant precipitation) the mentioned stream washes the bank and damages the road section entering the village (up to 100 meters). In case of further activation of the bank washing process, the plots and the agricultural lands of the inhabitants living on the nearby territory will be endangered by the flood.


**Satskhvitao Village**

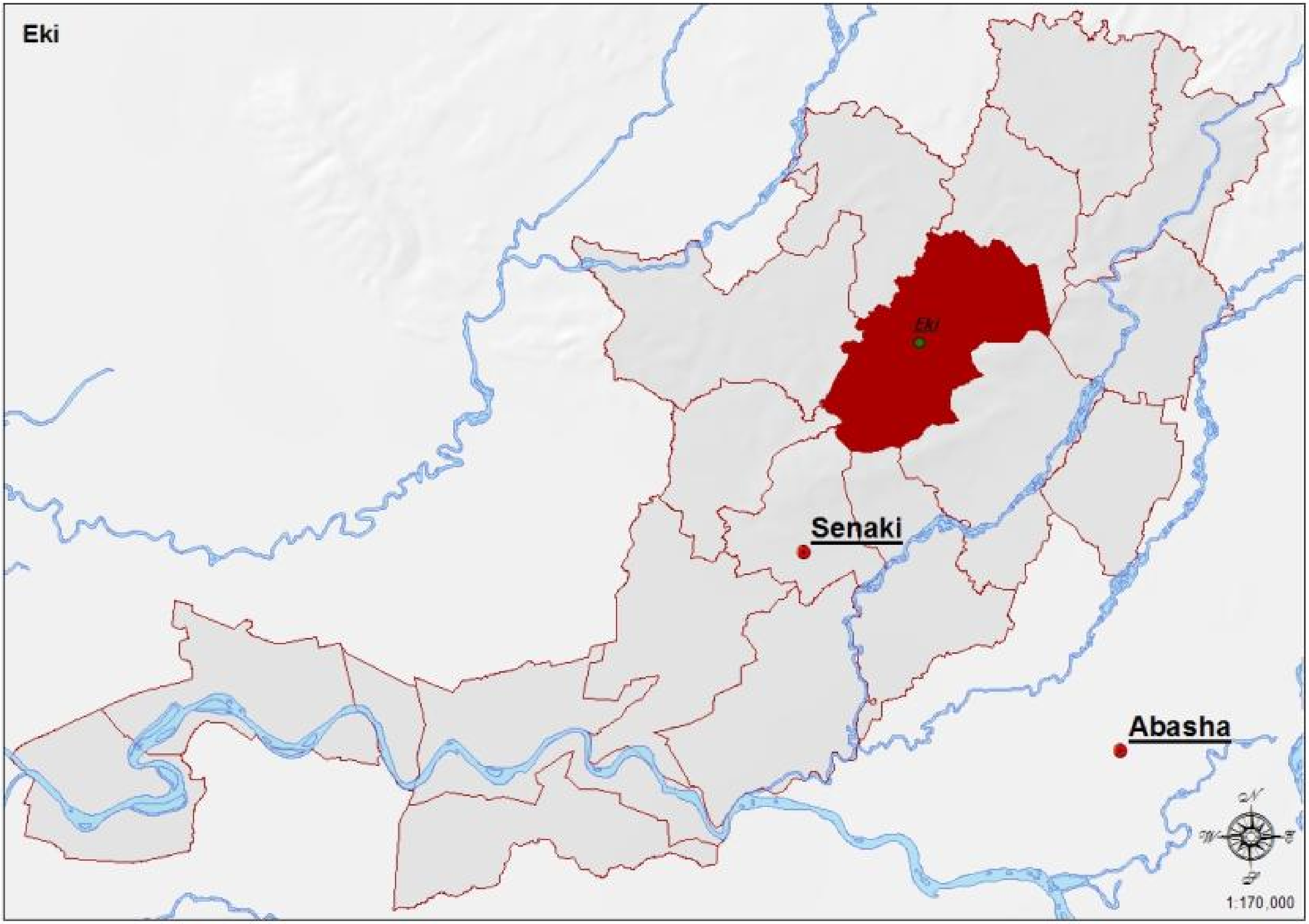
The village of Satskhvitao is located in the western part of the Eki community, and occupies the territory of the right bank of the Tsivi River. The natural disaster developed in the village, the ***landslide*** process, is connected with the erosive activity of the Tsivi River. In particular, the Tsivi River, the channel of which was significantly changed during the Soviet period, intensively washes the right bank during the floods, damages the retaining part of the slope and causes the developemt of the landslide body. As a result, the plots, ancillaries and agricultural lands of the local inhabitants are endangered (in total, about 15 ha). As a result of the erosive activity of the river, the central bridge connected with the village is also threatened. One of the supporting piers of the bridge is already damaged.




**Eki Village**

Field research revealed that out of the hazardous natural processes, ***landslide*** processes are present in the village of Eki. The landslide process affects the inhabited territory of the village on the slopes of the unnamed tributary gorge of the Tsivi River. In 2008, based on the visual research, specialists of the National Environmental Agency determined that two houses built on landslide-prone slopes were inappropriate for living. Now 5 houses, plots (more than 3 ha) and 300 meters of the agricultural lands are endangered. The landslide is also represented in the central part of the village (Middle Eki), where the developed process threatens the house, ancillaries and plots of one inhabitant (Nodar Sichinava). In total, about 1.25 ha is endangered.

It should be mentioned that the high risk of the activation of the landslide processes is underlined in almost all annual publications of the National Environmental Agency.

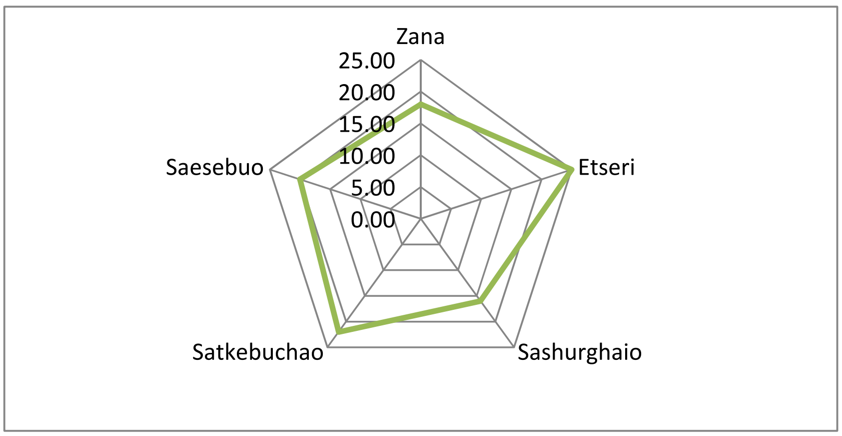

Eki
Eki
Senaki
Abasha
1:170,000

*__2.7.4. Zana Community__*

The Zana community is located in the northern part of Senaki Municipality, and borders Khobi municipality. It should be noted that the community territory includes parts of the basins of two big rivers, Rioni and Khobistskali Rivers. The western part of the community territory is crossed by the Zana River, which is the left tributary of Khobitskali River; the eastern part is crossed by the Meteria River, which is the right tributary of the Tsivi River, and part of the Rioni River basin. The dividing ridge of these river basins is the central road, which crosses the whole community territory in a meridian direction.

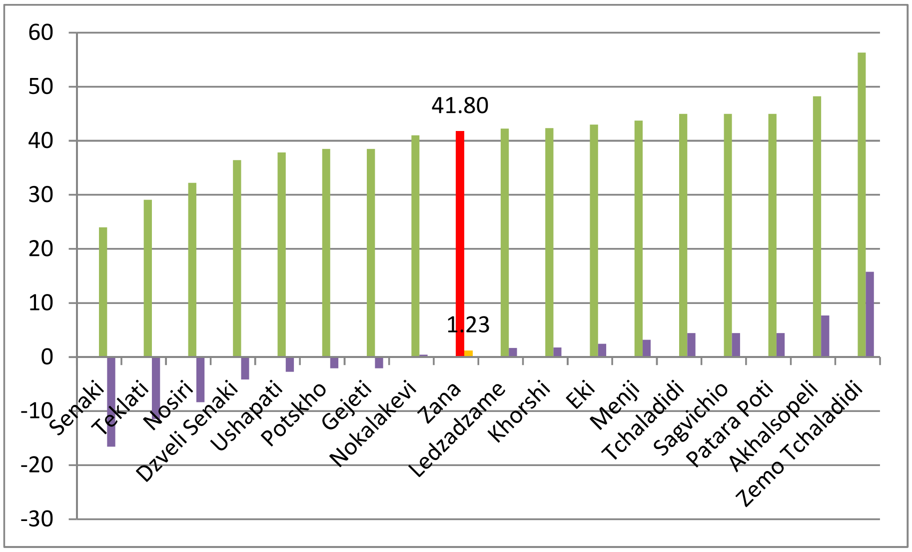
The Zana community consists of five villages: Zana, Saesebuo, Etseri, Sashurghaio and Satkebuchao. The villages of Etseri and Satkebuchao are part of the Khobistskali River basin, while the village of Sashurghaio is part of the Rioni River basin. The villages of Zana and Saesebuo  are located on the watershed road of two rivers, therefore, their territory belongs to the both basins.

The average distance of the villages from the municipal center is no more than 21 km.

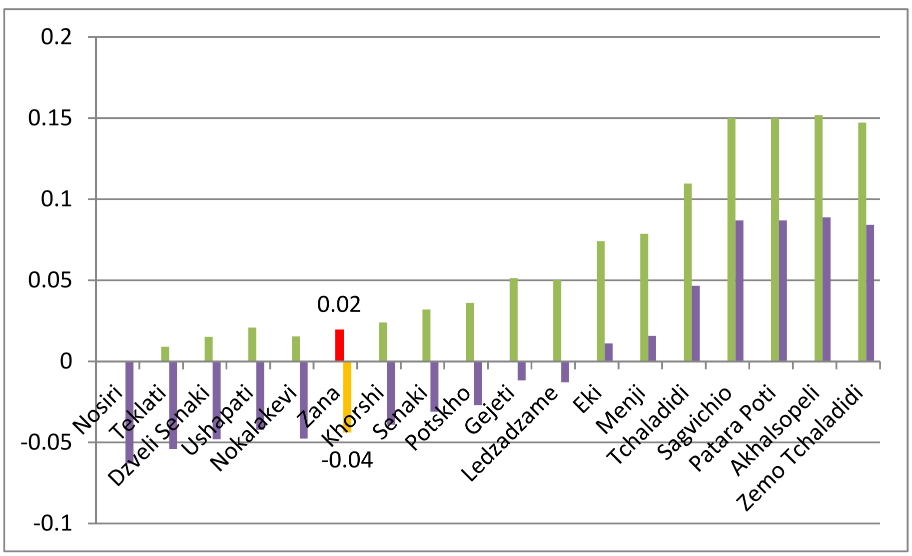



Field research has revealed that the main problems of the community in regards to the hazardous natural events are landslide and flood processes.

As a result of the research conducted within the framework of the program, the vulnerability indicator of the Zana community was assessed at 41.80 points. This indicator is almost the same as the average of the communities located in the lower stream of the Rioni River basin which is 40.57. The difference from the average is minimal and comprises 1.23 points (see the diagram). In general, on the scale of the target area of the program, the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).




The risk level for the Zana community, according to the research, comprised 0.02 points. This indicator is lower than the average of the communities of the lower stream of the Rioni River basin. The difference from the average is 0.04 points (see the diagram). In general, on the scale of the target scope of the program, the risk level of the community was assessed as lower than the average (see the map – Assessment of Disaster Risks of Senaki Municipality).




In details, the situation in the villages of the Zana community in regards to natural disasters is as follows.

**Zana Village**

The village of Zana is located in the center of the community territory. The main problem for the village is ***landslide*** process, which damages houses and agricultural lands of the inhabitants located on the nearby territory of the village council. Several houses were severely damaged as a result of the landslide process (8 houses and 6 ha of land). The rural road was damaged as well. At this stage the landslide is stabilized and there are no signs of activity. However, the annual reports of the National Environmental Agency indicate a high risk probability of landslide activation. Activation of landslide process will endanger the houses of the inhabitants and their lands, as well as the village stadium, the church yard and the building of the village council, where the the police department building is also located.




A landslide is presented on Senaki-Chkhorotsku road, near the village hospital. The landslide damaged approximately 0.5km of the central and internal roads of the village.

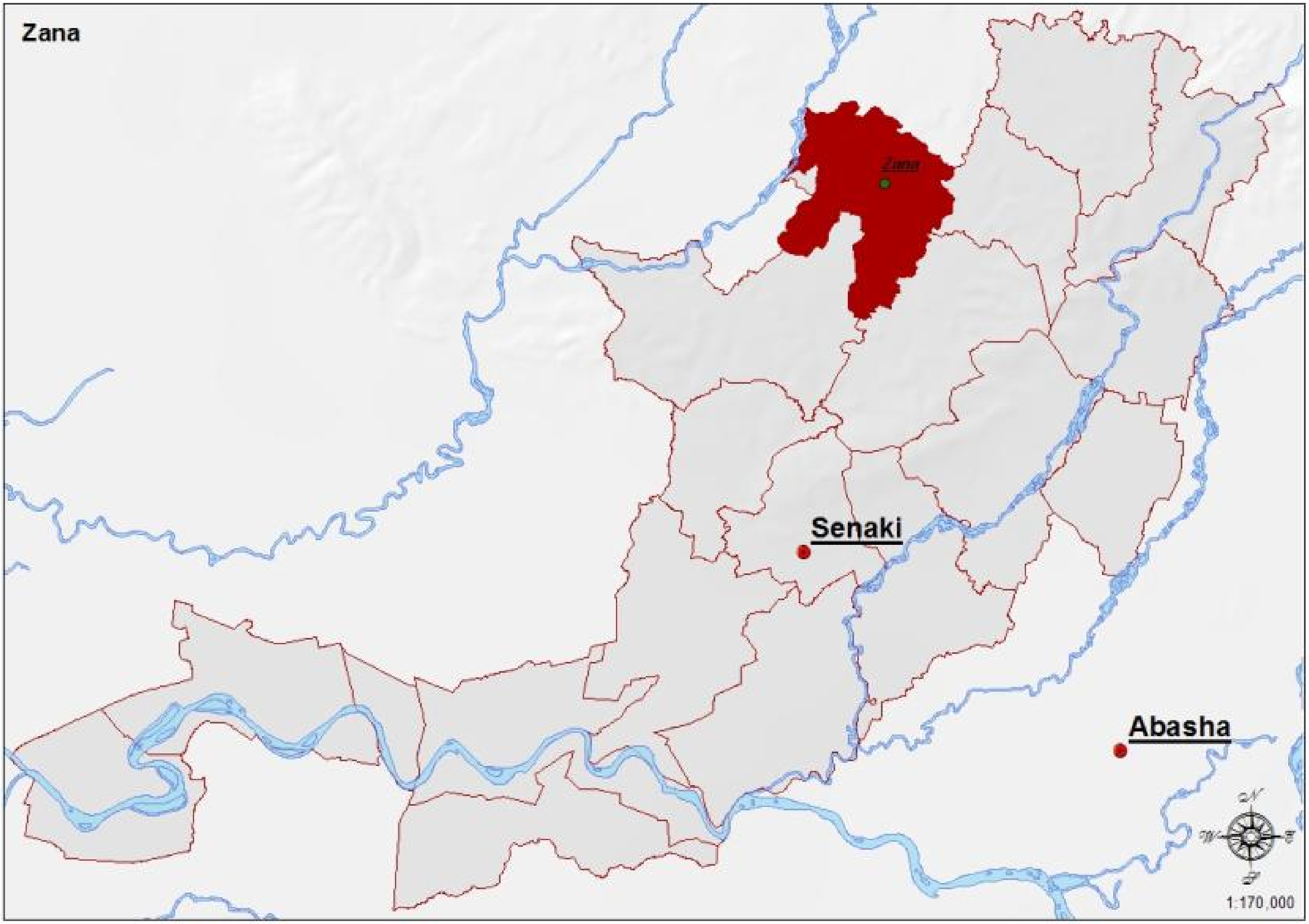

**Etseri Village**

The village of Etseri is located at southernmost part of the municipality, on the right bank of the Zana River. The main problems of the village are ***floods*** and bank washing by the river. As a result of river activity, the central bridge located on the road connecting the villages of Zana and Etseri is damaged.


**Satkebuchao Village**

The village of Satkebuchao is located at northern part of community, on the right bank of the Zana River. The main problem in terms of hazardous natural events is ***landslide*** process. The houses, surrounding plots and agricultural lands of four inhabitants were damaged by this process (up to 8 ha). Lands of eight more inhabitants are at risk.





Zana
Zana
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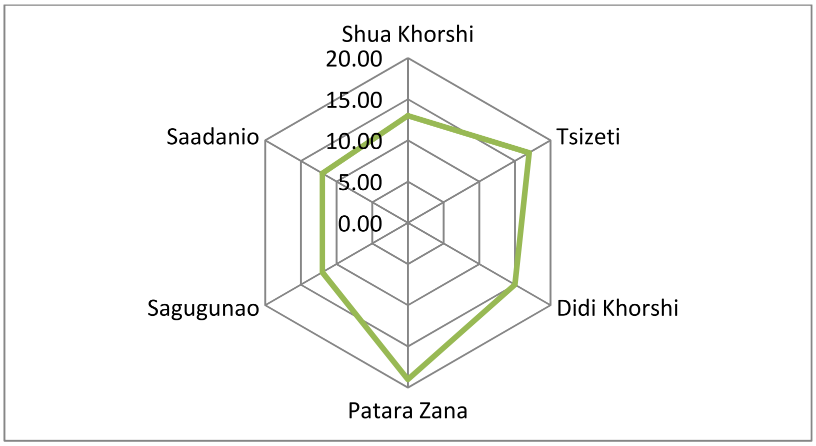
1:170,000

### *2.7.5. Khorshi Community*

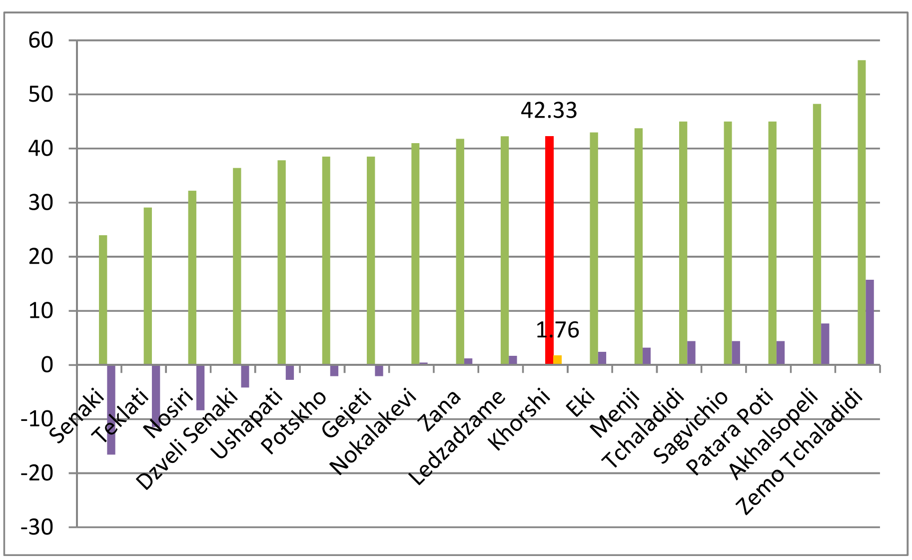
The Khorshi community is located in the northern part of Senaki Municipality, and borders Khobi municipality. It should be noted that like the Zana community, the Khorshi community territory includes part of the basins of two big rivers - Rioni and Khobistskali Rivers. Mostly small scale rivers are represented on the community territory; they are on the by the central watershed road crossing the territory on full length, just in case of the Zana community.

The Khorshi community consists of six villages: Shua Khorshi, Tsizeti, Didi Khorshi, Patara Zana, Sagugunao and Saadanio. The average distance of the villages from the municipal center is up to 15 km.

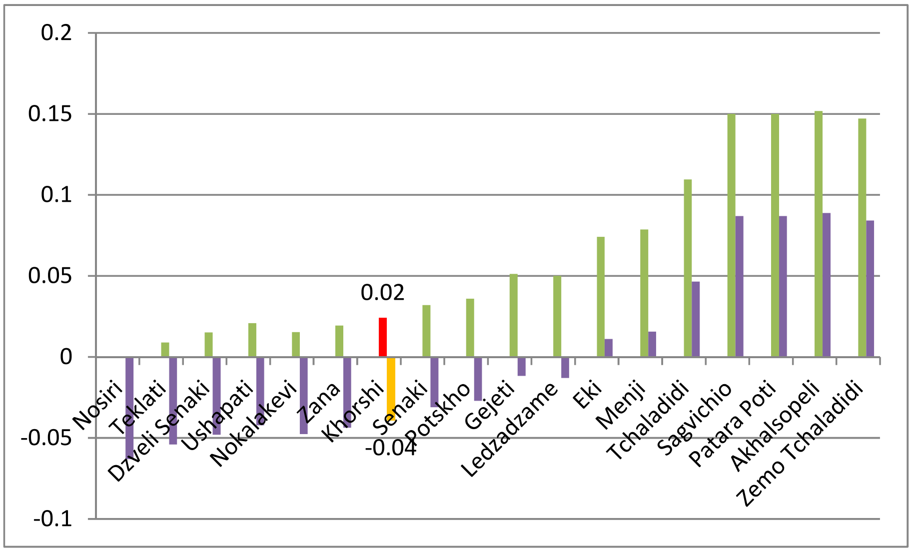



The main problems of the community in regards to the hazardous natural events revealed during field research are landslide and flood processes.

As a result of the research conducted within the framework of the program, the vulnerability indicator of the Khorshi community was assessed at 42.33 points. This indicator is slightly more than the average of the communities located in the lower stream of the Rioni River basin. The difference is slight and comprises 1.76 points (see the diagram). On the scale of the target area of the program, the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).



The risk level for the Khorshi community, like Zana, is quite low and comprises 0.02 points. This indicator is lower than the average of the communities of the lower stream of the Rioni River basin. The difference from the average is 0.04 points (see the diagram). On the scale of the target area of the program, the risk level of the community was assessed as lower than average (see the map – Assessment of Disaster Risks of Senaki Municipality).




In detail, the situation in the villages of the Khorshi community in regards to hazardous natural events is as follows.

**Shua Khorshi Village**

The village of Shua Khorshi is located in the central part of the Khorshi community. The village territory includes the sources of a small river Skurcha, which is the right tributary of the Tsivi River. Also, the village borders the Tsivi River; consequently, the village territory belongs to the Rioni River basin. During the field research, ***landslide*** processes were identified as the main problem in village in respect to the hazardous natural events. A landslide is developed on the nearby territory of the road connecting the villages of Shua Khorshi and Menji. Landslides are caused by the erosive bank washing process developed by the Tsivi River; therefore, the landslide process developed in the clay ground endangers agricultural lands and a bridge located on the Tsivi River.

A landslide is also developed on the main road connecting the village with the city of Senaki, where about 150 m of road is damaged as a result of the process.


**Tsizeti Village**

The village of Tsizeti is located in the northwestern part of the community. The village is located near Nishnia River, a small left tributary of the Khobistskali River. Besides, the village of Tsizeti also borders the left bank of the Khobistskali River. Consequently, the village of Tsizeti from the Khorshi community belongs to the Khobistskali river basin.

From hazardous natural processes, **landslides** and **floods** were revealed as main problems of the village.

The territory near the bridge over the Khobistskali River located in the village has been impacted by floods. During floods the Khobistskali River washes the banks; as a result almost 20 ha of agricultural lands are damaged. Another 30 ha of lands are in danger. In spring, during intensive snowmelt and/or abundant rainfall conditions, the Khobistskali River overflows the banks and damages agricultural lands and plots. According to the population, the main reason for problem is that during the Soviet period the river channel was changed, which requires constant protective activities. Such construction activities were sharply reduced after the Soviet period.



The village also suffers from the impact of landslides. The landslide process is developed in several places in the village. The process damages the inner ground way of the village, houses (2 families), plots and agricultural lands (2 ha).

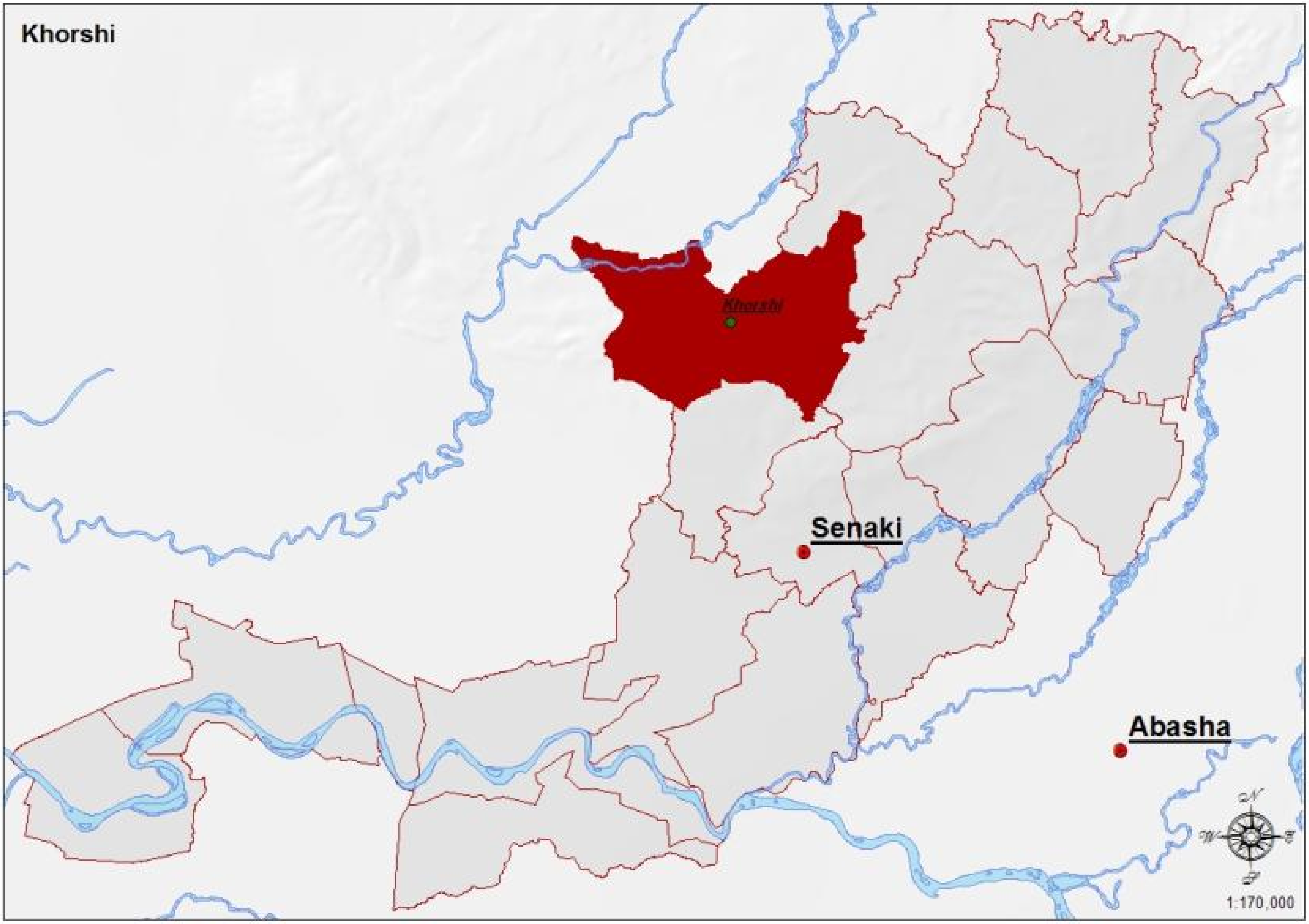
### Patara Zana Village

The village of Patara Zana is located in the northern part of the community and belongs to the Khobistskali River basin. During the field research ***floods*** were identified as main problem of the village. In spring and abundant rainfall conditions, the Zana River overflows the banks and washes the coast. It damages agricultural lands (about 10 ha). Another 10 ha of lands, a 150-meter road section connecting the villages of Zana and Patara Zana, and the power transmission poles are in danger. Based on information from the population, a 70-meter bridge was destroyed completely by floods during the 1980s.


**Saadanaio Village**

The village of Saadanaio is located in the eastern part of the community, on the right bank of the Tsivi River. From this perspective, the village territory belongs to the Rioni River basin. ***Landslide*** processes were observed during field research. The landslide is represented on the nearby territory of the central road connecting the villages of Saadanio, Didi Khorshi and Sagugunao. Because of the landslides, about 30 meters of the road section is damaged. The 20 meter pipeline supplying the village of Sagugunao with drinking water is threatened by the landslides.

It should be noted that the whole territory of the Horsham community is distinguished by having the high level of landslide activity. Because of this, in order to make the territory usable for agricultural or other purposes, detailed research should be conducted to develop recommendations against landslide processes.


Khorshi
Khorshi
Senaki
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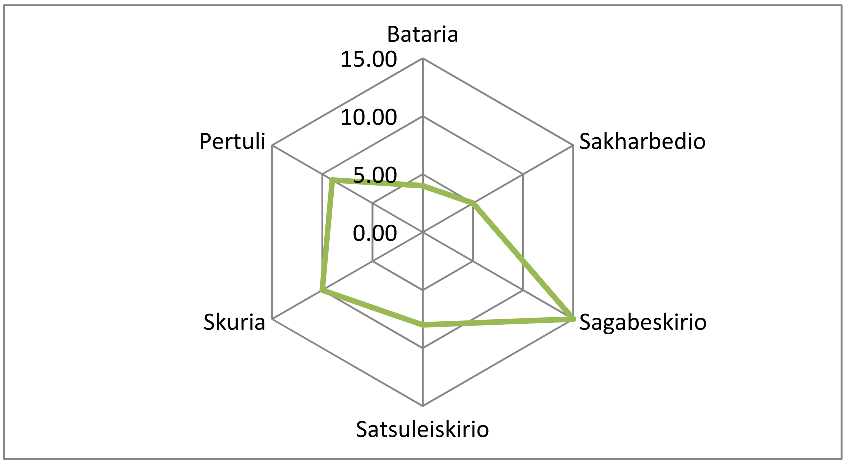
***2.7.6. Menji Community***

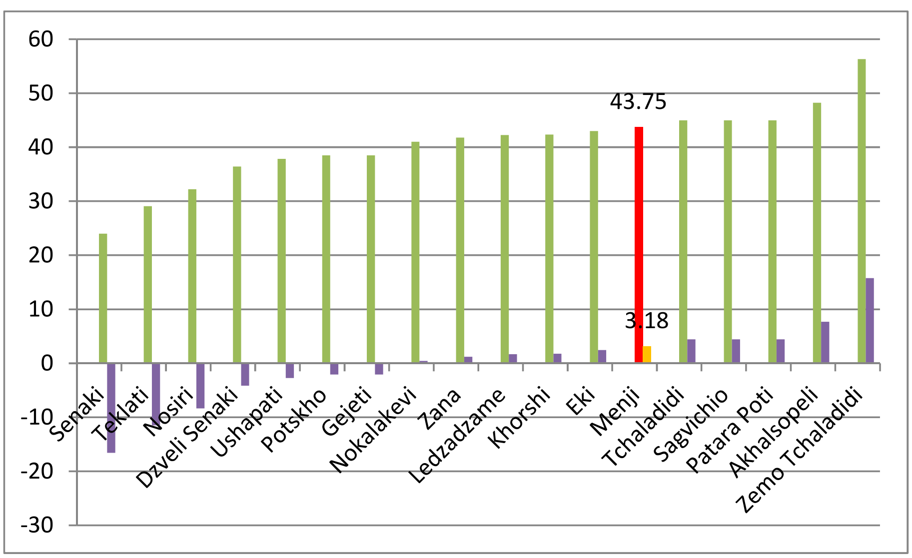
The Menji community is located in the western part of the municipality territory, bordering the Kobe municipality. The community territory contains the western bank of the Trivia River and is crossed by the constant and temporary channels of small rivers.

The Menji community consists of six villages: Batavia, Sakharbedio, Sagabiskirio, Satsulieiskirio, Skuria and Pertuli. The average distance of the villages from the municipal center is 9 km.

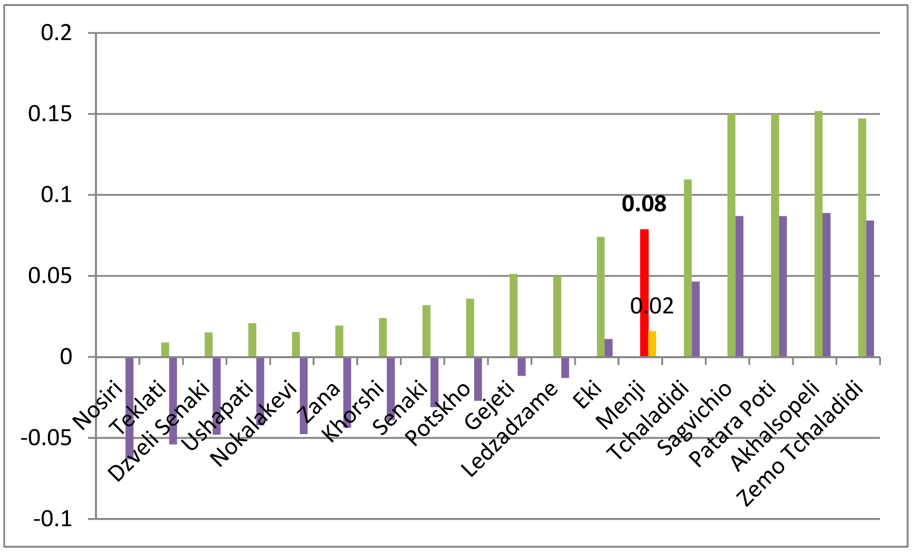



The main problems of the community in regards to hazardous natural events revealed during the field research are landslide and flood processes.

As a result of the research conducted within the framework of the program, the vulnerability indicator of the community was assessed at 43.75 points. This indicator slightly exceeds the average indicator of the communities located in the lower stream of the Rioni River basin. The difference from the average is 3.18 points (see the diagram). On the scale of the target area of the program (target river basins), the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).



The risk level for the Menji community comprised 0.08 points, which exceeds the average indicator of the communities of the lower stream of the Rioni River basin comprising 0.06 points. The difference from the average is 0.02 points (see the diagram). In general, on scale of the target scope of the program the risk level of the community was assessed as more than average (see the map – Assessment of Disaster Risks of Senaki Municipality).




In detail, the situation in the villages of the Menji community in regards to hazardous natural events is as follows:

**Bataria Village**

The village of Bataria is located in southern part of community, on right bank of the Tsivi River. In respect to the hazardous natural events the main problems for village are ***floods*** and ***landslide*** processes.

The landslide processes are developed on the road connecting the villages of Bataria and Sakharbedio. The landslide section of the road is on left side of the Tsivi River. The road connecting the villages lies at the bottom of the slopes with varying inclination of the northern exposition. Now, the slope is a stabilized old landslide body characterized by the wavy relief. It is formed by the milestones and marls of the Middle Miocene Age. The surface is covered by the delluvial sediments of the Quaternary Age; it is covered with forests. There are not any newly formed interstice systems. A 200-meter road section near the resort of Menji has fallen. According to the population, the falling of the road was a result of the landslide process; however, the field team observed that the processes might have been caused by the subsidence of the karst sinkholes developed in the rocks, limestones and marls that form the territory (suffosion).


In the village, the Tsivi River intensively washes the banks, in particular its right bank. The mentioned territory represents the first terrace of the Tsivi River floodplain. It is formed by contemporary Quartenary alluvial weakly connected sandstones and clays that are not sustainable against the side erosive processes caused by the river and are easily washed when the river floods. Near the railroad bridge, over the river bend, a wired dike is built up that lasts till the inhabited area. The Tsivi River washes the right bank near the inhabited area around the village of Bataria; as a result of this activity the river gradually takes away the plots of the inhabitants and comes nearer to the houses.


**Sakharbedio Village**

The village of Sakhabedio is located in the eastern part of the community territory, on the right bank of the Tsivi River. The main problem for community is ***flood*** and ***landslide*** processes developed on the Tsivi River.

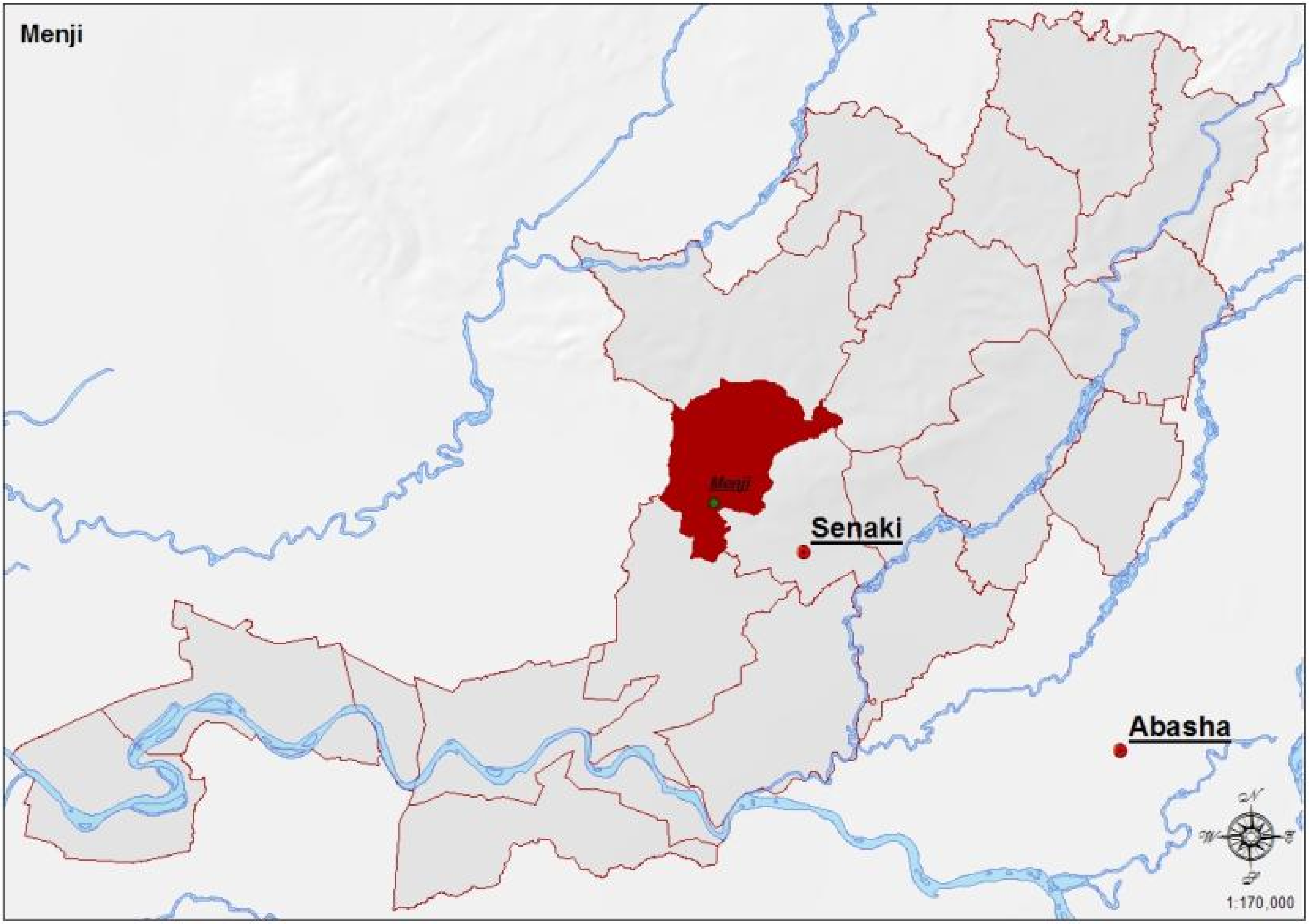
The landslide is represented on the nearby territory of a former restaurant on the Senaki-Chkhorotsku central road. Part of this road is damaged by the landslide processes. A drinking water pipeline of the Menji community is also impacted by the landslide processes (this pipeline supplies 30% of the community population).

In northern part of the village, during ***floods*** the erosion activities of the Tsivi River damage agricultural lands and intensively wash the right bank. As a result, the plots (500 $m^2$) and ancillaries of local inhabitant (Avtandil Kharbedia) are damaged. Currently, the house is endangered because of the process. According to the inhabitant, less than 10 meter is left till the house.

**Satsuleiskirio Village**

The village of Satsuleiskirio is located in the northeasternmost part of the community territory. The village territory comprises the left bank of the Tsivi River and the foothills of the Eki mountain. The main problems of the village are created by ***landslide*** and ***debris flow*** processes. The landslide is developed in the central part of the village on about 10 ha. As a result of the process the house , ancillaries, plots of about 1 ha and about 7 ha of the agricultural land of the local inhabitant (Pevdoti Tsuleiskiri) are damaged.

A dry ravine coming from the Eki mountain, where debris flows are formed in case of abundant precipitation, creates the problem in the southern part of the village. The mentioned debris flows flood the plots (5 ha) of 5 inhabitants. About 100 meters of the road section is also damaged.



Menji
Menji
Senaki
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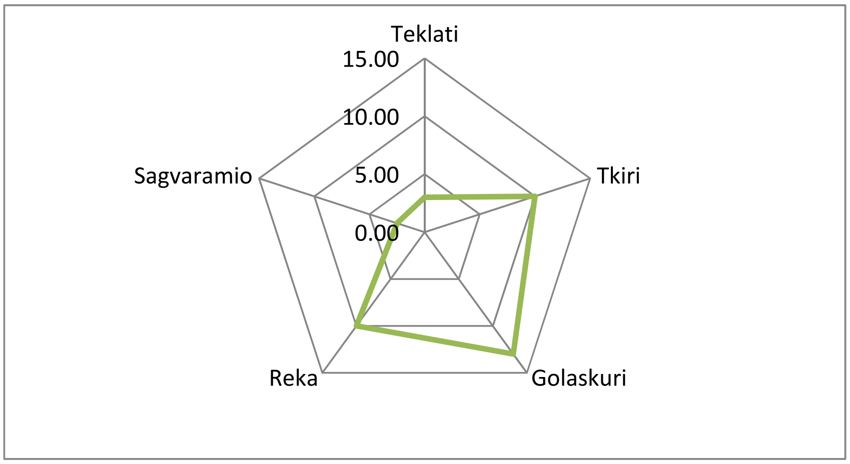
***2.7.7. Teklati Community***

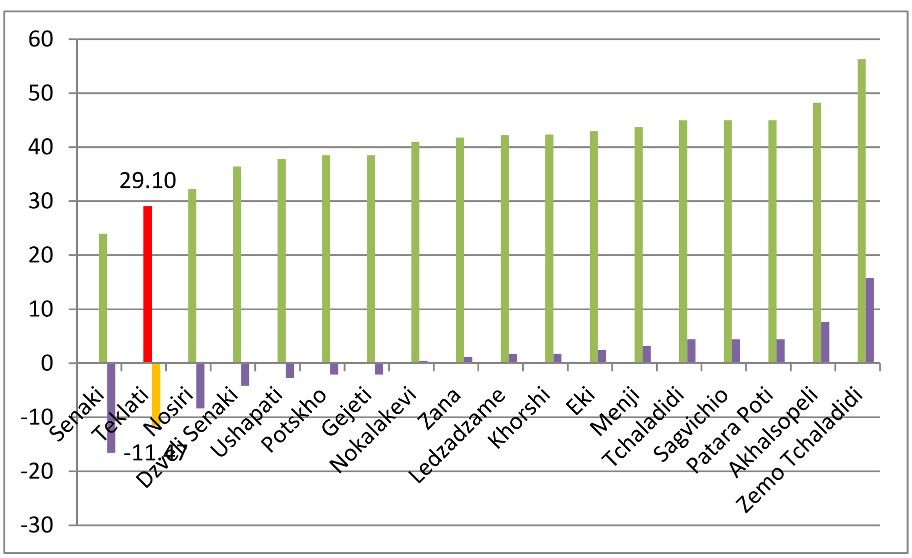
Teklati community is located in the western part of Senaki Municipality. On almost all the length of the community, the territory is crossed by the Tsivi River in the meridian dirtection. The community is located on both banks of the river. The easternmost part of the community is bordered by the Rioni River. The section is mainly occupied by the agricultural lands of the local population.

The Teklati community consists of five villages: Teklati, Tkiri, Golaskuri, Reka, Sagvaramio. The average distance of the villages from the municipal center is 8 km.

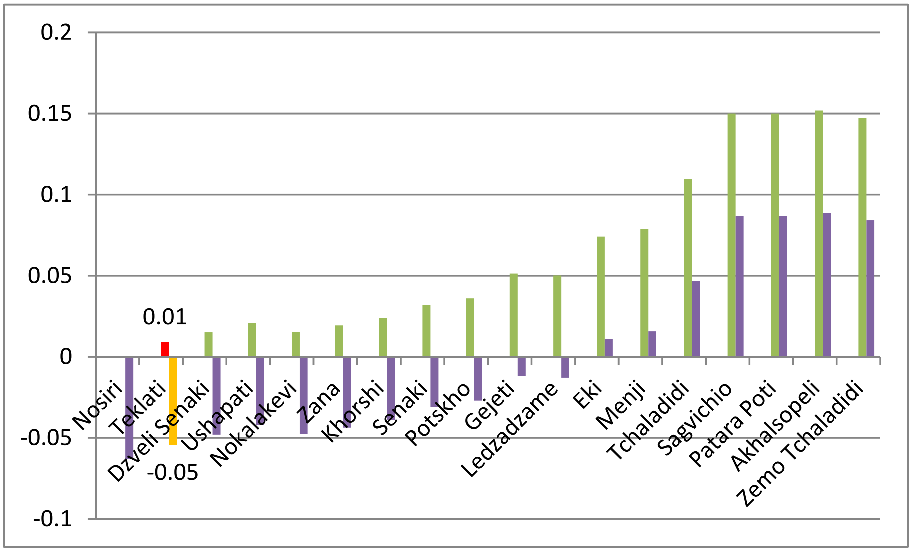



Field research has revealed that the main problem of the community in regards to hazardous natural events is flooding.

As a result of the research conducted within the framework of the program, the vulnerability of the community was assessed at 29.10 points. This indicator is one of the lowest among the communities located in the lower stream of the Rioni River basin. The difference from the average is 11.47 points (see the diagram). On the scale of the target area of the program (target river basins), the vulnerability of the Teklati community was assessed as lower than average (see the map – Assessment of the Vulnerability of Senaki Municipality).

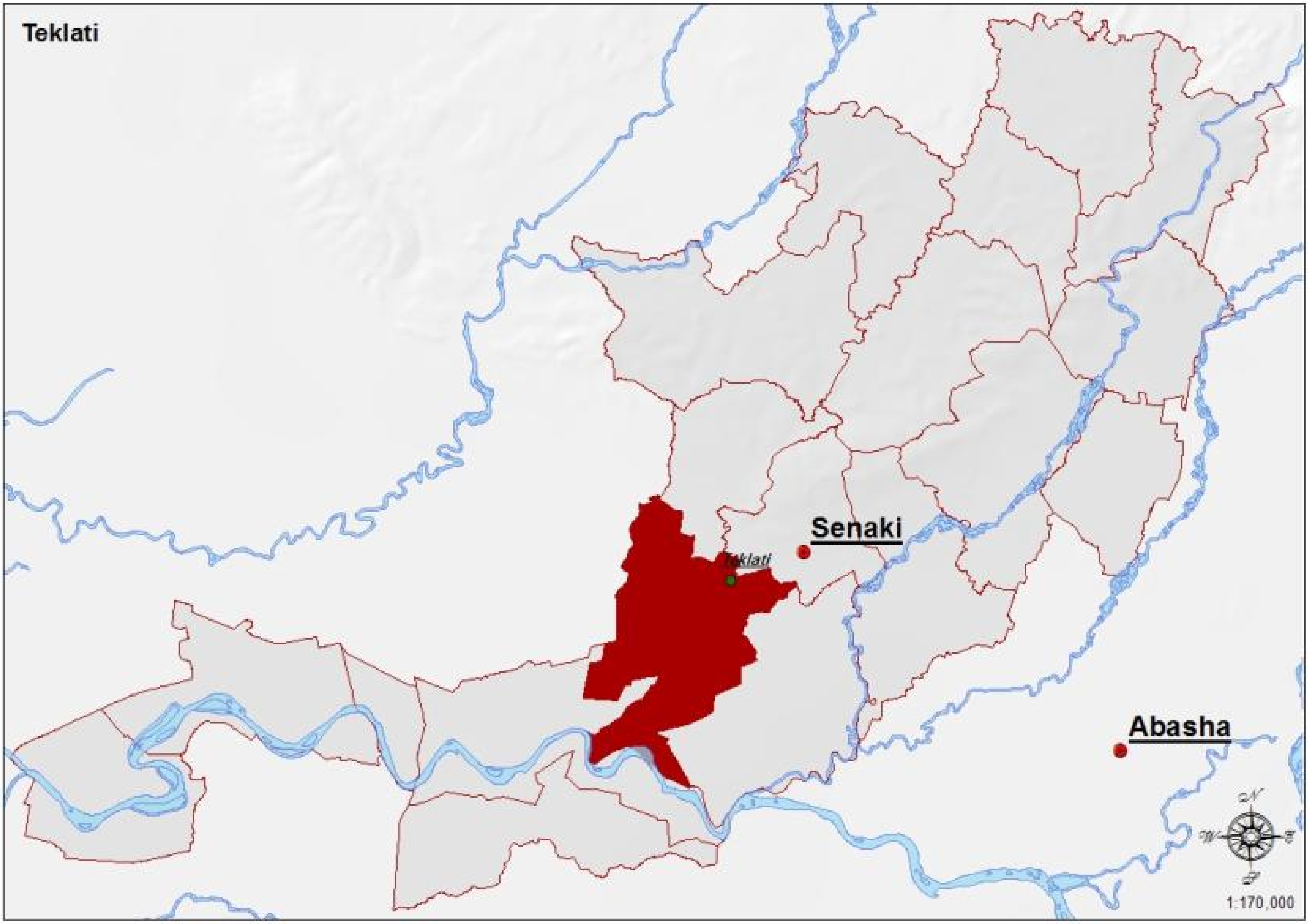


According to the same research, the risk level for the Teklati community was determined to be 0.01 points. As in case of the vulnerability index, this indicator is also one of the lowest among the communities of the lower stream of the Rioni River basin. The difference from the average is 0.05 points (see the diagram). Teklati is the community with one of the lowest risk levels. On the one hand, such a low risk level was determined by the low level of vulnerability, and on the other, by the fact that the natural disasters are mainly observed in the southern part of the community territory where population does not live and, therefore, they are not directly impacted by the hazardous natural events. In general, on scale of the target area of the program (target river basins), the risk level of the community was assessed as very low (see the map – Assessment of Disaster Risks of Senaki Municipality).




In detail, the situation of the community in regards to hazardous natural events is as follows:

As it was mentioned, the hazardous natural events are not obsereved in any of the community villages. Hazardous natural events, i.e., ***floods*** are observed in the southernmost part of the community covered by agricultural lands. On this section, and in particular, on the nearby territory of the hydrological-observation point of Tsivi-Tkiri, the Rioni River intensively washes the banks during floods. The protective dam (on about 200 meters) is damaged. Another 200-meter section is also threatened. As a result of the mentioned process, agricultural lands, pastures, mowers, etc, are being flooded.


Teklati
Senaki
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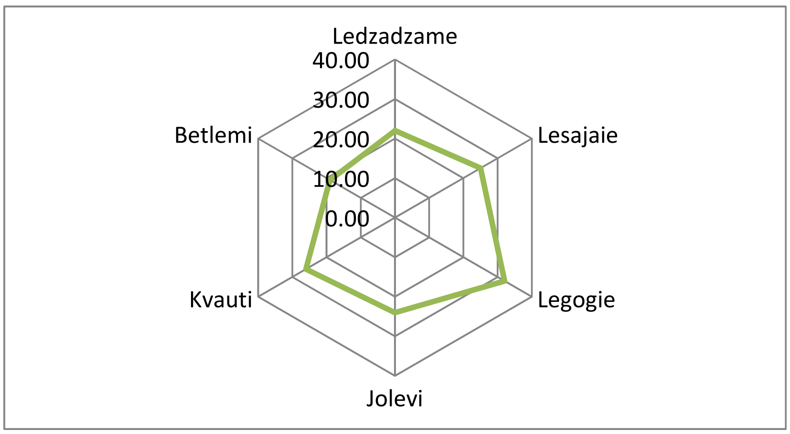
### *2.7.8. Ledzadzame Community*

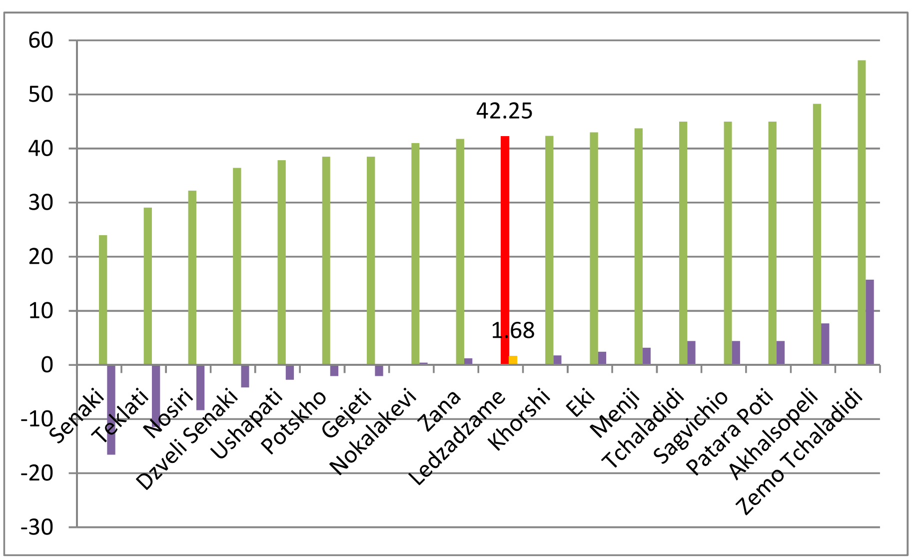
Ledzadzame community is located in the easternmost part of Senaki Municipality, bordering Martvili municipality. The community is located in the Tekhura River (a right tributary of the Rioni River) basin, its territory is spread on both banks of the river. The western part of the community is crossed by the Gudzemi River, which is itself a right tributary of the Tekhura River. The Gudzemi River gathers its waters on the territory of Ledzadzame community, flows through Potskho community and merges into the Tekhura River back within the territory of Ledzadzame community.

Ledzadzame community is comprised of six villages – Ledzadzame, Lesadjaie, Legogie, Djolevi, Kvauti, Betlemi. The average distance of the villages from the municipal center is 25 km.

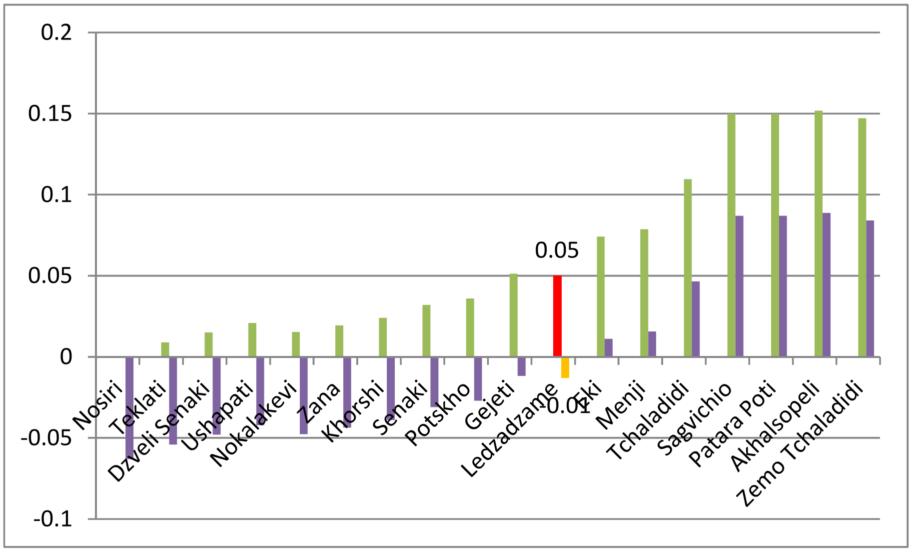



As a result of field studies, landslide process and floods were detected on the territory of Ledzadzame community.

Studies conducted within the framework of the program have shown that the vulnerability of Ledzadzame community is 42.25 points. This indicator is slightly higher than the average for the communities of the lower course of the Rioni River. The difference from the average is 1.68 points (see the graph). On the scale of the target region of the program, the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).



The indicator of risk for Ledzadzame community, according to the results of the same study, was assessed as 0.05 points. With this indicator too, the community is practically on par with the average for the lower course of the Rioni River basin, which is 0.06 points (the difference is -0.01 point. See the graph). Accordingly, the level of risk of Ledzadzame community can be assessed as average on the scale of the lower course of the basin. On the scale of the target region of the program (target watersheds), the risk level of the community can be assessed as average (see the map – Assessment of Disaster Risks of Senaki Municipality).




A detailed picture of natural hazards detected in the villages of the community is provided below.

**Ledzadzame Village**

The village of Ledzadzame is located in the central part of Ledzadzame community on the right bank of the Tekhura River. The source of the natural hazards facing the village is the Tekhura River and its erosive action. As a result of this action, the village is affected by ***floods*** and ***landslide*** processes.

The Tekhura River washes the left bank, which is composed of alluvial pebbles and inclined clay sediments that are characterized with low physical-mechanical qualities and have low resistance to erosion. As a result of shore washing, a landside process is formed. Its base is an alluvial fan composed of alluvial material and formed as a result of landslide mass pressure. At the head of the landslide, a wall of fall of 7 m height is distinctively visible. In the central part, there are micro relief forms – open gaps, steps, etc. – that suggest the active dynamics of the process. According to visual signs, the power of the landslide is up to 7 m. The main deformed horizon on the landslide consists of neogenic marls covered with inclined sediments. As a result of this process, houses and croft of 5 households are endangered. At present, the landslide body is relatively stabilized. Reports of the National Environmental Agency, however, indicate a high probability of reactivation of the process.

The problem of floods in the village is also related to the erosive action of the Tekhura River. At the walking bridge in the village, the right bank of the Tekhura River is one terrace above the floodplain composed with sand-gravel filling. In this segment, the Tekhura River washes banks. As a result, the river has taken part of the agricultural lands (0.5 ha). Additionally, lands of about 2 ha are endangered. Under the conditions of abundant precipitation and snowmelt, the river flows over the damaged segment and floods adjacent agricultural lands.

The same problem is present along the road connecting the villages of Ledzadzame and Nokalakevi, where the Tekhura River washes the right bank intensively. The bank is composed of core rocks, sandstones and clays of middle Miocene, which are overlaid by alluvial and sand-gravel carried by the Tekhura River. During periods of flooding, the Tekhura River washes the right bank, floods, and endangers a 100 m segment of the road connecting Ledzadzame and Nokalakevi and the bridge over the river.


**Lesajaie Village**

The village of Lesajaie is located to the north of the village of Ledzadzame, on the right bank of the Tekhura River. The field studies on the territory of the village have detected a ***landslide*** body located along the road connecting Nokalakevi and Didi Tchkoni. The landslide is caused by the erosive action of the Tekhura River, which washes its right bank and causes the development of the landslide process. As a result of the process, the segment between the $10^{th}$ and the $11^{th}$ km of the road is damaged. The landslide also endangers houses and crofts of four households (up to 4 ha in total). Power transmission masts are also endangered.


**Legogie Village**

The village of Legogoie is located in the northernmost part of Ledzadzame community. The distance of the village from other villages of the community is relatively big. Unlike other villages of the community, all of which are located along the Tekhura River, the village of Legogoie is located on the right bank of the Gurdzemi River. In the course of the field study, the village population mentioned ***floods*** and a ***landslide*** process as natural hazards affecting the village.

A landslide is present on the motor-road connecting the villages of Ledzadzame and Legogie. A 20 m segment of the road is damaged as a result of the process. The information of this landslide spot was provided by the local population. After the field research group examined the site, it was suggested that instead of a landslide process, it could be a suffusion phenomenon. Additional investigation of the site is needed to decide the issue, which is a prerequisite for planning adequate preventive measures.


Another major problem mentioned by the local population during the field studies is floods. During springtime, in periods of intensive snowmelt and abundant precipitation, the Gurdzeme River, which flows through the eastern part of the village, overflows its banks and floods agricultural lands located in the southern part of the village. In total, approximately 10-15 ha lands are affected by the process.


**Jolevi Village**

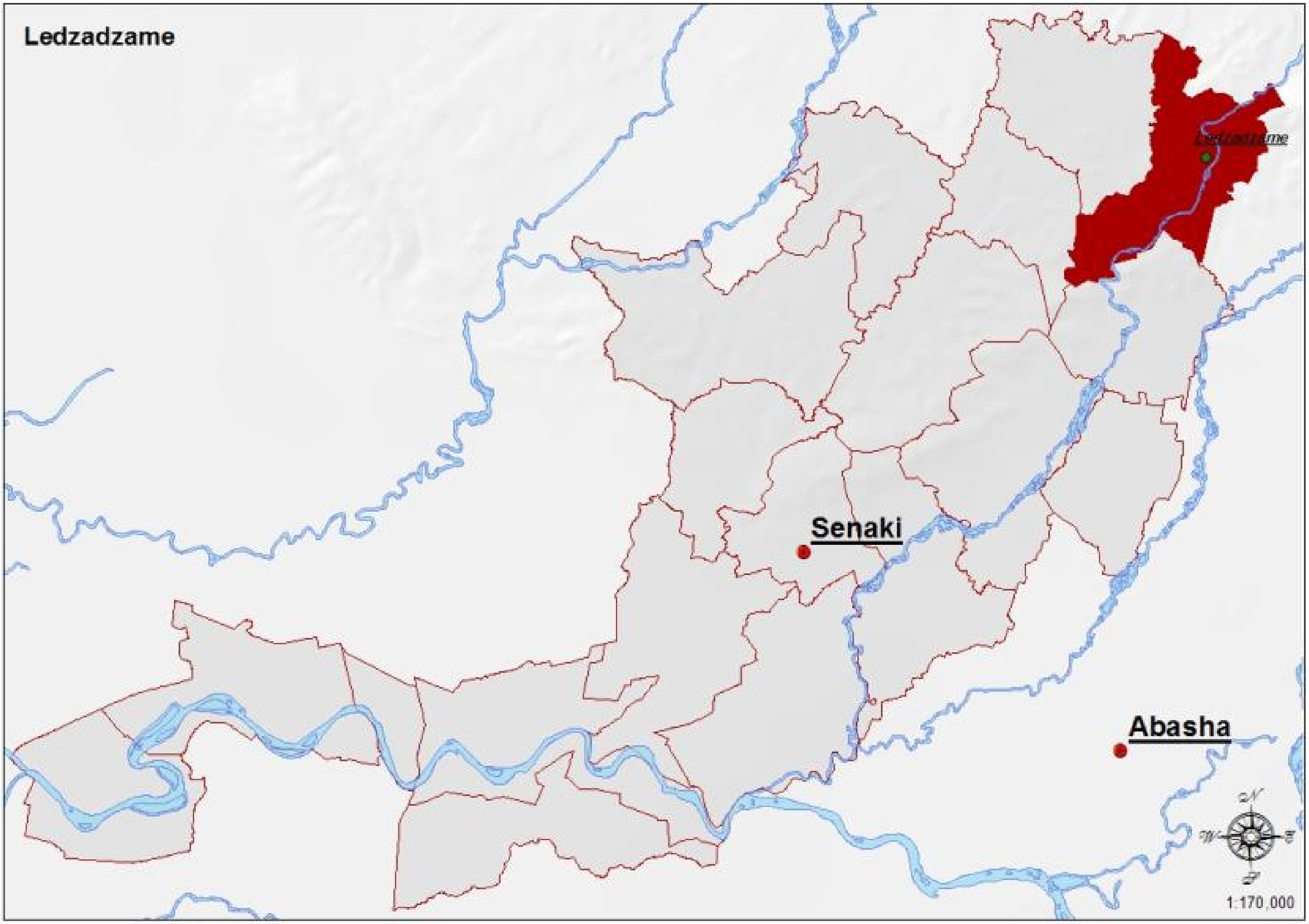
The village of Jolevi is located in the southern part of Ledzadzame community, on the right bank of the Tekhura River. The main problem of the village, with respect to natural hazards, is presented by a ***landslide*** process developed in its southern part, which encompasses a territory of up to 6 ha. As a result of the landslide process, houses and auxiliary constructions of four households are damaged.




**Kvauti Village**

The village of Kvauti is located in the eastern part of Ledzadzame community on the left bank of the Tekhura River. The main problem of the village, with respect to natural hazards, is presented by a ***landslide*** process developed here. A landslide body is formed in the village center. It has resulted from the erosive action of the Tekhura River that has carried away the support of the slope. According to the local population reports, on March 18. 2007, a landslide body formed suddenly s a result of heavy rainfall damaged crofts of the population (2 ha area of 4 households). At present, deep clefts are observed on the site. Further activation of the process is to be expected.

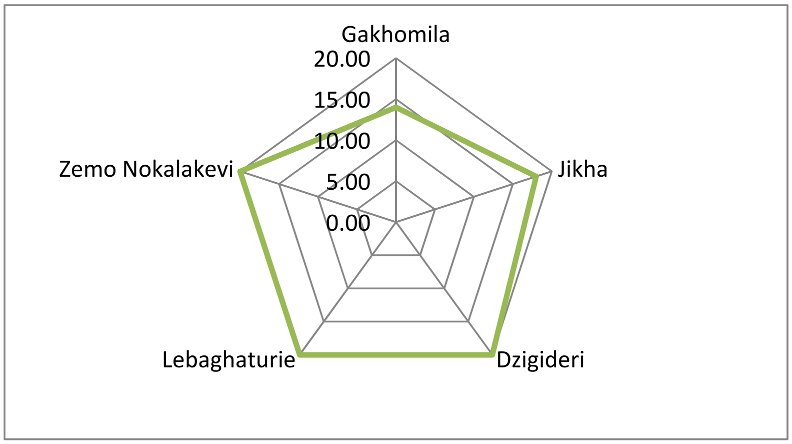

A landslide body is present also in the southern part of the village, along the road connecting to the so-called Lekirtskhaie neighborhood. A 50 m segment of the road is damaged as a result of the process. As a result, this part of the village is virtually isolated from the world.


Ledzadzame
Ledzadzame
Senaki
Abasha
1:170,000

*2.7.9. Nokalakevi Community*

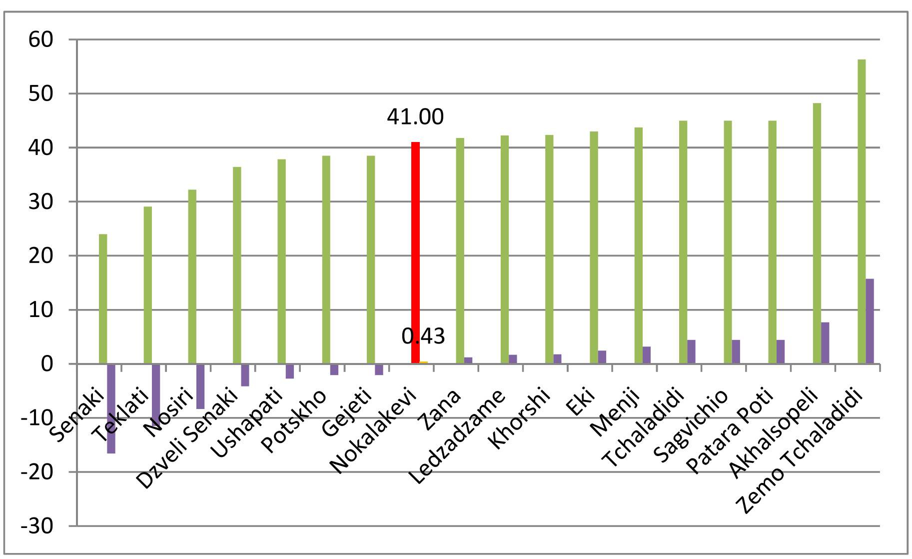
Nokalakevi community is located in the northeastern part of Senaki Municipality, bordering Martvili municipality. The territory of the community is divided in two almost equal parts by the Tekhura River. It should also be mentioned that the Abashistskali River passes the eastern part of the community. Surface watercourses of the territory of the community, therefore, are divided between the basins of the Tekhura and the Abashistskali rivers.

The community comprises five villages – Gakhmoila Jikha Dzigideri, Lebaghaturie, and Zemo Nokalakevi. The average distance of the villages from the municipal center is up to 18 km.

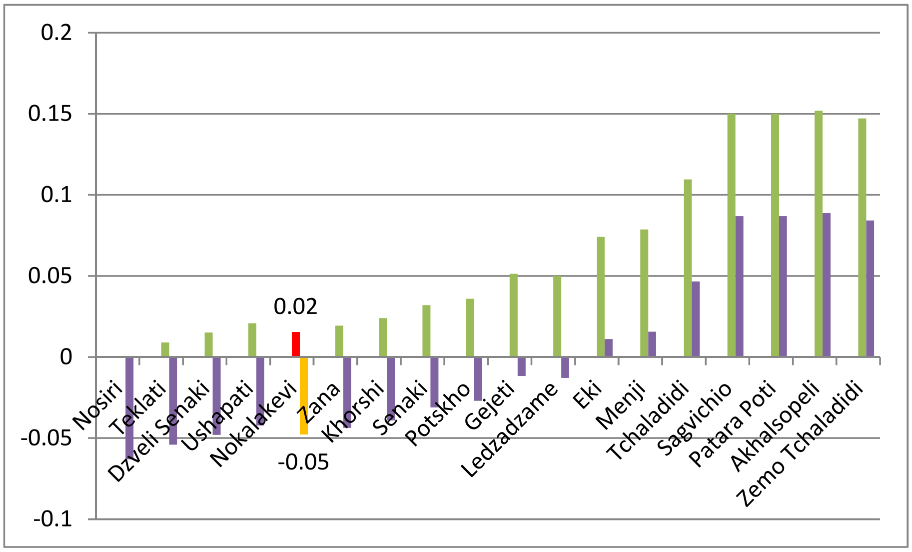



Among natural hazards, mainly the problem of floods was detected on the territory of the community. However, a landslide process should also be noted.

According to the results of the studies undertaken within the framework of the program, the vulnerability of Nokalakevi community was assessed as 41.00 points. This indicator slightly exceeds the average indicator for the communities of the lower course of the Rioni River basin. The difference is just 0.43 point (see the graph). On the scale of the target scope of the program (target watersheds), the vulnerability indicator of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).



The level of risk for the community was assessed as 0.02 point. This indicator is lower than the average indicator for the communities of the lower course of the Rioni River basin. The difference is -0.05. On the scale of the target scope of the program (target watersheds), the level of risk of the community is assessed as lower than average (see the map – Assessment of Disaster Risks of Senaki Municipality).




A detailed picture of the natural hazards detected in the community is provided below.

**Lebaghaturie Village**

The village is located in the easternmost part of the community, on the right bank of the Abashistskali River. In the course of the field studies, mainly ***floods*** and ***landslide*** processes were detected as the source of the problems of the village.

On a slope of about 150 inclination of southwestern exposition there is a manifest landslide process. At the head of the landslide, at a segment of the slope up to 200 m length, a wall of fall of 2-7 m high is discernible in the relief. In its opening, alluvial sediment pebbles with loam fillings are present. The relief on the landslide body is characterized with waves and steps; the surface is fragmented with open landslide clefts and minor erosional formations. The landslide is frontal, the height of the landslide-affected slope exceeds 30 m. On the lower part of the slope, the gorge of the nameless creek of the village is obstructed by landslide soil. Because of this, conditions for the formation of a mudflow stream are created. The landslide tongue in its peripheral part creates a turfed step up to 1 m high. In the vicinity of the mentioned morphological element, the house and auxiliary constructions of one local dweller are located. Further development of the process will endanger the village road and houses and lands of the population.

Apart from the described problems, problems of flood were also detected in the village. The Abashistskali River washes its banks during floods, as a result of which agricultural lands of the village (approximately 10 ha) get inundated during springs and periods of abundant precipitation.




Floods are characteristic of the Tarcheni River too, which flows through the village. The river washes its banks and damages agricultural lands. In total, an area of 7 ha is damaged. During floods, lands and pastures of the village (up to 15 ha) are also inundated. The process endangers also the bridge on the central motor-road connecting Senaki and Martvili.


**Jikha Village**

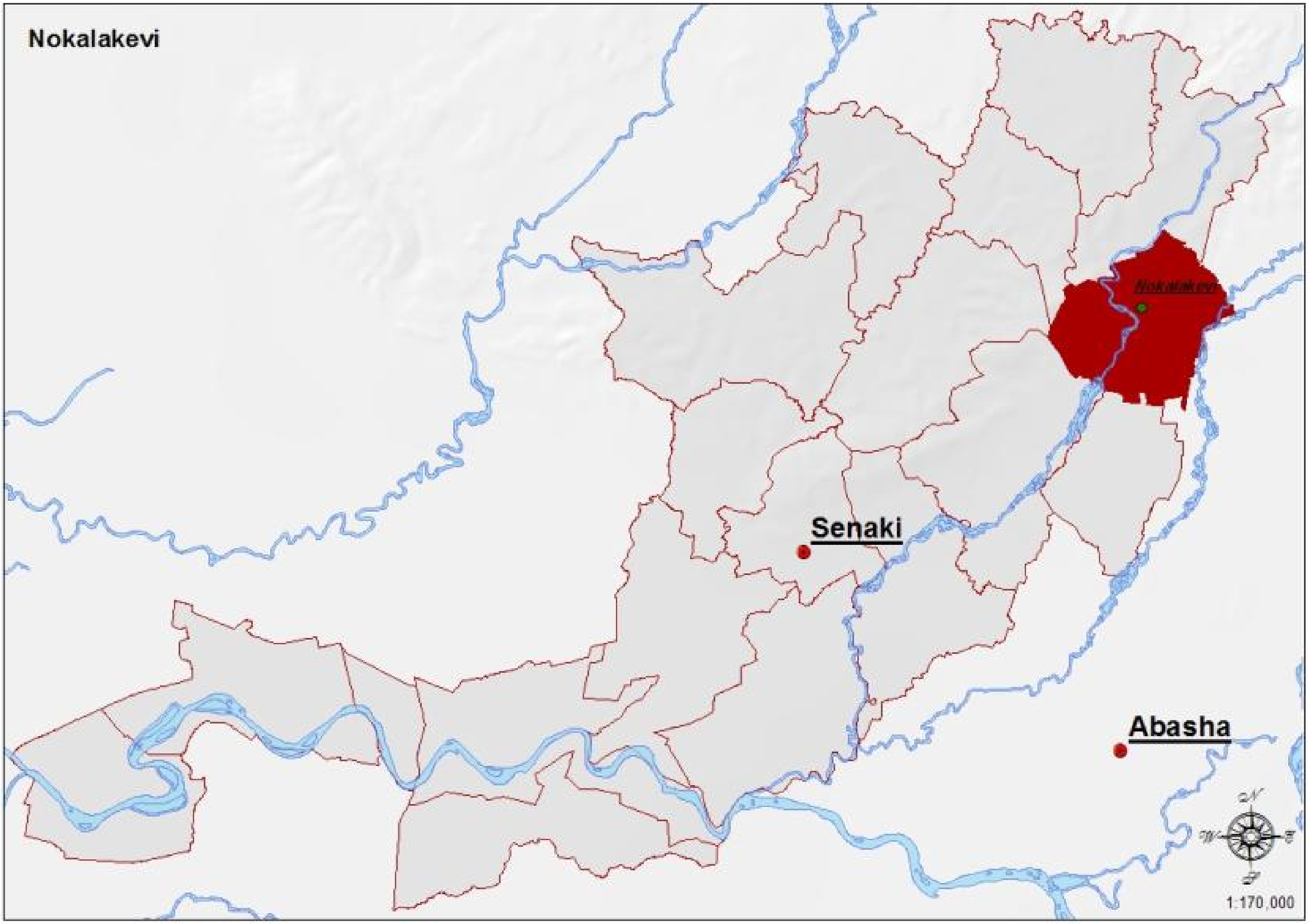
The village of Jikha is located in the central part of Nokalakevi community, along the left bank of the Tekhura River. Among natural hazards, ***landslide*** phenomena were detected by the field studies. There is a landslide in the so-called Kakuliebis neighborhood, where the process affects 1.5 ha and endangers the house and the croft (1 ha) of one household (Gocha Kharebava).


**Gakhomela Village**

The village of Gakhomela is located in the central part of Nokalakevi community on the right bank of the Tekhura River. The main problem for the village, with respect to natural hazards, is the erosive action of the Tekhura River. On the territory of the so-called Sabeselio, the river washes its right bank, as a result of which it carries away agricultural land and, during ***floods***, damages up to 6 ha of agricultural lands.


**Dzigideri Village**

The village of Dzigideri is located in the southern part of Nokalakevi community, on the left bank of the Tekhura River. The main problem of the village is related to ***floods*** on the Tekhura River. The Tekhura River washes the bank and inundates agricultural lands (approximately 5 ha in total) during floods. Crofts of households living nearby are also endangered.


Nokalakevi
Nokalakevi
Senaki
Abasha
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1:170,000

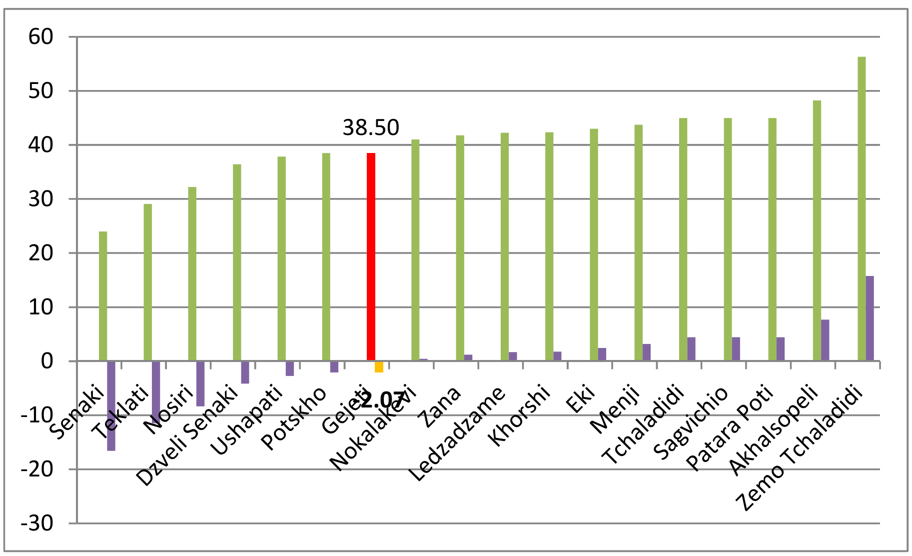
### *2.7.10. Ushapati Community*

Gedjieti community is located in the eastern part of Senaki Municipality, bordering Martvili municipality. The territory of the community is enclosed by gorges of the Tekhura and Abashistskali rivers. The community is located on the left bank of the Tekhura River and on the right bank of the Abashistskali River. Accordingly, surface watercourses present on the territory of the community are divided among the basins of these two rivers.

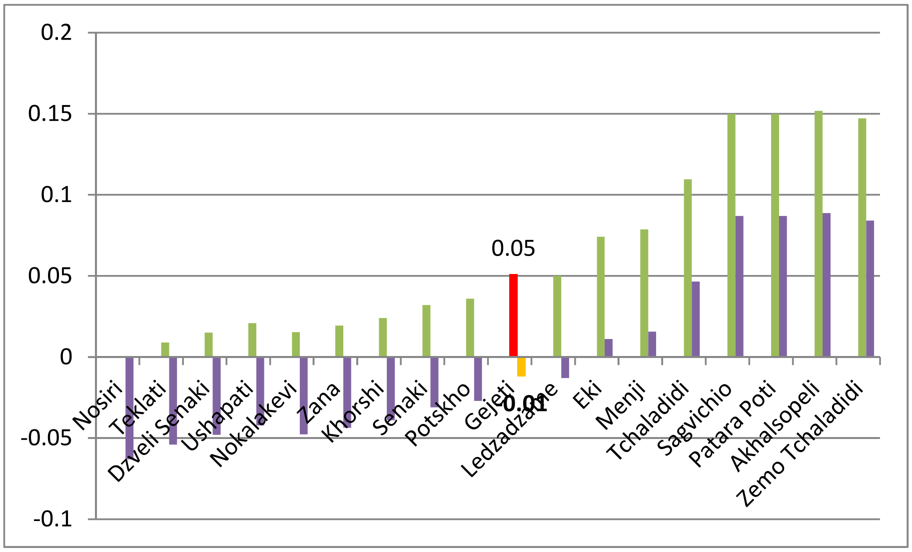
The community consists of a single village – the village of Gedjieti. The distance between the village and the municipal center is 14 km.

Among natural hazards, the problem of flood was detected in the course of the field study on the territory of the community.

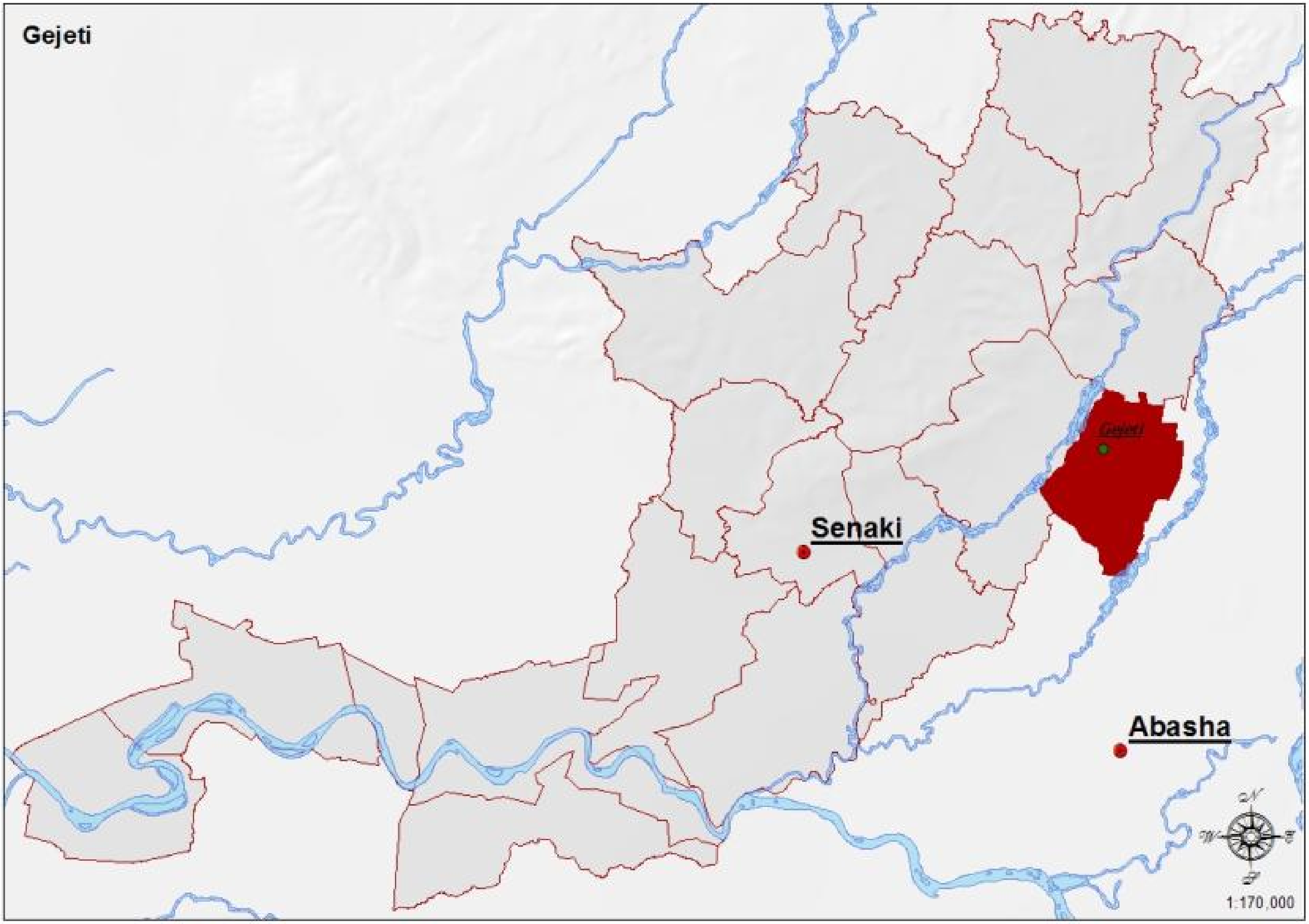
According to the data obtained through the research undertaken within the framework of the program, the vulnerability of Gedjieti community is assessed as 38.50 points, which is lower than the average indicator for the communities of the lower course of the Rioni River basin. The difference from the average is not big and equals -2.07 points (see the graph). On the scale of the whole target scope of the program (target watersheds), the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).




According to the results of the same study, the level of risk of Gedjieti community was assessed as 0.05 point. This indicator is higher than average for the communities of the lower course of the Rioni River basin. The difference is 0.01 point (see the graph). In general, on the scale of the whole target scope of the program, the level of risk of the community was assessed as average (see the map – Assessment of disaster risks of Senaki Municipality).




As was mentioned above, the community consists of a single village, the village of Gedjieti. In the course of field research, the local population singled out the problem of ***floods*** as the main problem of the village. Floods are caused by the channel that branches out from the Tekhura River and passes through the village center. During spring, in periods of snowmelt and abundant precipitation, its channel fails to conduct surplus rainwater, which is aggravated by the fact that an increased amount of water flows in from the Tekhura River since its banks are damaged. As a result, adjacent agricultural lands are inundated in total, houses, crofts and up to 70 ha agricultural lands of 70 households are affected by the hazard.


Gejeti
Gejeti
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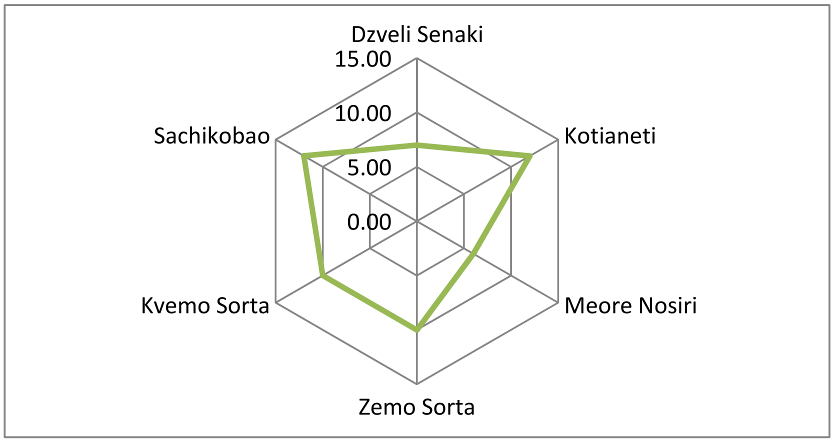
***2.7.11. Dzveli Senaki Community***

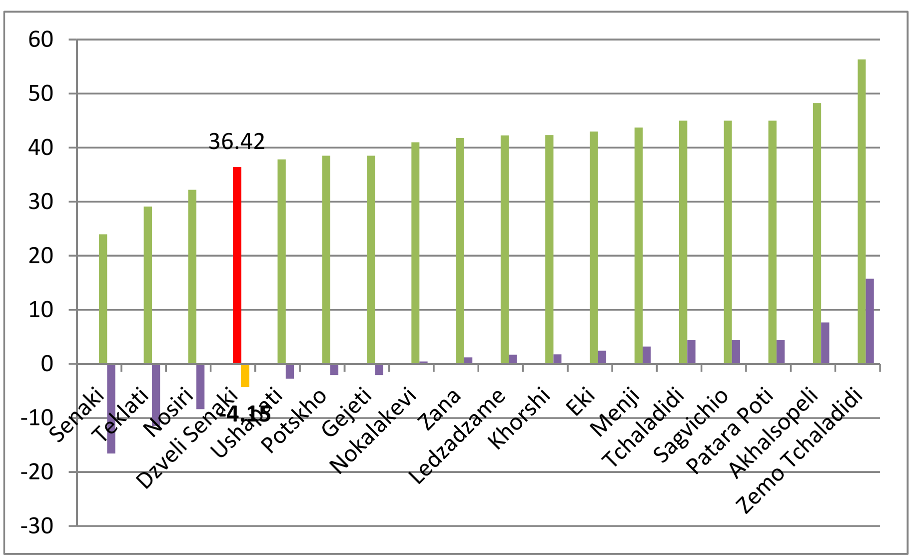
Dzveli Senaki community is located in the central part of the municipality, slightly eastward. The territory of the community is encompassed within the basin of the Tekhura River. The river crosses the eastern part of the community along the whole length.

Dzveli Senaki community is comprised of six villages. These villages are: Dzveli Senaki, Kotianeti, Meore Nosiri, Zemo Sorta, Kvemo Sorta, Sachikobao. The average distance between the villages and the municipal center is 10 km.

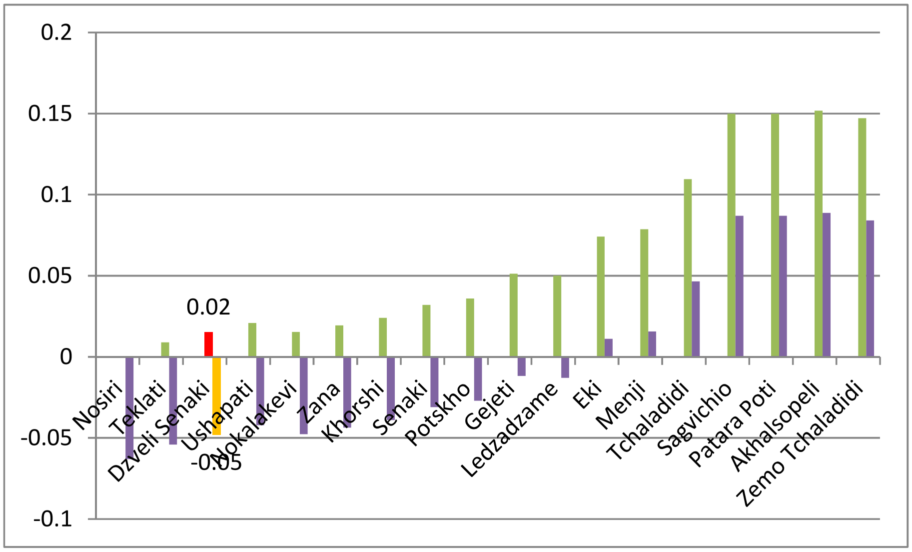



In course of the field studies, the following natural hazards were detected on the territory of the community: river-related erosions, floods and landslide processes.

According to the results of the studies conducted within the framework of the program, the vulnerability of Dzveli Senaki was assessed as 36.42 points, which is lower than the average indicator for the communities of the lower course of the Rioni River basin. The difference from the average is -4.15 points (see the graph). In general, on the scale of the target scope of the program (target watersheds), the vulnerability of the community was assessed as average (see the map – Assessment of the Vulnerability of Senaki Municipality).



The level of risk for Dzvelii Senaki community, according to the same study, is 0.02 point. This indicator is lower than the average for the communities of the lower course of the Rioni River basin, which is 0.06 point (the difference from the average is -0.05. See the graph). Accordingly, the level of risk of Dzveli Senaki community can be assessed at relatively low level of risk on the scale of the lower course of the basin. On the scale of the target scope of the program (target watersheds), the level of risk of the community will be assessed as lower than the average (see the map – Assessment of the Disaster Risks of Senaki Municipality).




A detailed picture of the natural hazards detected in the community is provided below.

### Dzveli Senaki Village

The village of Dzveli Senaki is located in the central part of the community. The main problem for the village is related to ***landslide*** processes developed there. In the basin of the Nakhura Creek – a tributary of the Tekhura River – on the slopes of southern exposition, a landslide process is actively developing, which, together with natura geological relief and climate-related conditions, is also aggravated by forest logging, degradation of soil-vegetative turf as a result of grazing, slope cutting and other anthropogenic factors. The landslide is developed in the reddish loam of the slope, as well as in the crust of exhausted basic rocks (paleogenic sandstone and shallow sea limestone). In this region of Dzveli Senaki, characteristic forms of the relief are landslide steps and open clefts. Landslide soil lacks resistance to erosive processes and is easily transported by rainwater along the channels of erosive formation. During heavy rainfalls, materials transported by streams are carried to the road of the village and municipal importance, which causes damage to roads, crofts, drainage channels and other communications. During heavy rainfalls, the volume of the solid material carried by streams for isolated occasions reaches hundreds of cubic meters and for the whole area of the Nakhuri basin – even thousands of cubic meters.

**Sachikobao Village**

The village of Sachikobao is located in the westernmost part of Dzveli Senaki community. The main problem of the village with respect to natural hazards is related to landslide processes developed there. In the village, on a slope of southern exposition, with an inclination from sloping to moderately steep, composed of limestone of the Jurassic period, a landslide process developed in the deluvial clay layer and damaged one house (Iuri Chikobava), which, according to the data of the national environmental agency has been under observation since 2006, when the conclusion was compiledand a recommendation was issued to immediately carry out works against the landslide, an alternative to which was rebuilding the house on a safe, stable plot. For the period since then, the scale of the deformation of the construction has increased. By present estimates, the house is wrecking and is unsuitable and unsafe for living in and the location of the house is the zone of a hazardous manifestation of the landslide process.

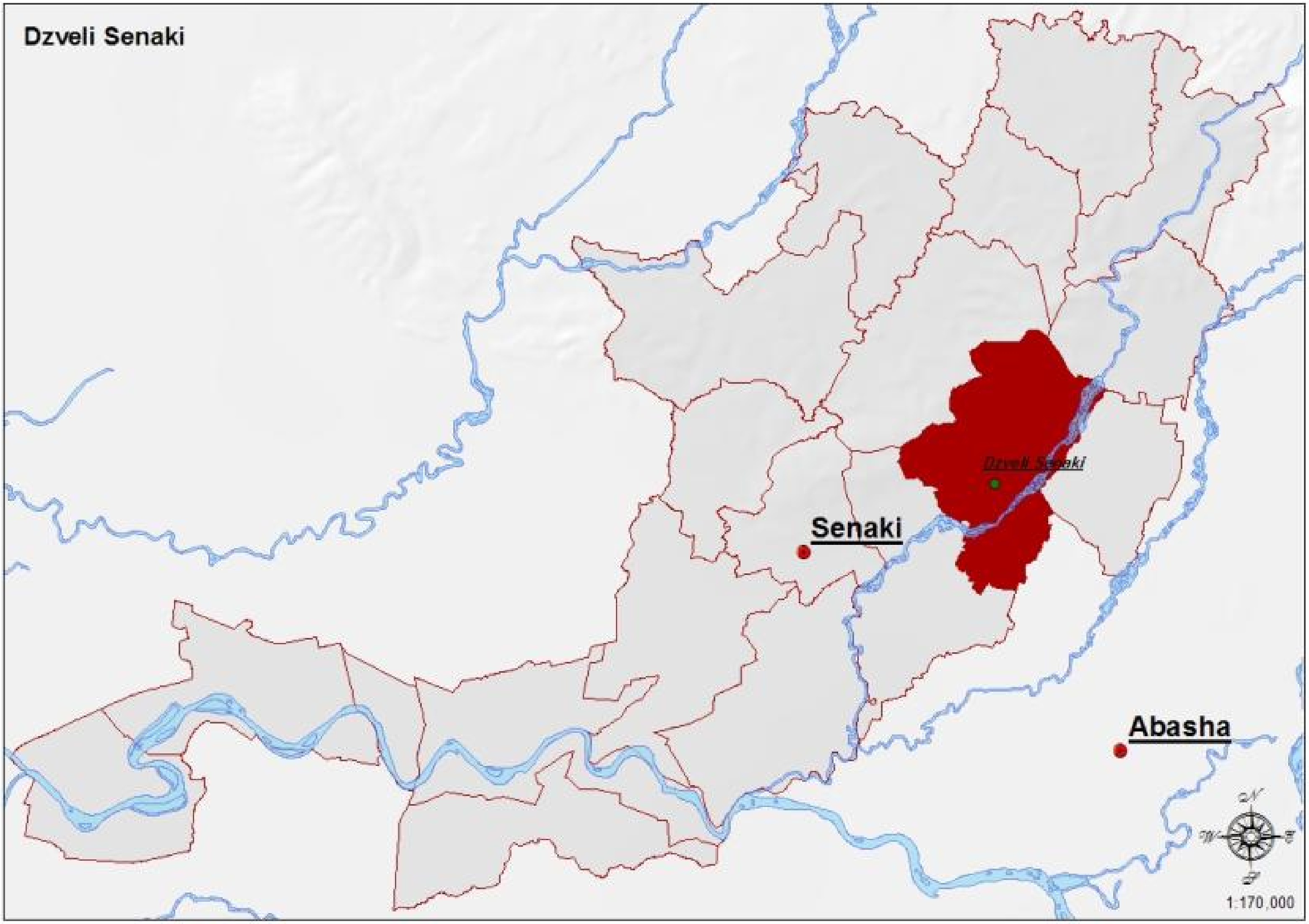
**Meore Nosiri Village**

As field studies have shown, the main problem of the village is related to ***erosive*** processes developed on the Tekhura River. As a result of these processes on the territory of the village, a 500 m segment of the only road connecting with the village of Gedjeti is damaged. The problem is caused by the fact that the Tekhura River washes its banks, as a result of which the protective gabion is damaged.

The same process damaged the main bridge on the road connecting Senaki and Martvili. The river has already damaged protective dams of the bridge and one of the supporting pillars.

The Tekhura River also causes a problem on the territory of the other side of Meore Nosiri, where it washes banks and damages agricultural lands. During spring and under conditions of abundant precipitation, ***floods*** occur on the river and agricultural lands are being inundated (up to 7 ha in total).

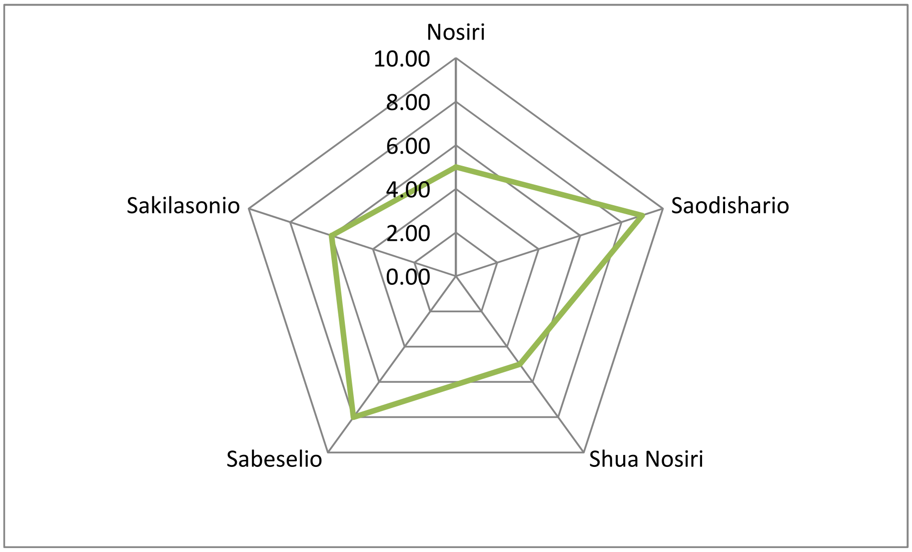
 


Dzveli Senaki
Senaki
Abasha
1:170,000

### *2.7.12. Nosiri Community*

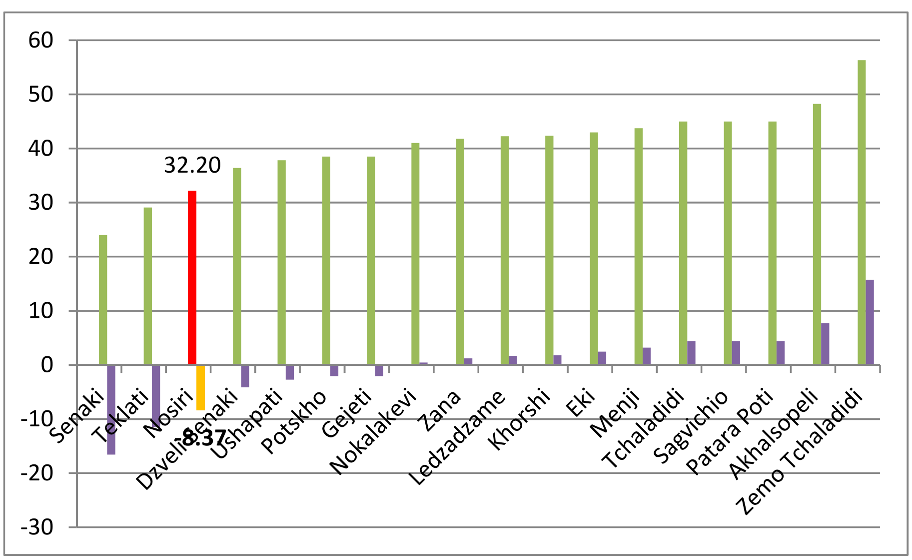
Nosiri community is located in the southeastern part of Senaki Municipality. The territory of the community is encompassed within the Tekhura River basin.

Nosiri community is composed of five villages – Nosiri, Saodishario, Shua Nosiri, Sabeselio, Sakilasonio. The average distance of the villages from the municipal center is 7 km.

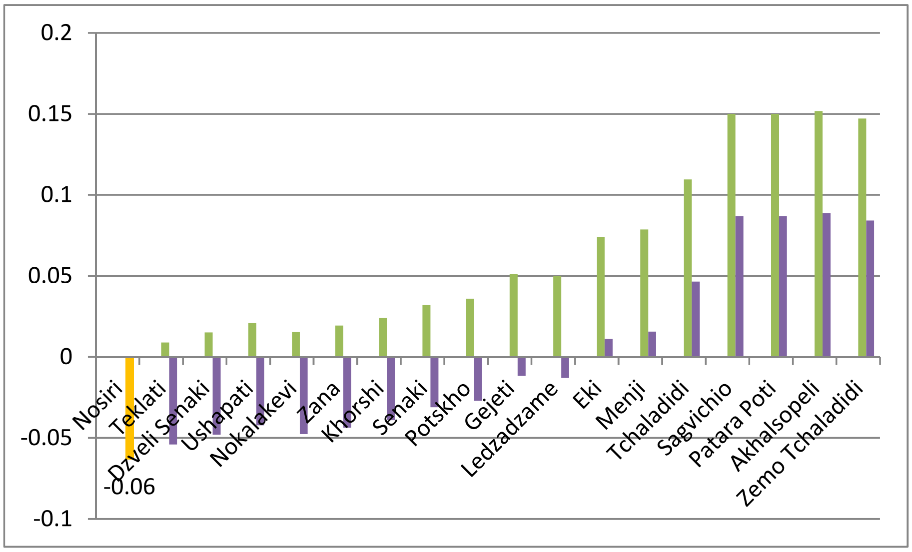


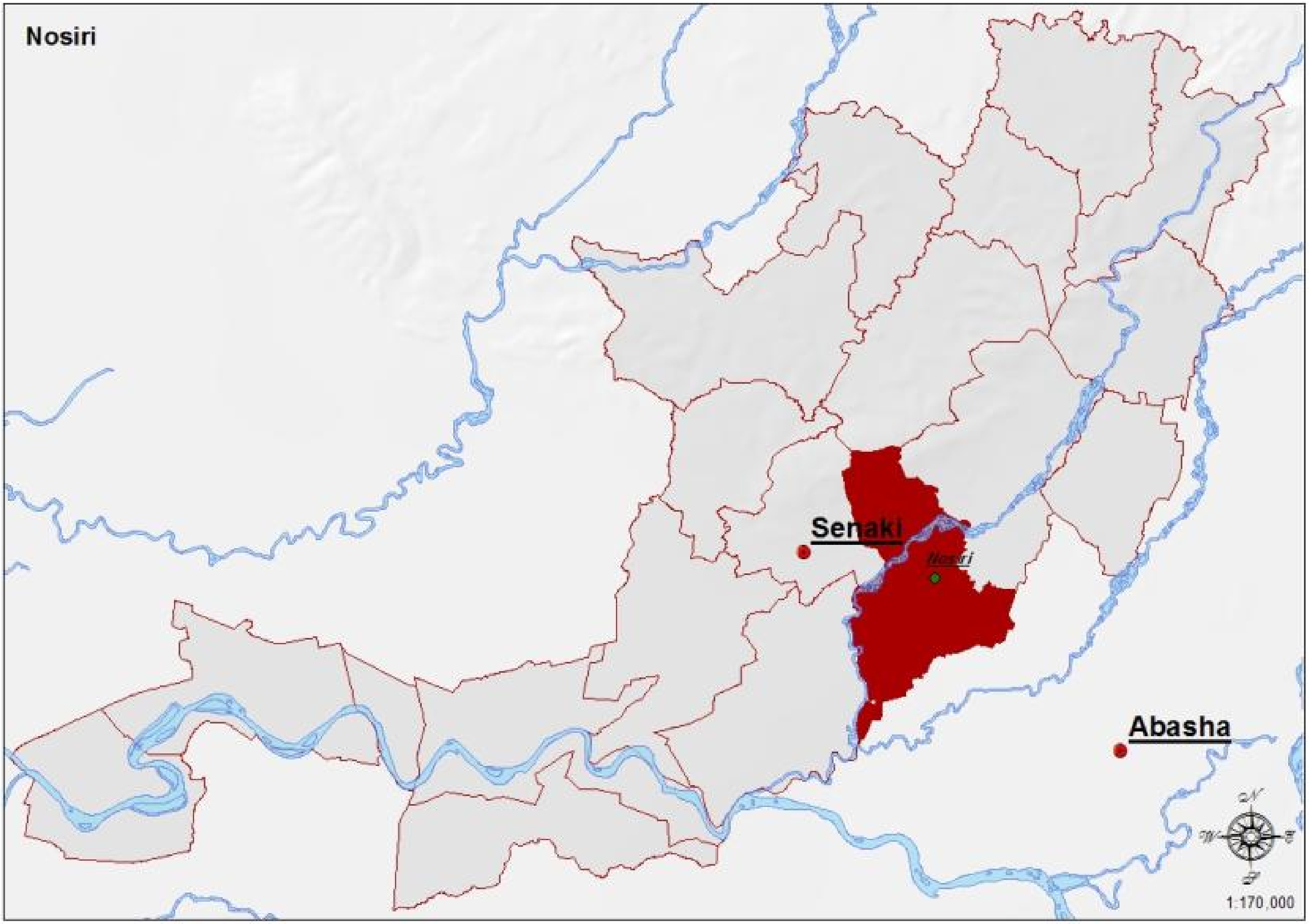

It must be noted that neither the field visits, nor any other sources identify any hazardous natural processes on the territory of Nosiri community.

According to the data obtained from the studies conducted within the framework of the program, the vulnerability indicator for Nosiri community is 32.20 points. This is one of the lowest indicators on the lower course of the Rioni River basin. The difference from the average is significant and equals -8.37 points (see the graph). On the scale of the whole target scope of the program (target basins), the vulnerability of Nosiri community was assessed as lower than average (see the map – Assessment of the Vulnerability of Senaki Municipality).



The level of risk for Nosiri community is the lowest in the lower course of the Rioni River basin. This is caused by the fact that no natural hazard of any kind has been detected on the territory of the community. Accordingly, the level of risk of the community was assessed as 0. On the scale of the target scope of the program (target river basins), the level of risk of the community was assessed as very low (see the map – Assessment of the Disaster Risks of Senaki Municipality).




Nosiri
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Nosiri
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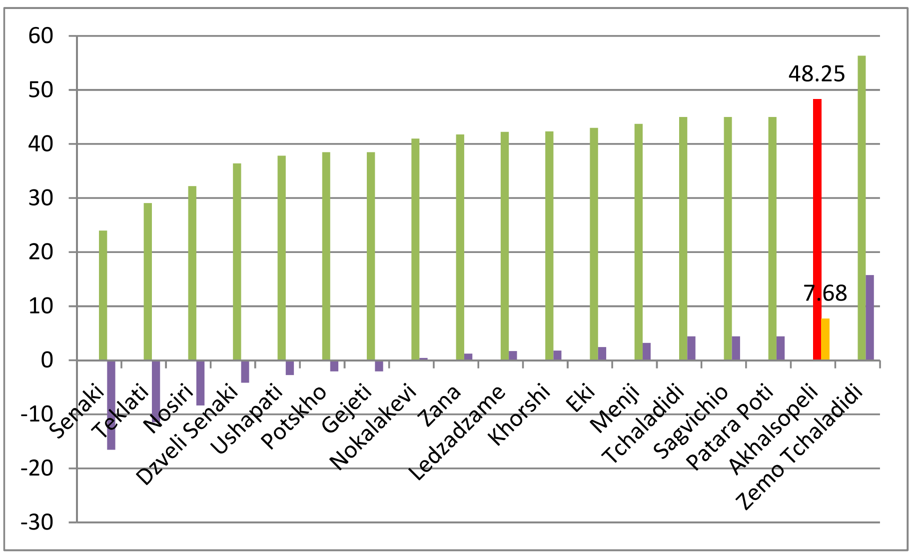
### *2.7.13. Akhalsopeli Community*

Akhalsopeli community is located in the southernmost part of Senaki Municipality. The territory of the community comprises the confluence of the rivers Tekhura and Rioni, however, inhabited areas are located only along the Tekhura River. Along the Rioni River, only agricultural lands of the community are located.

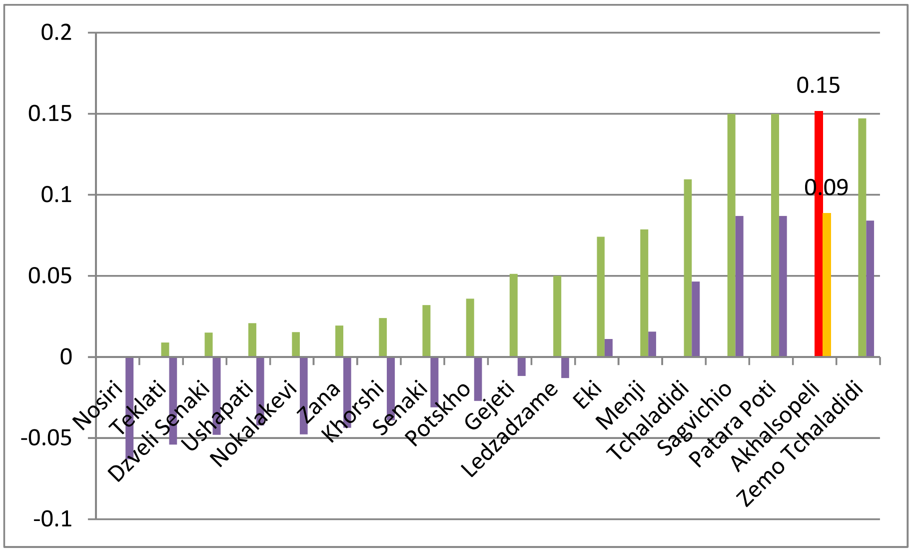
Akhalsopeli community is comprised of two villages – Akhalsopeli and Isula. The average distance of the villages from the municipal center is more than 5 km.

Field studies detected the problem of large-scale **floods** on the territory of Akhalsopeli community .

Based on data obtained through the studies conducted within the framework of the program, the vulnerability of Akhalsopeli community was assessed as 48.25 points. This indicator is considerably higher than the average indicator for the communities of the lower course of the Rioni River basin. The difference from the average is 7.68 points (see the graph). Therefore, Alkalsopeli community is one of the most vulnerable communities of the lower course of the Rioni River basin. On the scale of the target scope of the program (target river basins), the vulnerability of the community is assessed as higher than the average (see the map – Assessment of the Vulnerability of Senaki Municipality).




The level of risk for Akhalsopeli community is 0.15 point. This indicator is also one of the highest among the communities of the lower course of the Rioni River basin. The difference from the average is 0.09 point (see the graph). Such a high level of risk is determined by the scale and intensity of natural hazards present on the community, which is accompanied by a significantly high level of vulnerability. In general, on the scale of the target scope of the program (target river basins), the level of risk of the community can be assessed as very high (see the map – Assessment of the Disaster Risks of Senaki Municipality).




Accordingly, based on the abovementioned, Akhalsopeli community can be assessed as on of the "hot spots" of the lower course of the Rioni River basin with respect to the risk of disasters and climate change.

A detailed picture of the natural hazards detected in the community is provided below.

**Akhalsopeli Village**

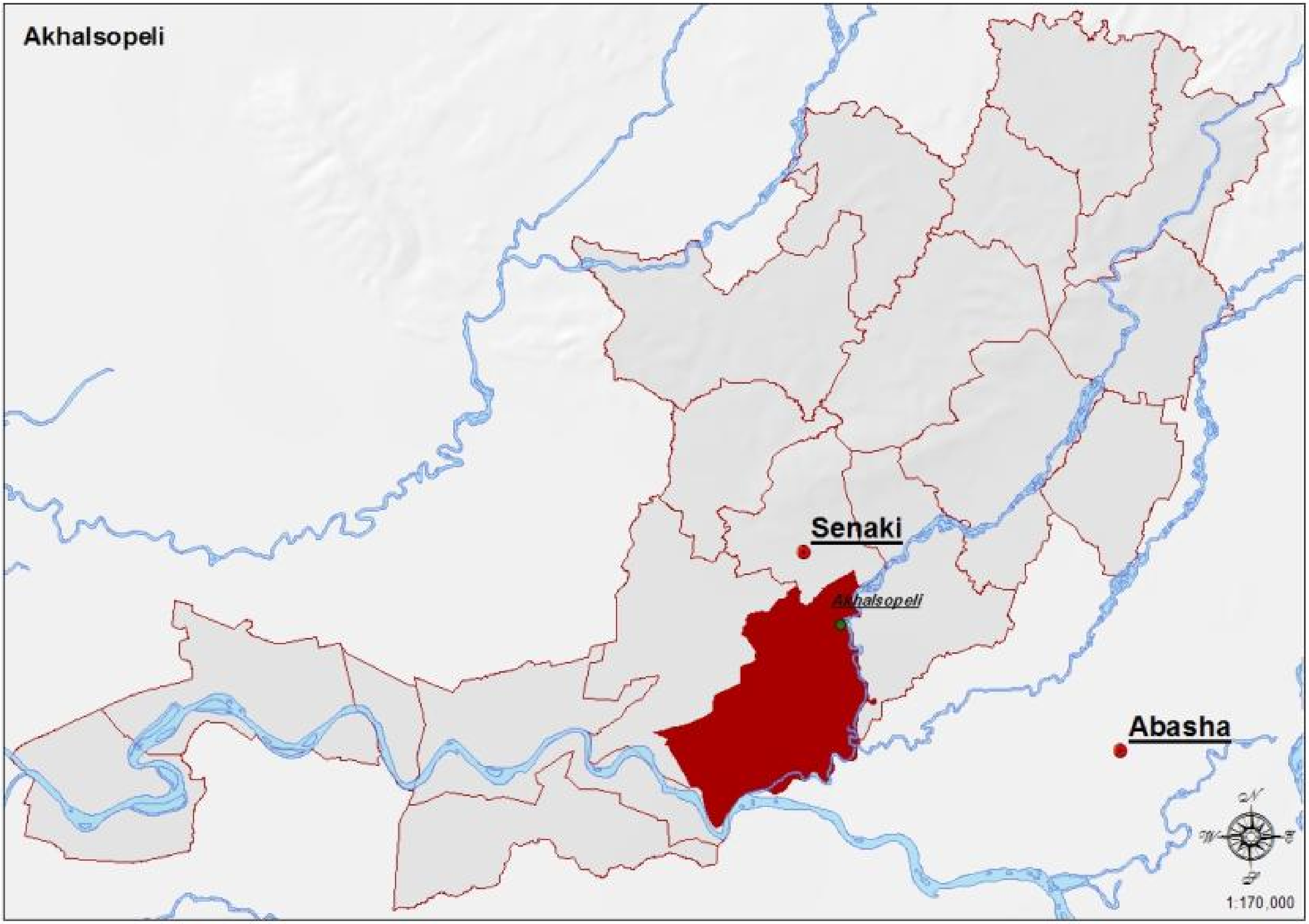
The village of Akhalsopeli is located in the northernmost part of the community, on the right bank of the Tekhura River. The main problem of the village is related to ***floods*** and river-related erosion developed on the Tekhura River. The dam and ground barrier constructed in the last century along the right bank of the Tekhura River near the village territory is severely damaged in several spots. Practically the whole village and the agricultural lands of the village are under the threat of inundation. As a result of intensive washing of banks, the Tekhura River has already taken away more than 30 ha of agricultural lands. Also an almost 6 km segment of the road connecting with the village of Isula is endangered and damaged.


### Isula Village

The village of Isula, like Akhalsopeli, is affected by the problem of ***floods*** on the Tekhura River. The river intensively washes its banks and causes floods in cases of abundant precipitation. Here too, the main problem is the damaged shore protective constructions on the river. Essentially, both villages of the community face the same big problem – floods on the Tekhura River, aggravated by damaged shore protection constructions (dams).As a result of the process, practically the whole village is endangered (population, agricultural lands, the village cemetery, and the church).



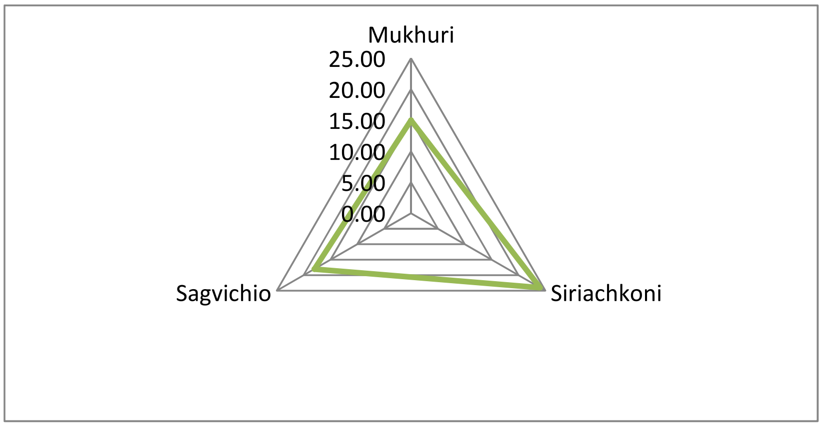

Together with the abovementioned, it should be noted that territories along the Rioni River are used intensively for agriculture. Shore protection dams along the Rioni River are also significantly damaged in several spots and floods endanger the main economic foundation of the community. In case of a relatively powerful flood, the community population may lose its whole agricultural production together with lands located along the Rioni River.


Akhalsopeli
Senaki
Akhalsopeli
Abasha
1:170,000

*2.7.14. Zemo Tchaladidi Community*

Zemo Tchaladidi community is located in the westernmost part of Saneki municipality. Its territory is spread on both banks of the Rioni River.

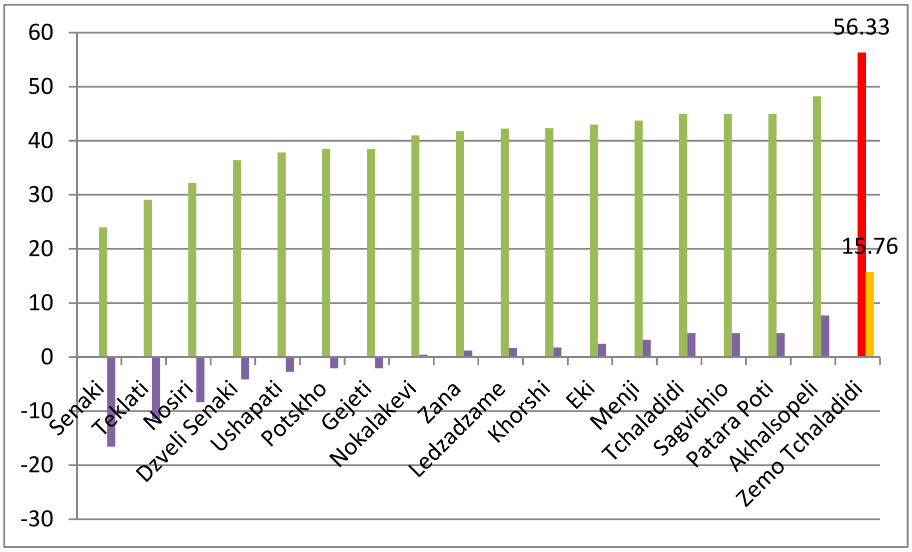
The community is comprised of three villages: Mukhuri, Sisiachkono, Sagvichio. Mukhuri is located on the right bank of the Rioni River, while Sagvichio and Siriachkoni are located on its left bank. The average distance of the villages from the municipal center is up to 20 km.



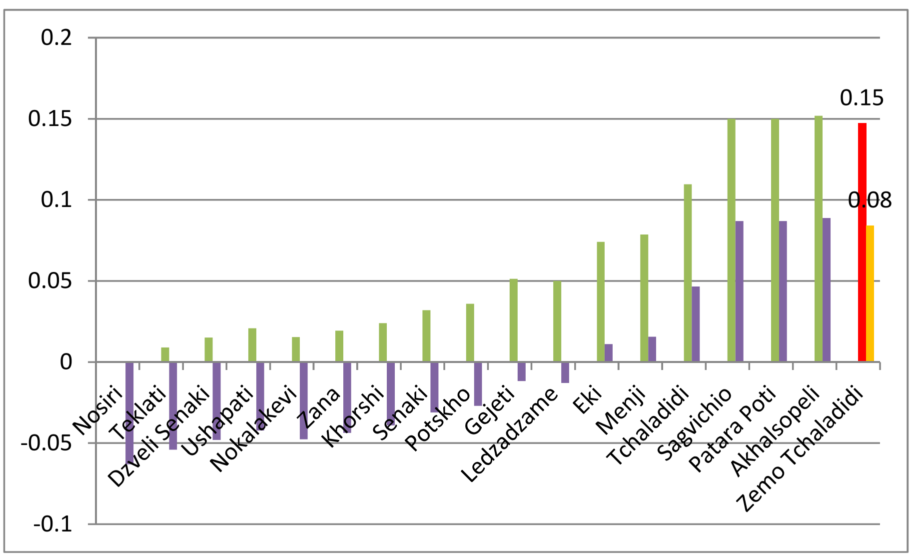

In the course of field studies on the territory of Zemo Tchaladidi community, the problem of large-scale floods was detected.

Based on the data obtained through studies conducted within the framework of the program, the vulnerability of Zemo Tchaladidi community was assessed as 56.33 points. This indicator is the maximum on the scale of the communities of the lower course of the Rioni River basin. The difference from the average is 15.76 points (see the graph). Therefore, Zemo Tchaladidi community is one of the most vulnerable communities both on the lower course of the Rioni River basin as well as on the scale of the whole target scope of the program. This situation, together with other causes, is determined by the fact that two villages belonging to the community – Sagvichio and Siriachkoni – are practically isolated from the outer world, there is no road to these villages, the only means of communication with them is the ferry transfer on the Riony River, which is practically amortized. In case of any major disaster or a flood on the Rioni River, these villages will be completely detached from the outer world and the only means for communication with them will be through airplanes (to illustrate this, the local population recalls an instance from 80s, when during a major flood, it was necessary to evacuate the inhabitants of these villages by helicopters). In this respect, the community is unique not only on the scale of the target scope of the program, but also practically on the scale of all of Georgia.

On the scale of the target scope of the program (target river basins), obviously, the vulnerability of Zemo Tchaladidi community is assessed as very high (see the map – Assessment of the Vulnerability of Senaki Municipality).




The level of risk for the Zemo Tchaladidi community is 0.15 point. This indicator is also one of the highest among the communities of the lower course of the Rioni River basin. The difference from the average is 0.09 point (see the graph). Such a high level of risk is determined first of all by the very high level of vulnerability of the villages of the community, but also by the scale and intensity of natural hazards present there. In general, on the scale of the target scope of the program (target river basins), the level of risk of the community will be assessed as very high (see the map – Assessment of the Disaster Risks of Senaki Municipality).




Accordingly, based on the abovementioned, the Zemo Tchaladidi community, on the scale of the lower course of the Rioni River basin, can be assessed as on of the “hot spots” with respect to the risk of disasters and climate change.

A detailed picture of the natural hazards detected in the community is provided below.

### Mukhuri Village

The village Mukhuri is located in the central part of Zemo Tchaladidi community on the right bank of the Rioni River. The Tsivi River also crosses the village. The main threat for the village is related to ***floods*** developed on the Tsivi River. The right bank of the river is the first terrace over the floodplain of the Tsivi River. It is composed of contemporary alluvial, loosely connected sand-soils and loams that have low resistance to lateral erosive processes. On the right bank of the river, in some places, vegetation on ground gabions is destroyed and gabions are lowered as a result of anthropogenic influence (in course of field studies, two such sites were identified). As a result of this, the flooded river has washed and carried away almost half of the soil of certain parts of the gabions. There is a risk that in case of another flooding, weakened parts of the gabions will be broken through, which will endanger the local population and their agricultural lands with inundation. Up to 40 households of the village and 35 ha agricultural lands are endangered. It should be noted that events developed in the village Mukhuri will affect directly the village of Kvaloni (Khobi municipality) bordering it, which will be also exposed to the threat of flooding.

Floods also endanger the dirt road connecting the village to the municipality.


### Siriachkoni Village

The village of Siriachkoni is located on the left bank of the Rioni River. It should be noted that the only means connecting the village to the outer world is a ferry transfer on the Rioni River that is practically amortized.

The village mainly is affected by the danger of ***floods*** developed on the Rioni River. In the vicinity of the village, the left bank of the Rioni River, which is the first terrace above the floodplain of the Rioni River, is composed of contemporary quaternary alluvial, loosely connected sand-soils and loams, that have low resistance to lateral erosive processes. When the Rioni River is blocked, the water level rises significantly and, as a result of damaged protective hills (dams), floods large areas of the shore zone and endangers residences, yards, and crofts of the population of the villages of Seriachkoni and Sagvichio (24 households in total), as well as the village road. It should be mentioned that flooding causes significant damage to the biodiversity of the Kolkheti National Park, the territory of which immediately borders these villages. On this territory, water destroys populations of protected species and their habitats.

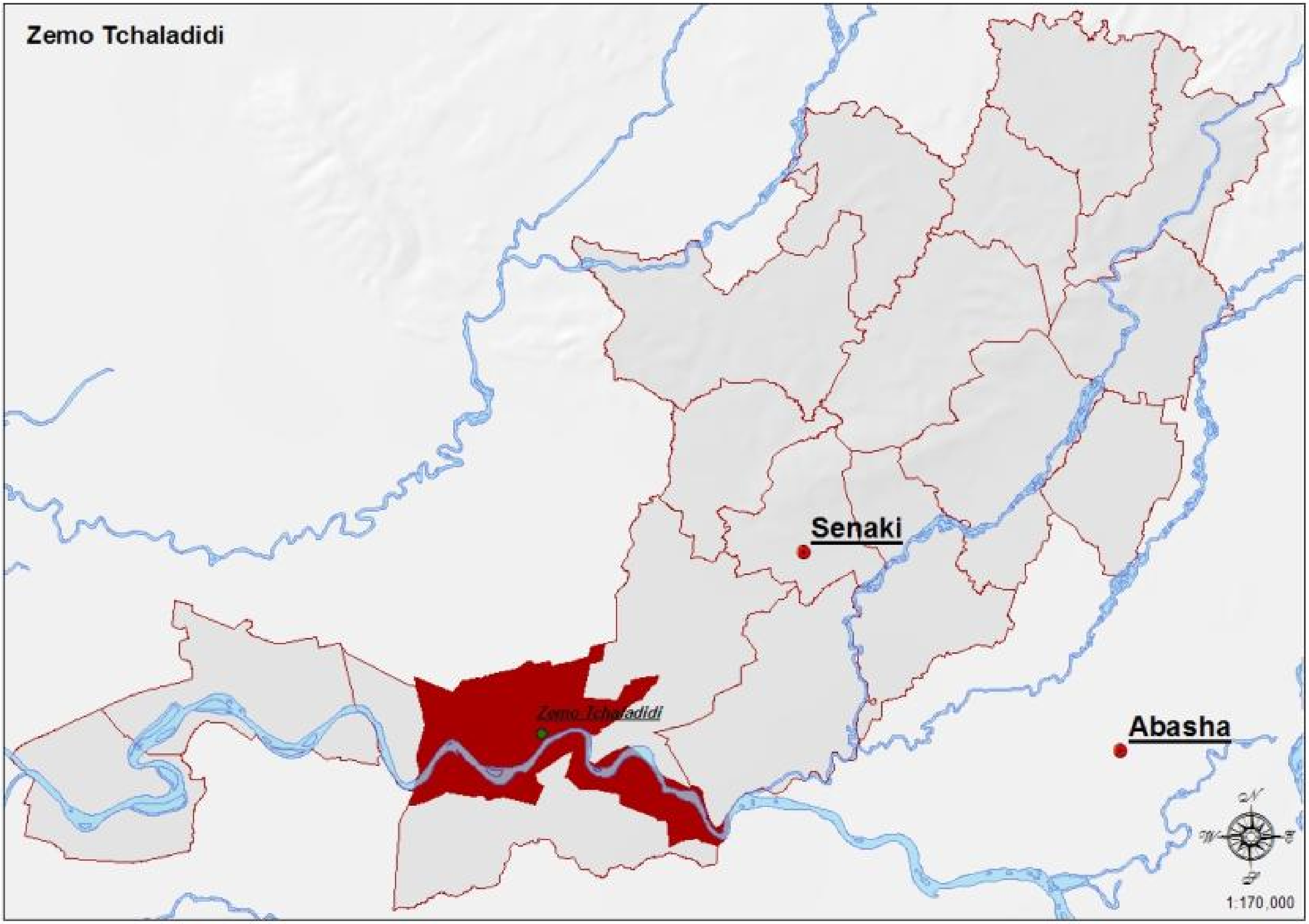
The abovementioned blocking of the Rioni River should be noted separately. The Rioni River, in cases of abundant precipitation and large-scale floods, is purposely blocked by the hydro-technical construction at the 7$^{th}$ kilometer from the city of Poti. The reason for this is the Black Sea is incapable of receiving the surplus water discharged by the Rioni River, which creates the danger of flooding the city of Poti. Therefore, in periods of floods, the channel of the Rioni River is closed at the 7th kilometer, which endangers settlements in the upper course of the region, Zemo Tchaladidi community among them.

At present, the protective dam of the Rioni River is completely broken between the villages of Seriachkoni and Sagvicho. The length of the damaged segment is approximately 1 to 1.5 km. As a result, residences and crofts of 7 households of the village Sagvichio are inundated during floods (the village of Seriachkoni is located above this segment, therefore, in this case it is not endangered). According to the village inhabitants, there were cases of floods when, because of the inundation of the village of Sagvichio, communications that were already weak broke down completely necessitating distribution of produce with boats and evacuation of the population with helicopters. It would not be surprising if a similar situation recurred in future.

A similar situation is detected in the upper neighborhood of the village Seriachkoni, along a segment of about 150 m. There the Rioni River makes a sharp turn, and it intensively washes the shore zone and protective constructions. The protective dam has lost half of its width, so when the river is blocked and the water level is raised, there is a risk that water will break through this weak segment. This will endanger the whole territory of Seriachkoni. The picture below presents a satellite image of the damaged segment.





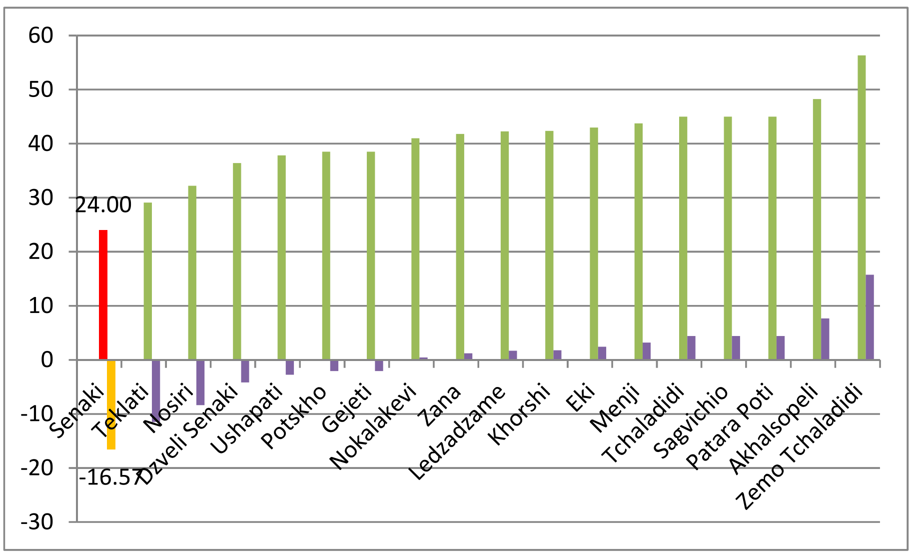


Zemo Tchaladidi
Senaki
Abasha
Zemo Tchaladidi
1:170,000

*__2.7.15. Senaki Town__*

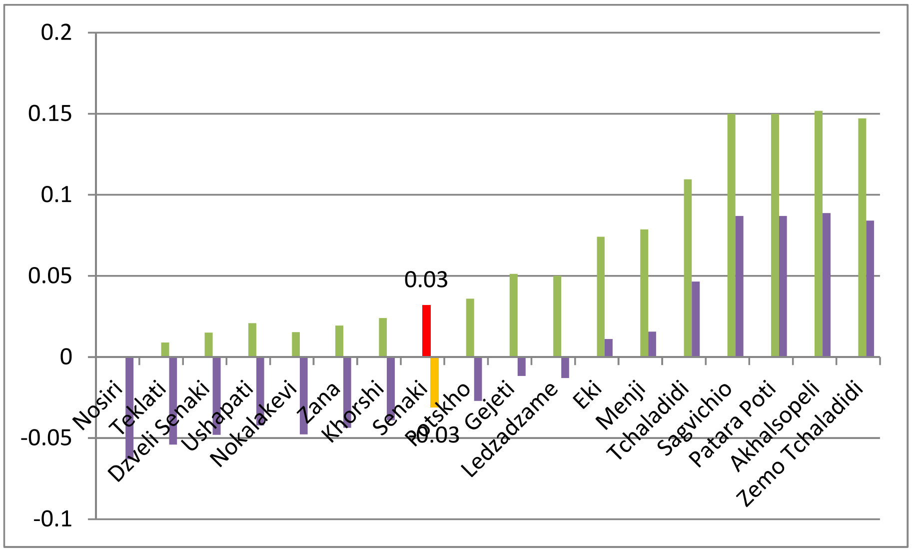
Senaki town occupies the central part of Senaki Municiplaity. The town area is border by the Tsivi River from the west and by the Tekhura River from the east, so that the town is located in-between these two rivers.

During the field research, landslides and floods were detected as main natural disasters in the municipal area.

Vulnerability of Senaki town to natural disasters and climate change was assessed at 24.00 points. This figure represents the minimum indicator in the scale of the Lower Rioni basin. Variance between the average municipal indicator and town's is important and equals to -16.57 points. Such a low rate can be easily explained by the fact that in Senaki town, as in any municipal center, social infrastructure, transport, and communications are well-developed with more or less potable water infrastructure. Also, the capability of the town to resist the negative effects of possible catastrophic events is much higher due to the Response Services located in the municipal center. As for the general vulnerability index compared to program target area (target river basins), Senaki Town belongs to a very low vulnerability category (see map - vulnerability assessment for Senaki Municipality).




Senaki town risk was assessed as 0.03 points. The latter is compared with the average index of the lower Rioni River communities. Variance from the mean equals -0.03 points (see diagram). However, in terms of dramatically lower vulnerability these figures indicating risks are somewhat higher, that can be explained in reference to diversity and magnitude of natural hazards in the town territory. At the level of the program target area, town risks were assessed as medium to high (see map - Senaki Municipal Disaster Risk Assessment).




One of the most threatening natural processes for Senaki Town is ***landslide*** occurrence. In Senaki the Eki Hillock on the southern exposition of the upper part of the slope is distinguished in contrast to the lower part of the inclined surface (10-12$^0$ or more). The main ground in this part of the town is Paleogene shallow marine limestone overlain by delluvial clays and Neogene age sandstones. The landslide processes are developed in the abovementioned rocks overlaid by steep loam sediments.

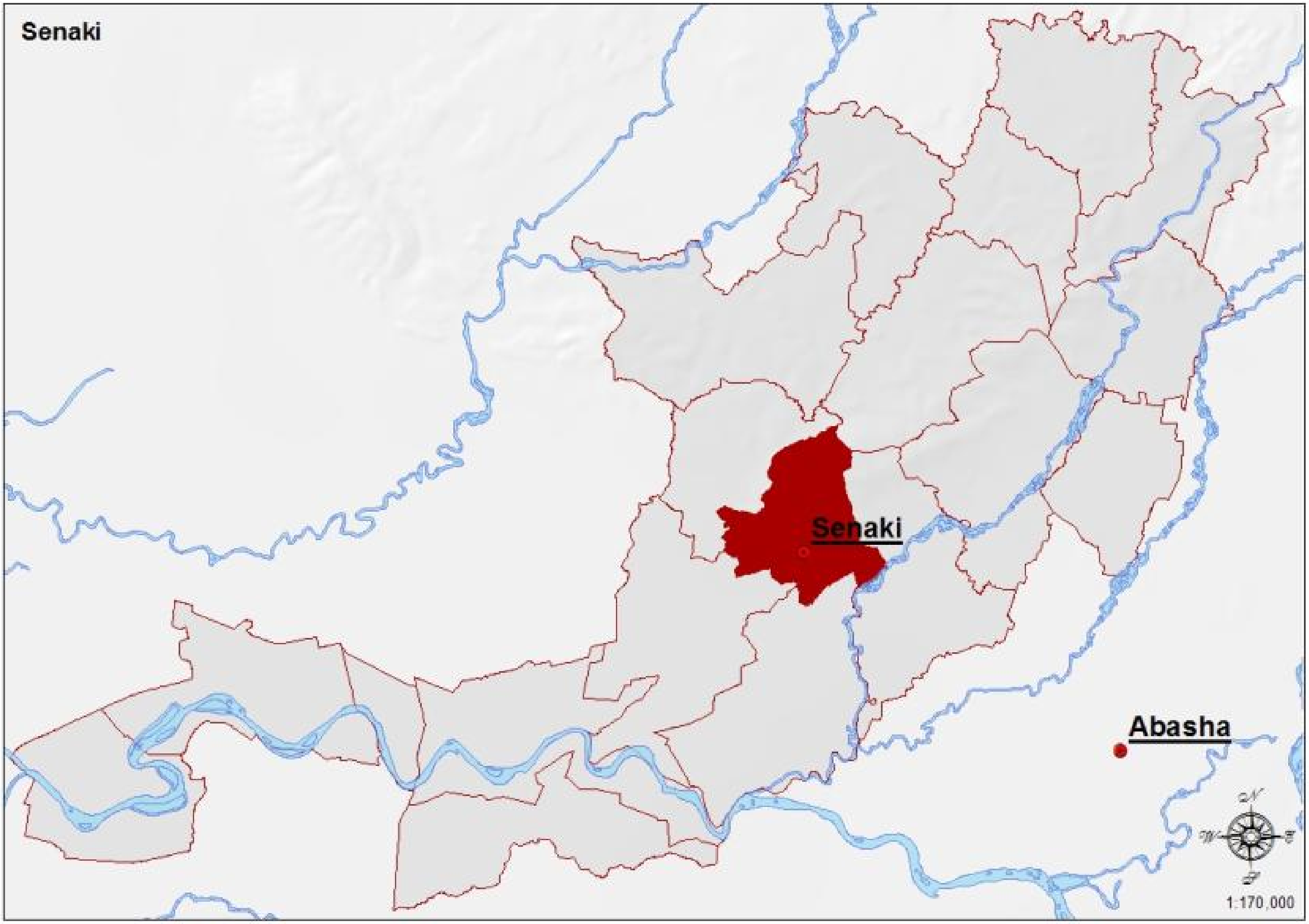
The District for dozens of years has been a research object of geologists and the National Environment Agency specialists. The process causes deformation of the houses. At the initial stage development of micro and small fissures starts in the walls, which over time transform into macro acute fissures in the floor. The number of houses significantly damaged by landslide processes has reached several dozen in the town.

In the northern part of Senaki Town, at the Eki Hillock, several small streams originate that significantly increase their charges after joining sewerage waters, but during heavy rainfalls they turn into hydrodynamic flows with destructive potential. In the eastern part of the town one of the streams flows in its natural river bed, and along Rustaveli and Chkhetia Streets the stream flows in a sealed concrete riverbed. To the natural solid sediments are added household and construction waste that fills the drainage channel and causes its suppression. In the last section along Khorava Street, the increased stream flows out of the bed, causing floods and inundation of agricultural crofts and first-floor rooms in lots of houses. This occurs regularly, almost every year.

Along the eastern periphery of the town the Tekhuri River actively washes the right bank, which is constructed with alluvial boulders. Erosion damages and washes away fertile agricultural lands and crofts including hazelnut plantations (total area of approx. 7 ha); also, households of six families and power transmission poles. If the bank scouring trend is maintained, the Senaki-Tbilisi Highway and the bridge are expected to get damagedalso.







Senaki
Senaki
Abasha
1:170,000

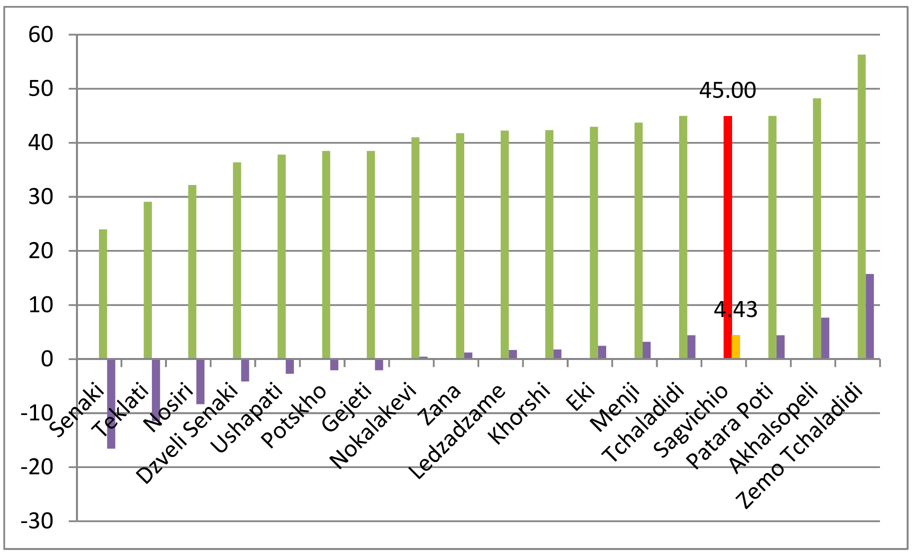
*2.7.16. Sagvichio Community*

Sagvichio community is located in the southern part of the Khobi municipality, along the Rioni River. The community area includes both banks of the river, but only the right bank is populated.

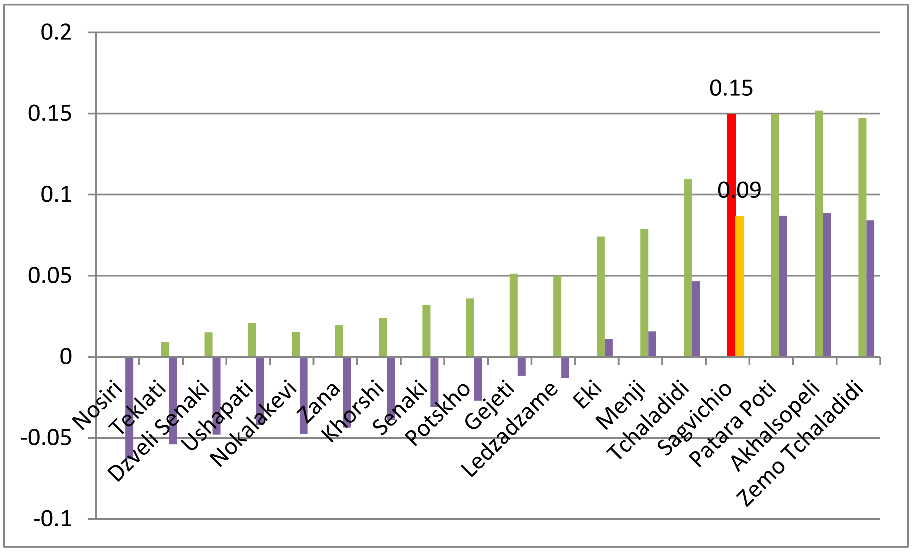
Sagvichio community includes only Sagvichio village. The distance from the Municipal Center (Khobi Town) is 25 km.

As field studies reported, a large-scale flood threatens the Sagvichio area.

According to the results of the research accomplished in the frame of the program Sagvichio's vulnerability was assessed as 45.00 points. This figure exceeds the average indices of the Lower Rioni basin communities. Variance from the average equals 4.43 points (see diagram). The community vulnerability throughout the target area (target river basins) was defined as average (see map - vulnerability assessment for Senaki Municipality).




Risk for Sagvichio community amounted to 0.15 points. This indicator is also one of the highest rates in the Lower Rioni basin communities. Variance from the average is 0.09 points (see diagram). In general, the Sagvichio community risk index was assessed as high compared to the program-wide target area (target river basins) (see map - Disaster Risk Assessment for Senaki Municipality).

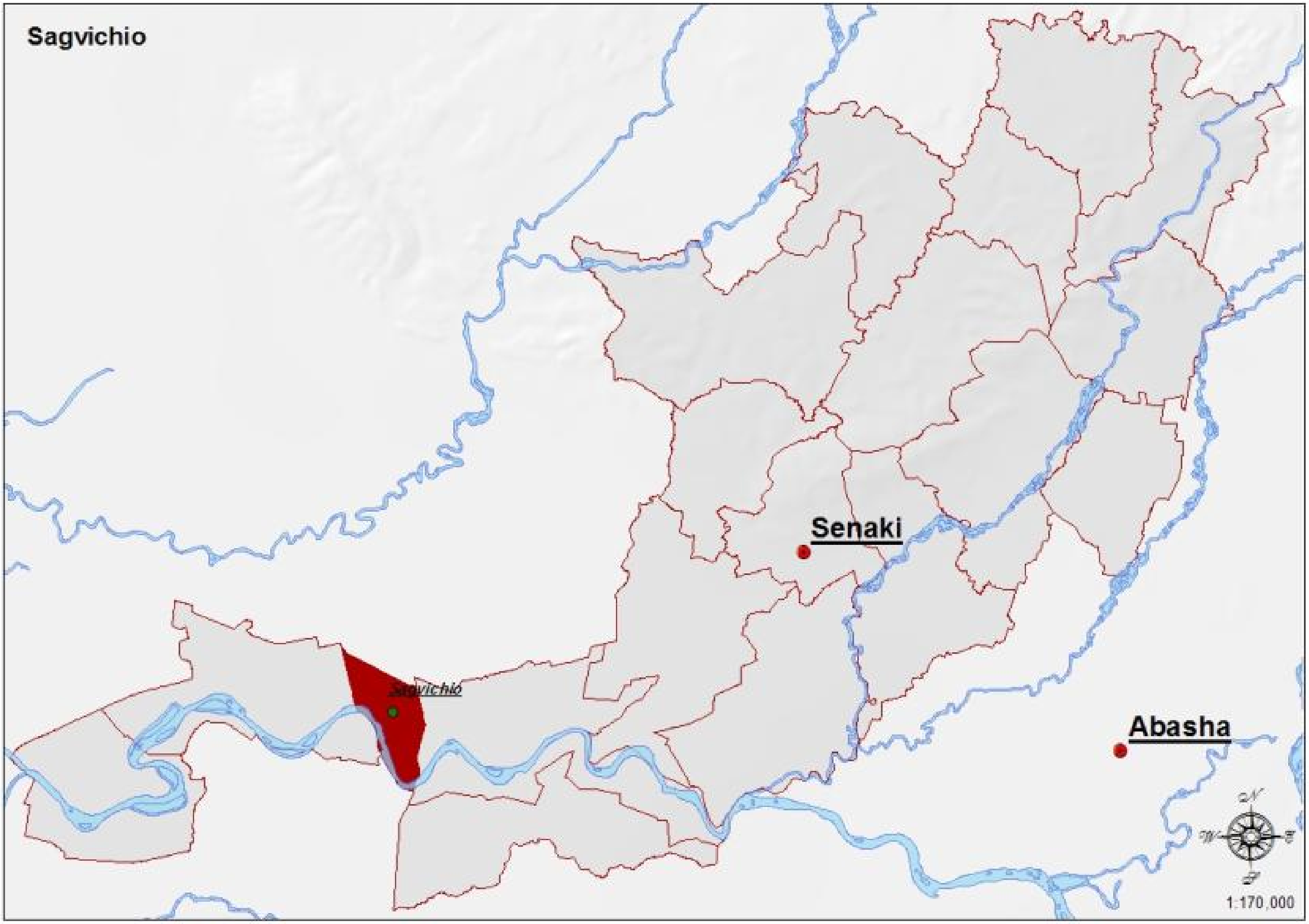



Therefore, according to the data, Sagvchio Community is one of the so-called "Hot spots" of the Lower Rioni Basin in terms of the risk of disasters and climate change.

A detailed picture of the natural hazards detected in the community is provided below.

As mentioned above, here the river-generated ***floods*** are a main problem. Near the village, adjacent to church and cemetery, the Rioni River washes the banks. Consequently, gabions and bank walls built in 1987 are damaged. Accordingly, if the protective dike is destroyed, the whole village will face danger. It should be noted that 80 years ago the Rioni River flooded virtually the entire village causing human fatalities as well.

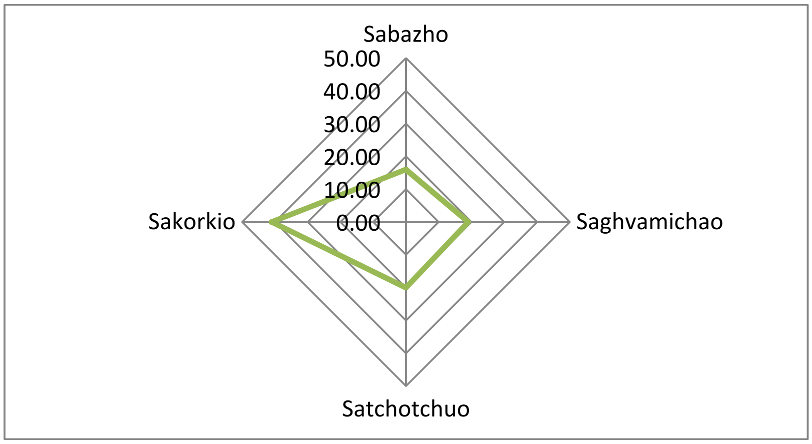
A similar situation is reported at the border of Sagvichio and Saghvamichao villages, where the Rioni River extensively washes the banks. It washes the pastures (30 ha) and a part of the forest. As a result of the process, as the local population reports, the river comes closer to the village by 20 m each year. The protective dams are also damaged in this section and if the river approaches the village, they would not be capable of excess water retention. Lands of Sagvichio village and all of Saghvamichao village are under threat.


Sagvichio
Sagvichio
Senaki
Abasha
1:170,000

***2.7.17. Chaladidi Community***

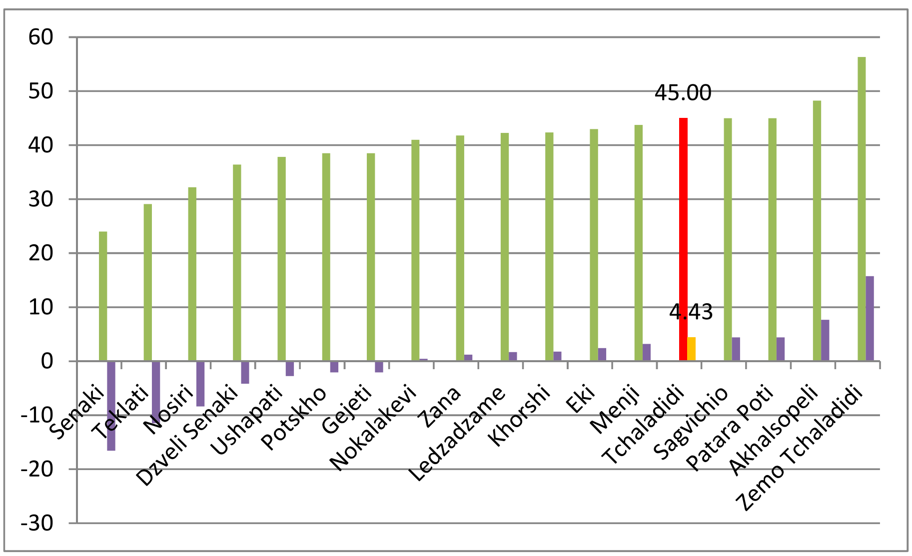
Chaladidi community is located in the southern part of the Khobi Municipality, along the Rioni River.

Chaladidi community includes 4 villages. These villages are Sabazho, Saghvamichao, Sachochuo, and Sakorkio. The average distance from the municipal center (Khobi town) is 25 km.

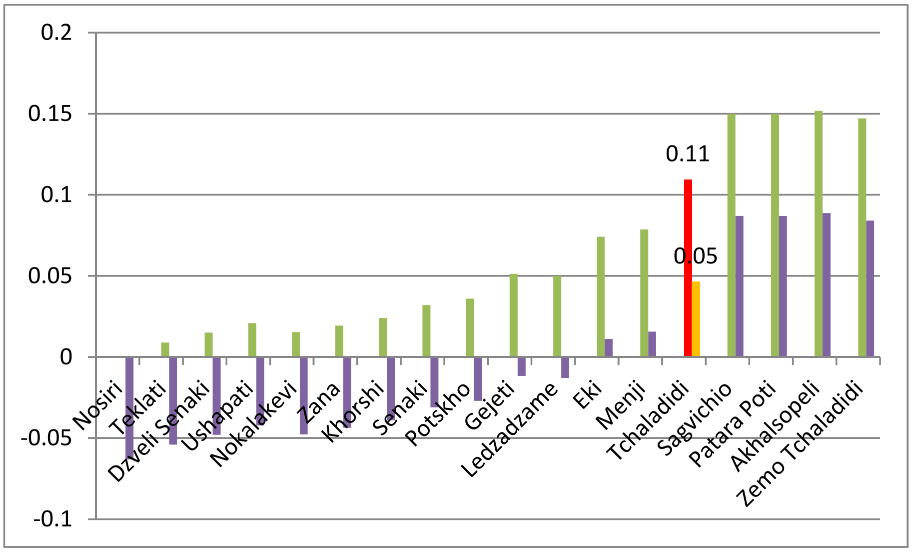



According to the field studies, large-scale flood hazards were observed in Chaladidi community.

According to the results of the research accomplished in the frame of the program, Chaladidi's vulnerability was assessed as 45.00 points. This figure exceeds the average indices of the Lower Rioni basin communities. Variance from the average equals 4.43 points (see diagram). The community vulnerability as compared to the target area (target river basins) was defined as average (see map - Vulnerability Assessment for Senaki Municipality).




Respectively, according to the same studies, risks for Chaladidi community amounted to 0.11 points. This indicator exceeds the average rate of the Lower Rioni Basin communities. Variance from the average is 0.05 points (see diagram). In general, Chaladidi community risk index was assessed as higher than average compared to the program-wide target area (target river basins) (see map - Disaster Risk Assessment for Senaki Municipality).




Detailed information on natural disasters threatening the villages is represented below.

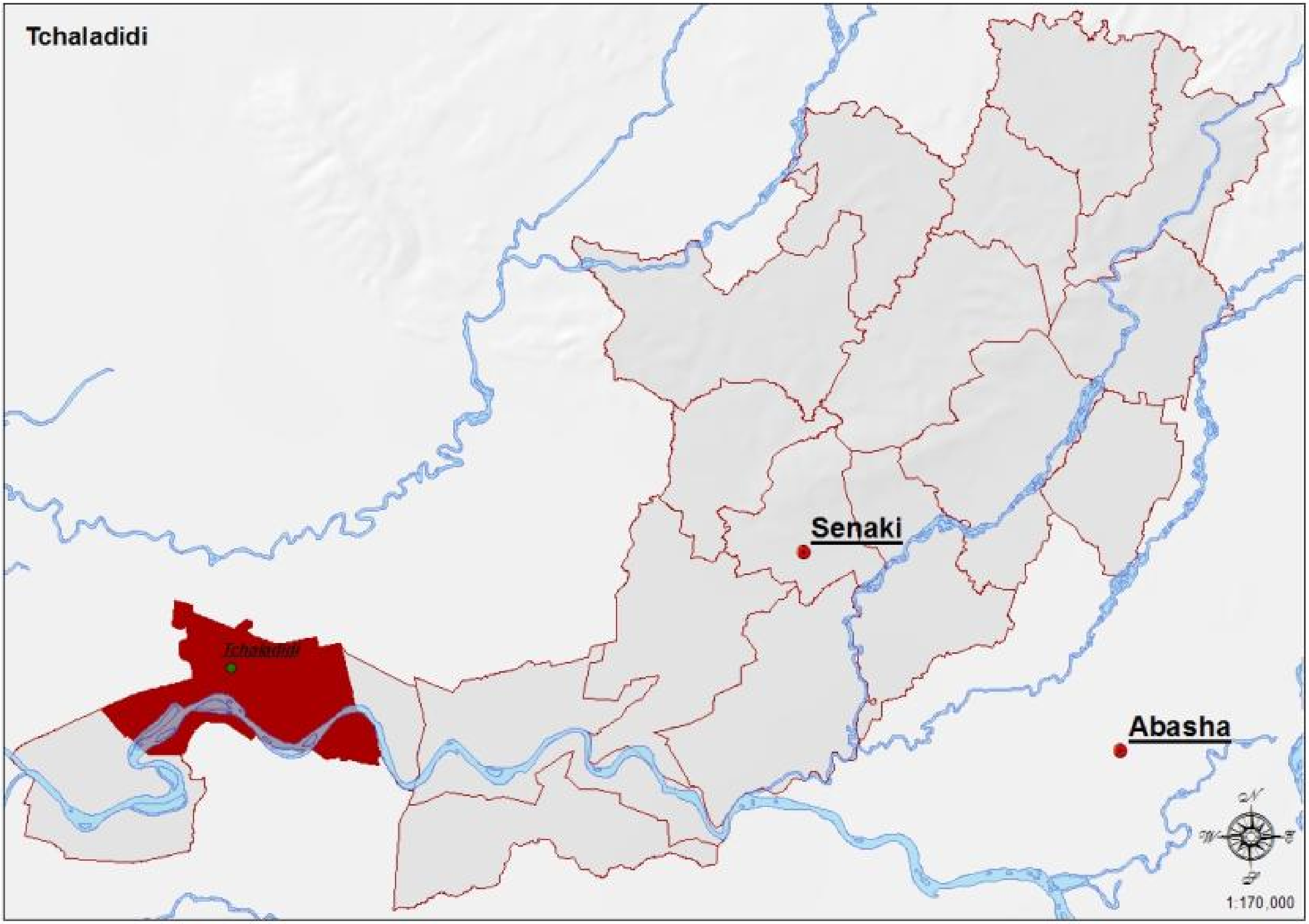
**Saghvamichao Village**

Sagvamichio xillage is located in the eastern part of Chaladidi community and neighbors Sarvichio Village. The main problem of the village is the river-generated ***floods***. In the village area due to the intensive erosive processes, the Rioni River protective dams (150, 100 and 15 m sections) are damaged. Consequently, if the Rioni River floods and destroys a protective dike, the whole village, as well as entire Chaladidi community, will come across serious dangers.


**Sabazho Village**

The main problem of the Sabazho Village, as well as of the entire community is intensive erosive processes generated by the Rioni River. As a result, the river washes the dams and threatens the village population with ***floods***. Similar to other villages, protective dams are damaged in various places. Consequently, if the Rioni River floods and destroys the protective dam, Sabazho Village, as well as entire Chaladidi community will be under serious threats.





Tchaladidi
Tchaladidi
Senaki
Abasha
1:170,000

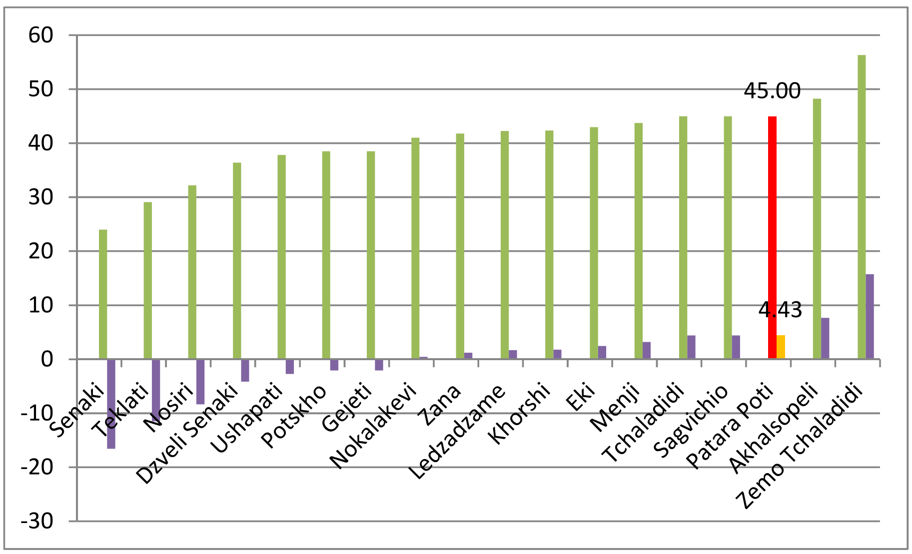
*2.7.18. Patara Poti Community*

Patara Poti Community is located in the southern part of the Khobi Municipality, along the Rioni River, and occupies the extreme west part. The community neighbors the Poti Town area.

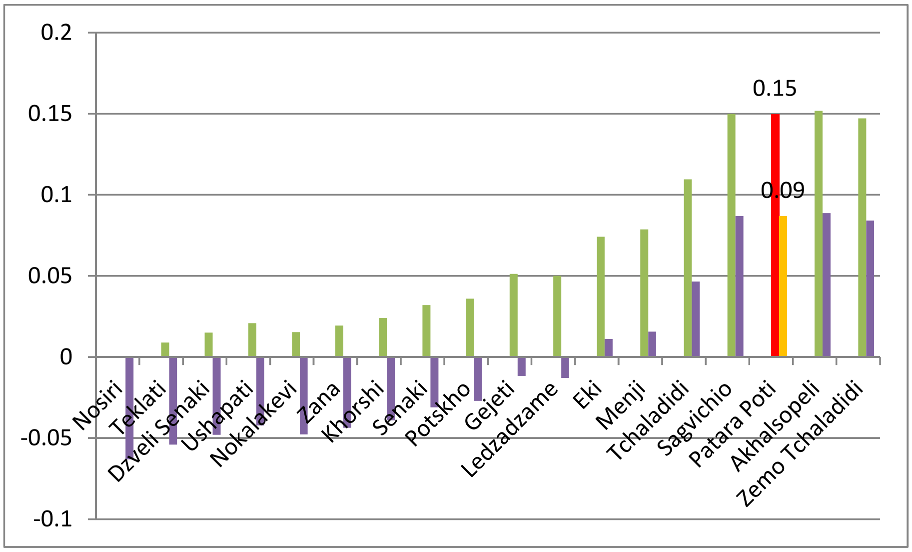
Patara Poti Community includes just Patara Poti Village. The average distance from the Municipal Center (Khobi town) is 25 km.

As field studies reported, large-scale floods threaten Patara Poti area.

According to the results of the research accomplished in the frame of the program, Patara Poti vulnerability was assessed as 45.00 points. This figure exceeds the average indices of the Lower Rioni basin communities. Variance from the average equals 4.43 points (see diagram). The community vulnerability throughout the target area (target river basins) was defined as average (see map - vulnerability assessment for Senaki Municipality).



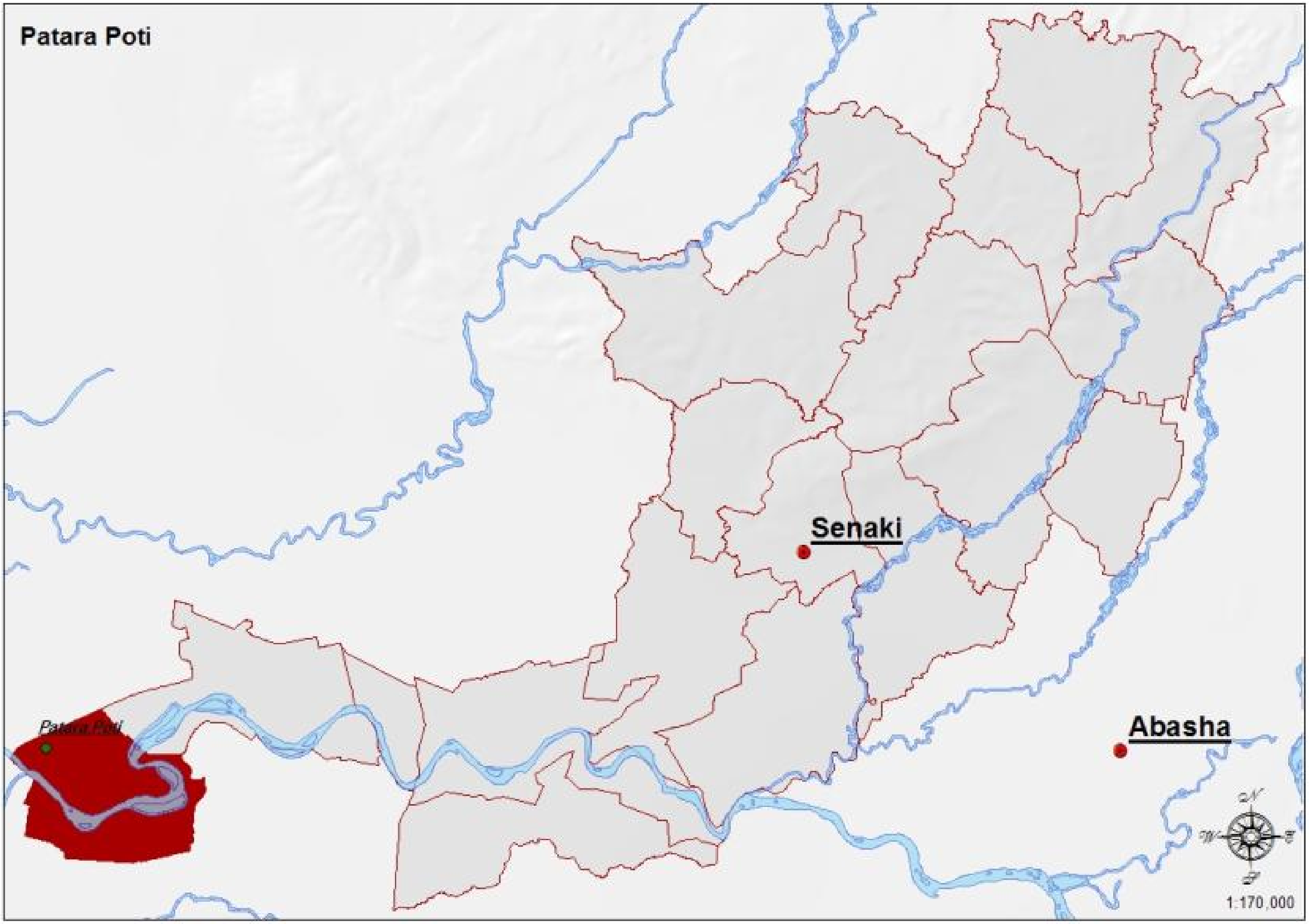

Risk for Patara Poti community amounted to 0.15 points. This indicator is one of the highest rates in the Lower Rioni Basin communities. Variance from the average is 0.09 points (see diagram). In general, the Patara Poti community risk index was assessed as very high in the program-wide target area (target river basins) (see map - Disaster Risk Assessment for Senaki Municipality).




Therefore, according to the data, Patara Poti Community could be described as one of the "ot spots" across the Lower Rioni Basin in terms of the risk of disasters and climate change.

A thorough description of, the condition of the community in reference to dangerous natural occurrences is as follows: In Patara Poti, as well as in the other lower Rioni Basin villages, the river-generated intensive erosion is a problem expressed mainly in washing the river banks. Consequently, the river washes protective dams and threatens the village with ***floods***. Similar to other villages, various sections of bank protective dams are damaged in Patara Poti. Among them is a 30-meter section, adjacent to the Braimbetoni territories, where several enterprises are under threat (a concrete mill; 5 terminals; a petrol station, Michel Ltd; a fish enterprise, Fishfactory; a parking lot of Barville Ltd, etc).





Patara Poti
Senaki
Abasha
Patara Poti
1:170,000

### *2.8. Conclusions*

Table 2.8 provides a summary of information on natural hazards, described for the territories in the Lower Rioni Basin. The table demonstrates a general picture of the dangerous natural occurrences reported in the lower Rioni Basin communities.

***Table 2.8. A summary of natural hazards detected in the territory of Lower Rioni Watershed***

| Community | | Natural Disasters | | | |
|---|---|---|---|---|---|
| | | **Flood** | **Mudflow** | **Washing of the banks** | **Landslide** |
| **1** | Photsko | + | | + | + |
| **2** | Ushapati | | | | + |
| **3** | Eki | | | + | + |
| **4** | Zana | + | | + | + |
| **5** | Khorshi | + | | | + |
| **6** | Menji | + | + | + | + |
| **7** | Teklati | + | | + | |
| **8** | Ledzadzame | + | | | + |
| **9** | Nokalakevi | + | | + | + |
| **10** | Gejeti | + | | | |
| **11** | Dzveli Senaki | + | | + | + |
| **12** | Nosiri | | | | |
| **13** | Akhalsopeli | + | | + | |
| **14** | Zemo Tchaladidi | + | | + | |
| **15** | Sagvichio | + | | + | |
| **16** | Tchaladidi | + | | + | |
| **17** | Patara Poti | + | | + | |
| **18** | Senaki | + | | + | + |

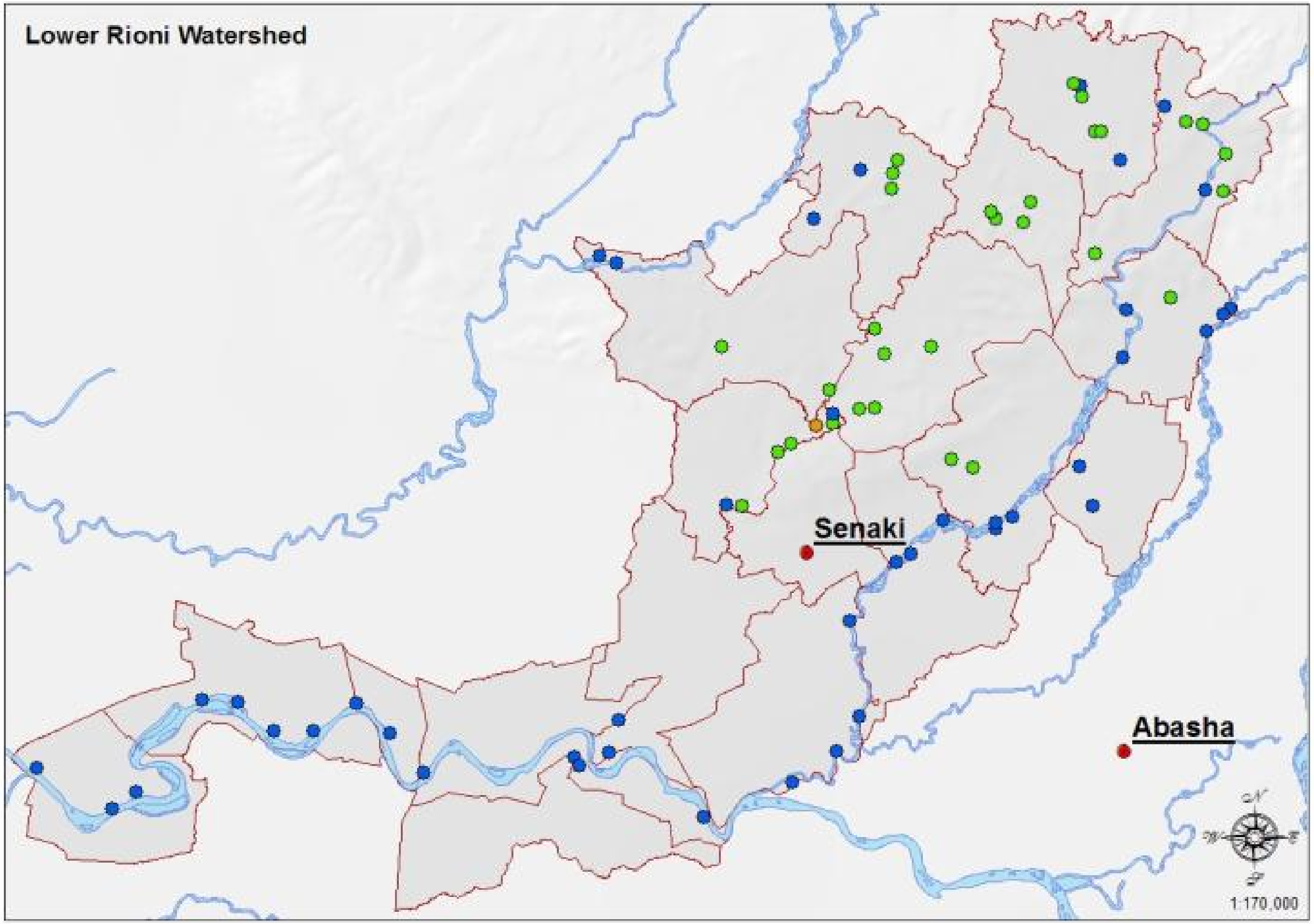
Based on the table, we can conclude that the communities located in the lower Rioni Basin area are exposed to natural hazards like floods, washing of the banks and landslide processes. These occurrences are menacing problems for virtually all communities of the target territory.

Among these communities, Menji Community is distinguished with a diversity of hazardous natural processes. In the Nosir Community area, quite the opposite, none of the hazardous natural processes are documented by the field surveys conducted by the program or by the National Environment Agency or other sources. Two or three processes are present in the rest of the communities of the target area[2].

Information received through the field studies about hazardous natural processes is reflected on Map 2.1. Green dots stand for landslide processes, blue and brown ones for floods / washing of banks and mudflows, respectively.

[2] In this case, the magnitude of the natural disaster is not considered. The table only gives a clear picture of the existence of those occurrences, which were observed during the program field studies or were reported by other sources in the community.

*Map 2.1. Natural Hazards Detected on the Territory of Lower Rioni Pilot Watarshed As a result of Field Research*



The map clearly demonstrates that floods/erosion and landslide occurrences are major problems for the target area communities. The abovementioned hazards are present approximately in the whole target area. A striking difference is noticeable in the spatial distribution of hazards. Apparently, floods and washing of the banks are characteristic in the river (Rioni, Tekhura) surrounding communities. Landslide processes are mostly present in the northern part of the target area, where the relief is more or less mountainous.

Information obtained during field studies was connected to information acquired from other sources, and based on GIS analysis a potential distribution map of geodynamic natural hazards in the lower Rioni Basin has been developed (see Map 2.2 a potential distribution map of geodynamic natural hazards in the lower Rioni Basin). It should be noted that basically geodynamic processes are meant in this case and the map does not reflect the area distribution of flood hazards. The map clearly shows that the distribution of geodynamic processes (primarily landslides) is mainly characteristic to the communities located in the northern part of the target area.

Vulnerability assessment of the communities located in the target area (the lower Rioni Basin) was also conducted in the frame of the program. Vulnerability assessment was mainly conducted based on calculation of different socio-economic parameters of rural communities. In addition, consideration was given to the villages under natural hazards. For assessment conclusions see Map 2.3 – vulnerability of the communities located in the lower Rioni Basin and Table 2.9 Distribution of the communities (located in the lower Rioni Basin) in accordance with vulnerability degrees.

The map and the table enable us to conclude that the majority of the lower Rioni Basin communities belong to a category of medium vulnerability. Analysis of vulnerability components showed that the main determining factors of vulnerability to natural disasters and climate change for the villages are deficiencies in social infrastructure (health and education access, as well as low purchasing power, and low safety level), communication difficulties, difficult economic conditions, and a low readiness level for natural disasters and climate changes (lack of information and necessary skills). The aulnerability index was also significantly influenced by an index of communications, economic means (crofts) and by the number of people living in the danger zones. It should also be noted that Zemo Chaladidi community, which is known throughout the country due to absence of community access roads to the village, is located in the target area. The only means of connection to the village is an old ferry along the Rioni River. Therefore, accessibility became the vulnerability assessing factor for the communities of Zemo Chaladidi.

***Table 2.9. Distribution of the communities of Lower Rioni Watershed by the level of vulnerability***

| Community | | Degree of Vulnerability | | | | |
|---|---|---|---|---|---|---|
| | | Low | Lower than average | Average | Higher than average | High |
| **1** | Photsko | | | + | | |
| **2** | Ushapati | | | + | | |
| **3** | Eki | | | + | | |
| **4** | Zana | | | + | | |
| **5** | Khorshi | | | + | | |
| **6** | Menji | | | + | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **7** | Teklati | | + | | | |
| **8** | Ledzadzame | | | + | | |
| **9** | Nokalakevi | | | + | | |
| **10** | Gejeti | | | + | | |
| **11** | Dzveli Senaki | | | + | | |
| **12** | Nosiri | | + | | | |
| **13** | Akhalsopeli | | | | + | |
| **14** | Zemo Tchaladidi | | | | | + |
| **15** | Sagvichio | | | + | | |
| **16** | Tchaladidi | | | + | | |
| **17** | Patara Poti | | | + | | |
| **18** | Senaki | + | | | | |

Vulnerability and hazard assessments were applied for the risk ratio calculation of the lower Rioni Basin communities (see Map 2.4 Community risks to Natural hazards (the Lower Rioni Basin). As the map shows, the geographic distribution of high-risk communities is related to the Rioni River (high-risk communities are located along the river gorge). Thus, it can be concluded that the main factor determining the risk to the target area is the Rioni River and the processes developed along it. This conclusion is enough reason to plan risk reduction measures. Obviously, while planning risk reduction measures primary attention should be given to the Rioni River and improvement of its basin state (in terms of sustainable management of resources). According to the survey, it is a decisive factor in community risk reduction. Risk assessment with reference to the communities is given in Table 2.10.

In this respect, the following factors should be emphasized. As demonstrated in the detailed description, high risks of communities under the target area are related mostly to the floods generated in the Rioni River bed. In order to understand the nature of the hazard, it is important to trace the area history during the Soviet period. In the past, in terms of the abundant sediments due to the river level rise, the river gorge's inability to pass excess water through its bed caused flooding of a large area around it. In order to avoid the abovementioned dangers, 3-4 m high, 6-8 m wide dams, which still protect effectively, were constructed in 1930-1950. While constructing the dams, the river beds were changed in some sections. Also, in the same period extensive depletion of the marshes through large-scale drainage systems were initiated.

Dams have the form of continuous embankments built mostly of local materials (sandstones and clays). Their surface is cultivated with perennial trees and bushes and is covered with grass vegetation, so that a root system fairly bonds the dams and still meets the current requirements.

At present, the main source of hazard is the protective structures that have been laterally damaged by intense erosion caused by the rivers. As a result of the damage to the dams during the annual floods, the rivers flood village houses, yards, gardens, agricultural lands and crofts. The floods also impair the agricultural roadsthat connect the rural population to the municipal centers. That is why particularly high-risk communities are located along the large rivers, including the Rioni River.

***Table 2.10. Distribution of the communities of Lower Rioni Watershed by the level of vulnerability according to the level of risk***

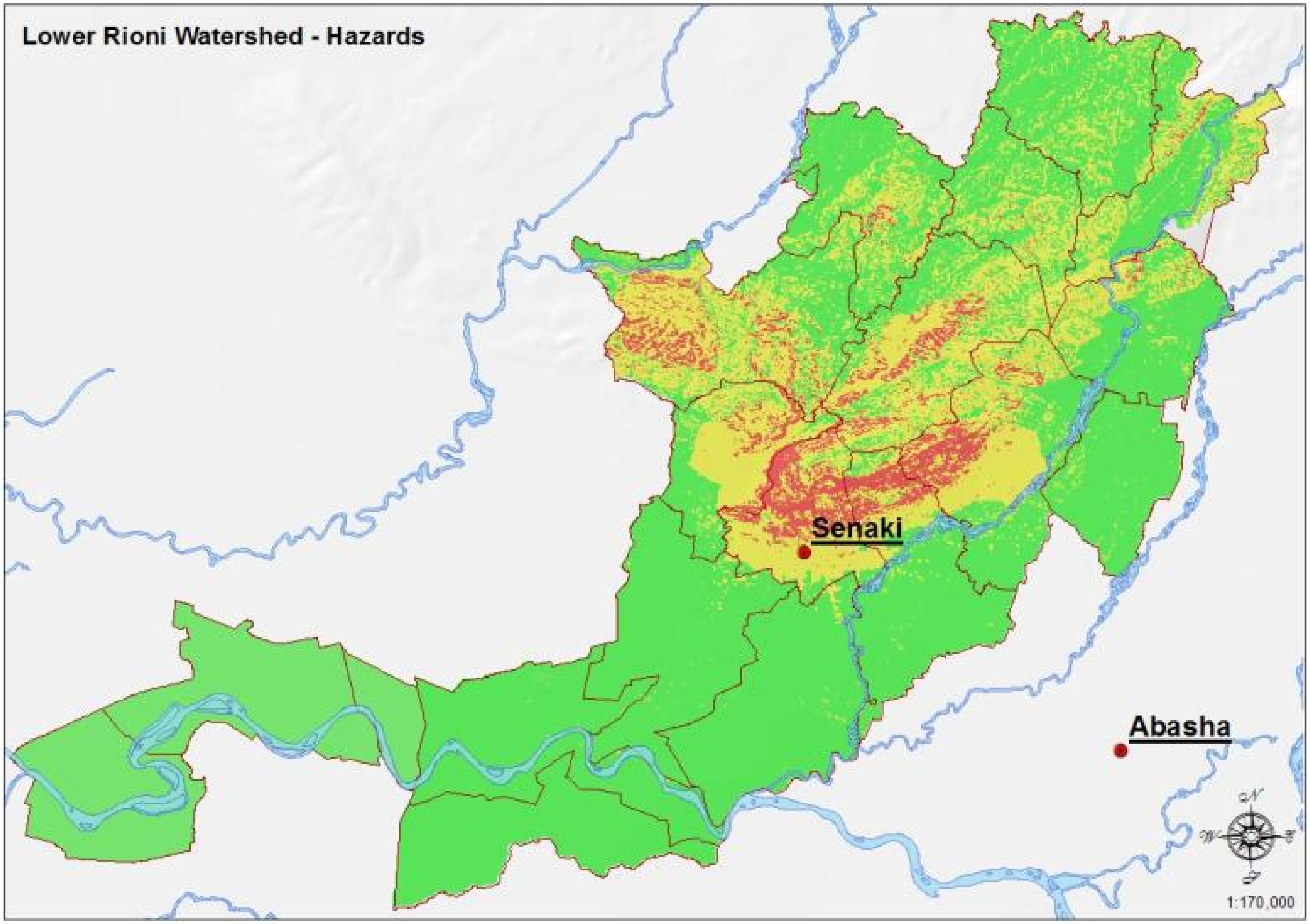
| Community | | Degree of Vulnerability | | | | |
|---|---|---|---|---|---|---|
| | | Low | Lower than average | Average | Higher than average | High |
| **1** | Photsko | | + | | | |
| **2** | Ushapati | | + | | | |
| **3** | Eki | | | + | | |
| **4** | Zana | | + | | | |
| **5** | Khorshi | | + | | | |
| **6** | Menji | | | | + | |
| **7** | Teklati | + | | | | |
| **8** | Ledzadzame | | | + | | |
| **9** | Nokalakevi | | + | | | |
| **10** | Gejeti | | | + | | |
| **11** | Dzveli Senaki | | + | | | |
| **12** | Nosiri | + | | | | |
| **13** | Akhalsopeli | | | | | + |
| **14** | Zemo Tchaladidi | | | | | + |
| **15** | Sagvichio | | | | | + |
| **16** | Tchaladidi | | | | + | |
| **17** | Patara Poti | | | | | + |
| **18** | Senaki | | + | | | |

On the basis of the table and the map we are able to note that one group of the Rioni Basin communities belongs to a medium and low-risk category, while the second group belongs to a very high-risk category. Accordingly, the target area risk ratio is at high risk for natural disasters and climate change.

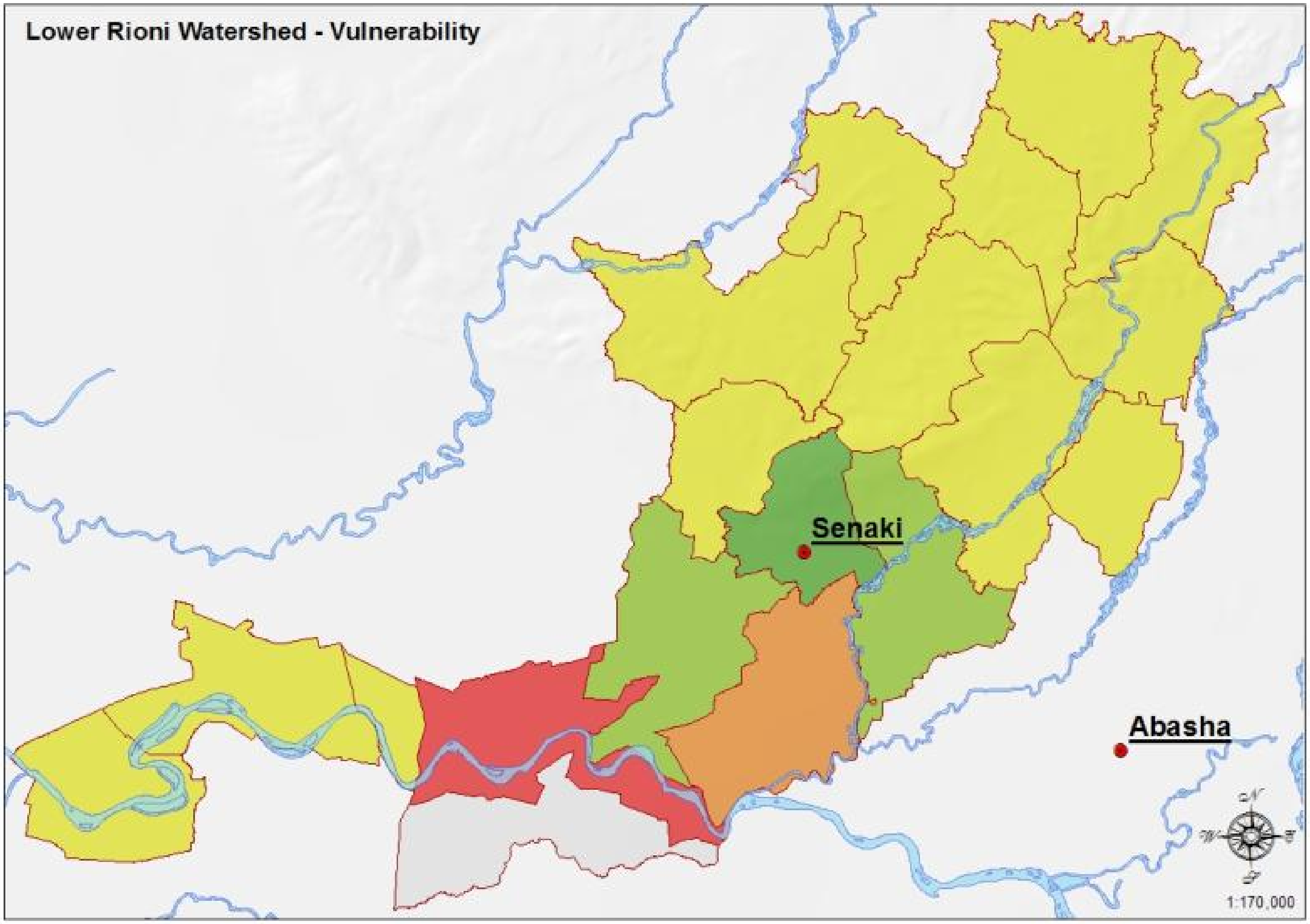
Based on the information provided above, it can be concluded that as the future climate change scenarios developed for the lower Rioni Basin show, as a result of climactic parameter changes, increased flood risks will be of primary importance.

Accordingly, the vulnerability index of the municipal communities will significantly increase and as a result, the risk of natural disasters will also rise. This will influence the growth of sustained damage due to disasters.

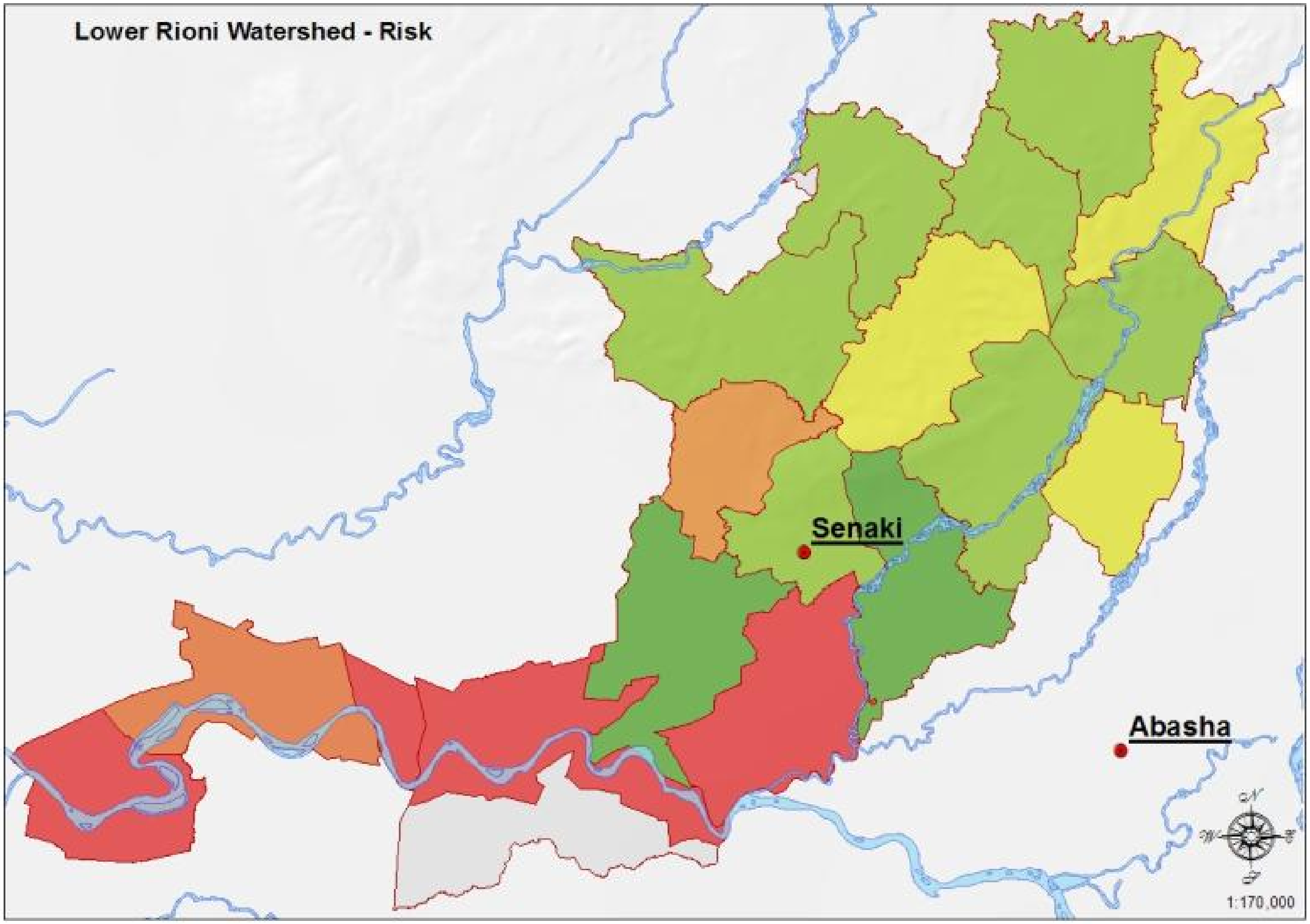
*Map 2.2. Probability of Distribution of Natural Hazards in Lower Rioni Pilot Watershed*



***Map 2.3. Vulnerability of the Communities of Lower Rioni Pilot Watershed to Natural Disasters***



***Map 2.4. The Level of Risk of the Communities of Lower Rioni Pilot Watershed to Natural Disasters***



# 3 Problems Related to Expected Climate Changes for the years 2020 to 2050 and Respective Adaptation and Mitigation Measures

A list of measures was developed based on the vulnerability and disaster assessment implemented in the municipality which, if carried out in the municipalities of the lower course of the Rioni river (Senaki and partly Khobi Municipalities), will reduce their vulnerability to natural disasters and climate change and increase endurance.

It should be noted that the list of the measures developed is somewhat general due to the scale of the implemented activities – the assessment fully covered the target communities. The expert group assessed the situation in terms of the river basin lower course and field surveys were carried out in every village of the target territory. Thus, recommendations developed in the survey framework are, in a way, river basin level recommendations, which exclude specification of a place (community, village or a part of the village) with regards to a specific problem. At the next stage of the program, the scale of the activities will be extended to the community level, which will use the present survey outcomes and will allow elaboration of community action plans with maximum involvement of the local population which will reflect specific activities for risk reduction and resistance increase

Below are given the major problems caused by the expected changeability of meteorological elements and necessary adaptation activities for their mitigation in accordance with future climate change scenarios in the Rioni river basin lower course boundaries. Also, a list of the activities for mitigation and adaptation of the problematic aspects identified as a result of the field survey for each community.

### *3.1 Spatial Planning*

It is necessary to define areas implying high danger of natural disasters, so called “hot spots” on the municipality territory, management of which will be executed in accordance with the existing risks.

The risks faced by municipality communities are stipulated not only by the territories implying danger but also by the vulnerability level of the individual communities. It is important to implement vulnerability decreasing activities in this regard which, in turn, will increase resistance of the communities to potential natural catastrophes and negative influences of climate change. To decrease of vulnerability, it is important:

- To improve social infrastructure for the population of the municipality communities.
- To increase readiness of the communities as well as for the whole municipality for possible natural catastrophes. In this regards it is important:
    - To strengthen the regional rescue service through proper training and equipment.
    - To elaborate municipal response plans that will adequately reflect the dangers the municipality faces, will elaborate alternate scenarios of development and will elaborate an action plan according to these scenarios while taking into consideration community vulnerability levels.
    - To conduct periodical train and awareness raising campaigns on reaction to catastrophes
- To improve the economic well-being of the population through strengthening various prospective sectors (tourism, agriculture) that will decrease the vulnerability level as a result.

The abovementioned results will become a baseline for introduction of spatial planning elements in municipality management that will ensure minimization of the risks faced by the municipality through most effective use of existing resources. Spatial planning is the main recommendation in terms of adaptation to climate change and increased readiness. The work performed while preparing the present document may provide significant assistance to the municipality administration in the future in this regard.

### *3.2 Floods and River Erosion*

In order to avoid damage and breakdown of village population agricultural lands, roads and structures by the floods as well as to mitigate or eliminate the negative outcomes of washing of the banks in the Rioni, Tekhura and Tsivi river basins:

- Implement phyto-melioration activities on logged forest lands and areas with degraded natural vegetation coverto restore high-density forests and the natural-hydrological regime of the rivers, especially to reduce the maximum discharge.
- Artificially deepen the Rioni, Tsivi and Tekhura river channels that are filled with sediments and straighten some crooked sections to improve throughput capacity during floods within Senaki and Khobi municipality boundaries. Implementation of these activities is an essential precondition to reduction of heavy flood risk.
- Repair or completely restore the sections of the several dozen km flood prevention bunds (dams) damaged by amelioration activities since the 1930s-40s, which is an essential precondition to reduction of heavy flood risk.
- Elaborate an effective early warning system especially for communities along the Rioni river with permanent informing of the population of the riverside territories on possible floods and permanent training for readiness and action in case of disasters.

### *3.3 Landslide Process*

Implementation of landslide prevention activities on the territories damaged by the landslide which means:

- Construct a drainage network (channels) on the surface of the landslides to remove surface and ground water;
- Construct protective walls on piles on the front section of the landslide;
- Construct folding or massive mounting walls of monolithic steel-concrete block on the landslide surfaces;
- Apply anti-landslide bioengineering technologies including:
  - Terracing the landslide surface;
  - Moving ground on the landslide slopes to cut off slopes, expose soil etc.;
  - Turfing the landslide surface and surrounding territories;
  - Planting quickly growing vegetation (for example: nuts), improve forest management.

Also,

- Restrict water use for the population (limit irrigation of the landslide slopes, construct reservoirs on the landslide prone territories etc);
- Prohibit any construction without detailed study of the respective geological-geomorphologic conditions on the landslide prone territories;
- Permanently monitorthe landslide territories and permanently inform and periodically train the population on necessary landslide prevention measures;
- Involve the population in landslide prevention activities on the territories threatening their crofts.

### *3.4 Soils*

In order to protect the lower course of the Rioni river basin from erosion, flooding and bogging the following activities must be implemented:

- Introduce crop rotation;
- Arrange forest windbreak lines to regulate surface runoff;
- Plan/implement complex activities to protect the territories threatened by flood and river erosion;
- Restore the damaged drainage-amelioration systems; clean water channels.
- Prohibit illegal logging along the banks of the Rioni, Tekhura and Tsivi rivers.
- Implement forestation and erosive territory restoration activities.
- Permanently monitor erosive and flooded territories.

### *3.5 Vegetation Cover*

In order to protect the vegetation cover from global climate change impacts, implement the following actions in the future:

- Avoid self-drying of the different types of wetlands and wetland biomes;
- Avoid/preserve relict forest logging
- Inventory invasive neophytes and determine their population activity;
- Observe the vegetation period change and study indicators of the plant phenol-rhythms;
- Implement long-term monitoring of the geo-botanical environmental condition of the target territory.

### *3.6 Agriculture*

In order to mitigate or eliminate the negative impact of climate change and natural hazards on the agriculture it will be necessary to:

- Elaborate and introduce natural cataclysms prognosis, prevention and prompt reaction systems.
- Provide powerful agricultural equipment that works in the moist soil conditions.
- Consider frost prevention activities when planning and cultivating agricultural crops in greenhouses and plantations.
- Avoid plant diseases, increased numbers of pests and activation of the diffusion factors with the impact of the expected increase of relative humidity and high temperature
    - Test and introduce high temperature and drought resistant agricultural crops.
    - Apply anti-stress bio-preps and biologically effective microorganisms.
    - Immediately rehabilitate water collectors and drainage systems.
    - Plant moisture-loving, moisture-evaporating plants, and high-transpiration capacity trees in the windbreaks.
    - Test and introduce agricultural equipment and technologies tested in high humidity regions.
- Implement agro- and hydro-technical activities against water erosion.
- Plan and implement river flood and flash floods prevention activities (regulate leachate, strengthen banks and bridges);
- Artificially reforest areas under a landslide and erosion threat; protect and rehabilitate forests and windbreaks to protect soil.

Also,

- Organize and smoothly implement (where necessary) possible frost prevention activities for citrus (lemon, orange, tangerine,).
- Rehabilitate and upgrade the drainage systems to protect agricultural lands, pastures and, especially, riverside settlements from frequent floods; rehabilitate damaged flood prevention dams.
- Provide necessary information to the local population on problems related to agriculture.
- Organize permanent monitoring on rivers to avoid possible heavy floods.

### *3.7 Uncomfortable Temperatures*

In order to mitigate the possible negative impacts of climate change, mitigation activities are to be elaborated to reduce the unfavorable influence and its possible effect on the health of local population. The health protection activities by which the negative impact on human health can be reduced is divided into primary, secondary and tertiary preventions.

- The goal of primary prevention is monitoring of environment quality conditions and avoiding diseases in otherwise healthy people (by, for example, disinfecting drinking water, ensuring food safety, and fighting against emergence of communicable diseases).
- The secondary prevention implies carrying out warning activities at the first signs of any effect on human health (strengthening screening and epidemiological surveillance on respective communicable and incommunicable diseases and implementing adequate and complex activities to avoid epidemics).
- The tertiary prevention means minimizing complaints caused by existing diseases.

According to the analysis of the indicator of medical treatment per capita in the medical institutions of the Rioni river lower course municipalities from 2000-2010, the overall indicator of diseases is not expected to increase in the context of the climate change; however, specific trends in cardiovascular, respiratory, communicable, and endocrine diseases are important.

Spread of **communicable diseases'** group pathologies in the target municipalities as well as in the region is significantly lower than the country indicator. Besides, a trend of decreased of spreading can be observed from 2007. Thus the background does not give a basis to assume an unequivocally growing trend of communicable diseases. Though the general climate conditions and abundant water resources in some districts make increase the risk of water, food disease and respiratory infections in light of the expected development of climate change where increased temperature and humidity often cause unfavorable sanitary conditions, bank erosion and washing. Thus it is important to plan mitigation activities to address the impact and reduce population vulnerability, such as:

- Minimize and eliminate sanitary-hygiene problems (including planning/implementation of surface water protection and safety indicators for human health control and routine monitoring programs);
- Provide sanitary education for the population (personal, environment, food and water hygiene topics; waste collection and disposal aspects; pre-doctor medical assistance advice; water- and food-transmittable infections and prevention recommendations).

**Endocrine system diseases.** The indicator of patients suffering from endocrine system diseases in the target municipalities is significantly lower than the Samegrelo-Zemo Svaneti region and country indicators and a clear trend of increased or decreased diseases of the group is not observed. It should also be mentioned that diabetes has a significant place in the endocrine system disease group and this indicator is significantly higher than the regional indicator. An increase of diabetes is expected in the context of the climate change as food availability becomes a problem and healthy foods are replaced by high-energy carbohydrates and fats. Stress and complicated psycho conditions are also a risk factor for diabetes. Thus preventive activities should be planned to minimize the abovementioned problems. Including population health support plans with economic development strategies of the region is especially significant in this regard.

Besides, it is important to plan and implement screening programs to identify vulnerable groups in the population. To successfully implement disease prevention activities, special attention should be paid to people with chronic diseases.

Analysis of the **cardiovascular disease** indicator showed that the diseases of the group are widely spread in the Rioni basin lower course municipalities and are, in many cases, higher than the Samegrelo-Zemo Svaneti regional level. This shows the high sensitivity of the district population to this group of pathologies.

In addition, it is proved that 1/5 of the diseases caused by environment impact are cardiovascular diseases. Climate change related factors will make the current trend of cardiovascular diseases rise in future decades. Thus, the risk of cardiovascular disease complications will increase (myocardium infarct, insult). In order to prevent the abovementioned, routine screening programs are essential to identify risks and early stages of cardiovascular disease in order to successfully implement activities to prevent complications.

**Respiratory diseases** are widely spread in the target municipality. This shows that the population is vulnerable towards respiratory organ diseases and this vulnerability will increase with the impact of the factors accompanying climate change. Taking into consideration the Kolkheti lowland climate characteristics, increasing temperature and humidity will be expected to complicate asthma cases in children. An increase of chronic obstructive lung diseases caused by the use of solid fuel is also expected, especially among children and women. To prevent this, routine monitoring of air quality condition is of high importance both on regional and country levels along with increased awareness among the population and screening programs to identify chronic diseases at early stages. Beneficiaries of the mentioned programs should be first of all elderly people, people with special needs, children, and pregnant women.

**Digestive system** diseases in the Rioni river basin lower course municipalities are far beyond the region and country level. Thus an increase in this disease group caused by moderate climate change is not expected during the coming decade . As for natural hazards and catastrophes, the number of diseased people is expected to increase significantly due to reduction of food stocks and food availability. Thus prevention activities should address reduction of micronutrients and food deficit. Attention should be paid to child oriented programs, since this group is the most vulnerable.

**Traumas, intoxication and accidents** are medical conditions the population of the target communities is extremely sensitive to, since the indicators observed are higher than the regional and country indicators. This shows the vulnerability of the population of this area to damage. The abovementioned makes strengthening medical services essential in Senaki and Khobi municipalities.

Based on the abovementioned, the following main groups should be covering by health protection activities for climate change adaptation:

I. Implementation of the sanitary, hygiene and epidemic-prevention activities;

II. Early detection of chronic diseases and identification of risk groups;

III. Increase access to medical service (expand infrastructure and state/municipality programs).

A summary list of adaptation measures to be implemented is presented in Table 3.1.

***Table 3.1 Summarized list of adaptation measures to be implemented in the Rioni river basin lower course communities***

| Problem | List of Measures |
| --- | --- |
| **Floods and River Erosions** | • Implement phyto-melioration activities on logged forest lands and areas with degraded natural vegetation cover to restore high density forests and the natural-hydrological regime of the rivers especially to reduce the maximum discharge.<br>• Artificially deepen the Rioni, Tsivi and Tekhura rivers channels that are filled with sediments and straighten some crooked sections to improve throughput capacity during floods within Senaki and Khobi municipality boundaries. Implementation of these activities is an essential precondition to reduction of heavy flood risk.<br>• Repair or completely restore the sections of the several dozen km flood prevention bunds (dams) damaged by amelioration activities since the 1930s-40s, which is an essential precondition to reduction of heavy flood risk.<br>• Elaborate an effective early warning system especially for the communities along the Rioni river with permanent informing of the population of the riverside territories on possible floods and permanent training for readiness and actions in case of disasters. |

| | |
|---|---|
| **Landslide Processes** | • Construct a drainage network (channels) on the surface of the landslides to remove surface and ground water;<br>• Construct protective walls on piles on the front section of the landslide;<br>• Construct folding or massive mounting walls of monolithic steel-concrete block on the landslide surfaces;<br>• Apply anti-landslide bioengineering technologies including:<br>o Terracing the landslide surface;<br>o Moving ground on the landslide slopes to cut off slopes, expose soil etc.;<br>o Turfing the landslide surface and surrounding territories;<br>o Planting quickly growing vegetation (for example: nuts); improving forest management.<br>• Restrict water use for the population (limit irrigation of the landslide slopes, construct reservoirs on the landslide prone territories etc);<br>• Prohibit any construction without detailed study of the respective geological-geomorphologic conditions on the landslide prone territories;<br>• Permanently monitor the landslide territories and permanent inform and periodically train the population on necessary landslide prevention measures;<br>• Involve the population in landslide prevention activities the territories threatening their crofts. |
| **Soils** | • Introduce crop rotation practices ;<br>• Arrange forest windbreak lines to regulate surface runoff;<br>• Plan/implement complex activities to protect the territories threatened by flood and river erosion;<br>• Restore the damaged drainage-amelioration systems; clean water channels.<br>• Prohibit illegal logging along the banks of the Rioni, Tekhura and Tsivi rivers.<br>• Implement forestation and erosive territory restoration activities.<br>• Permanently monito erosive and flooded territories. |
| **Vegetation Cover** | • avoid self-drying of the different types of wetlands and wetland biomes;<br>• Avoid/preserve relict forest logging<br>• Inventory invasive neophytes and determine their population activity;<br>• Observe the vegetation period change and study indicators of the plant phenol-rhythms;<br>• Implement long-term monitoring of the geo-botanical environmental condition of the target territory. |
| **Agriculture** | • Elaborate and introduce natural cataclysms prognosis, prevention and prompt reaction systems. |

| | |
|---|---|
| | • Provide powerful agricultural equipment that works in the moist soil conditions.<br>• Consider frost prevention activities when planning and cultivating agricultural crops in greenhouses and plantations.<br>• Avoid plant diseases, increased numbers of pests, and activation of diffusion factors with the impact of the expected increase of relative humidity and high temperature<br>o Test and introduce high temperature and drought resistant agricultural crops;<br>o Apply anti-stress bio-preps and biologically effective microorganisms.<br>o Immediately rehabilitate water collectors and drainage systems.<br>o Plant moisture-loving, moisture-evaporating plants and high transpiration capacity trees in the windbreaks.<br>o Test and introduce agricultural equipment and technologies tested in high humidity regions.<br>• Implement agro- and hydro-technical activities against water erosion.<br>• Plan and implement river flood and flash flood prevention activities (regulate leachate, strengthen banks and bridges);<br>• Artificial reforest the areas under a landslide and erosion threat; protect and rehabilite forests and windbreaks to protect soil.<br>Also,<br>• Organize and smoothly implement (where necessary) possible frost prevention activities for citrus (lemon, orange, tangerine).<br>• Rehabilitate and upgrade the drainage systems to protect agricultural lands, pastures and especially, riverside settlements from frequent floods, rehabilitate damaged flood prevention dams.<br>• Provide necessary information to the local population on problems related to agriculture.<br>• Organize permanent monitoring on rivers to avoid possible heavy floods |
| **Uncomfortable Temperatures** | • Implement sanitary, hygiene and epidemic-prevention activities;<br>• Early detection of chronic diseases and identification of risk groups;<br>• Increase access to medical servicse (expansion of infrastructure and state/municipality programs). |

### *3.8 Activity Plan for the Rioni River Basin Lower Course Communities*

The described activities need to be specified according to the problems revealed for each community. Thus below is given a preliminary list of activities for each community and villages within the community, which ensures the strengthening of the communities against natural catastrophies and future climate change. The activities are summarized in Table 3.2. Each problem is assessed for its respective significance (H – high, M – medium, L – low). The assessment was made on the basis of field survey materials and data collected from other sources. In the assessment, determination of the significance level depended on the scale of the problem scale (size of the territory affected, population influenced, infrastructure). The assessment is preliminary and does not represent an outcome of the problem's detailed analysis thus the probability of error is quite high though we believe it gives an approximate view of the current situation. As for the list of activities, it is also developed based on the preliminary assessment. Implementation of a specific project is associated with detailed, large-scale research. In addition, the specific action plan should be developed on-site with direct engagement of the community in the action plan developed.

*Table 3.2. Summarized list of adaptation and risk reduction measures to be carried out in the communities of Lower Rioni pilot watershed*

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| Potskho | Potskho | Landslide | **M** | • Implement landslide prevention activities on landslide areas;<br>• Stabilize the landslide slope using bioengineering methods;<br>• Prohibit active agriculture on areas under a landslide threat;<br>• Arrange a drainage systems | < 50,000 | **MT** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Floods / Washing of river banks | **M** | • Implement bank protection activities on the Meteria river | < 50,000 | **MT** | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Mokhashi | Landslide | **L→M** | • Arrange drainage systems on the landslide slopes; | < 50,000 | **MT** | • Municipal government. | • Local budget;<br>• Development agencies |

[3] Determination of the activities for the problems assessed with medium or high significance. The list of activities is developed based on the preliminary assessment. Implementation of a specific activity should be associated with detailed research and assessment.
[4] Short-term (ST) implies a period of time up to 1 year; midterm (MT) is 1-5 years; long-term (LT) is more than 5 years.

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | • Stabilize the landslide slope using bioengineering methods;<br>• Prohibit active agriculture on areas under a landslide threat. | | | | (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Floods / Washing of river banks | **M** | • Implement bank protection activities on the Gurdzeme River.<br>• Restore the damaged bridge on the Gurdzeme River. | 50,000 – 100,000 | **MT** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| **Ledzadzame** | Ledzadzame | Landslide | **M** | • Deepen the Tekhura river channel along the landslide slope.<br>• Implement capital bank protection activities on the Tekhura River.<br>• Implement bioengineering landslide prevention activities on landslide areas if possible | 50,000 – 100,000 | **MT** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | Floods / Washing of river banks | M | • Lengthen the Tekhura river bank protection building and connect with the new construction by wires, part of which needs restoration.<br>• Strengthen the piers of the existing pedestrian bridge on the river<br>• Implement bank protection activities on the Tekhura river | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Lesajaie | Landslide | M | • Strengthen the river bank by constructing a bank protection building<br>• Arrange drainage systems on the landslide slopes;<br>• Stabilize the landslide slope using bioengineering methods. | < 50,000 | MT | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Legogie | Landslide | L | • Implement an additional survey to identify landslide process.<br>• Implement landslide prevention activities; | < 50,000 | ST | • Municipal government;<br>• Central government (Ministry of Environment Protection; Ministry of | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.); |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | • Arrange drainage systems | | | Regional Development and Infrastructure; NEA). | • NGOs. |
| | | Floods | L | • Implement bank protection activities on the Gurdzeme river<br>• Elaborate land management practice – define hazardous zones and introduce land use policy. | < 50,000 | ST | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Jolevi | Landslide | M | • Arrange drainage systems on landslide slopes;<br>• Stabiliz landslide slope using bioengineering methods. | < 50,000 | ST | • Municipal government;<br>• Central government (NEA). | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Kvauri | Landslide | L | • Arrange drainage systems on landslide slopes<br>• Stabilize the landslide slope using bioengineering methods<br>• Implement bank protection activities on the left bank of the Tekhura river | < 50,000 | ST | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | • Rehabilitate the road connecting to Lekirtskhalie neighborhood. | | | | |
| Ushapati | Ushapati | Landslide | **L→M** | • Arrange drainage systems on landslide slopes<br>• Stabilize the landslide slope using bioengineering methods. | < 50,000 | **ST** | • Municipal government;<br>• Central government (Ministry of Environment Protection; NEA). | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Lekokaie | Landslide | **L→M** | • Arrange drainage systems on landslide slopes;<br>• Stabilize landslide slope using bioengineering methods<br>• Implement an additional survey to study cause of landslide and identify scale | < 50,000 | **ST** | • Municipal government;<br>• Central government (Ministry of Environment Protection; NEA). | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| Eki | Eki | Landslide | **H** | • Arrange drainage systems on the landslide slopes<br>• Implement large scale landslide preventive engineering activities<br>• Stabilize landslide slope using | 50,000 – 100,000 | **MT** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | bioengineering methods if possible.<br>• Movepopulation from landslide territory based on conclusions by specialists | | | Regional Development and Infrastructure; NEA). | etc.);<br>• NGOs. |
| | Saadamio | Landslide | **L** | • Arrange of drainage systems on landslide slopes<br>• Stabilize landslide slope using bioengineering methods if possible. | < 50,000 | **ST** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Wash of river banks | **L** | • Clean and deepen the Chkhara river bed;<br>• Stabilize channel bank by implementing bank protection activities;<br>• Apply bioengineering activities | < 50,000 | **ST** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | Satskhvitao | Landslide | **L→M** | • Arrang drainage systems on landslide slopes<br>• Stabilize the landslide slope using bioengineering methods if possible;<br>• Implement bank protection activities on the Tsivi river | < 50,000 | **ST** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Washing of river banks | **L→M** | • Implement bank protection activities on the Tsivi river<br>• Rehabilitate the Tsivi river bridge. | < 50,000 | **ST** | • Municipal government;<br>• Central government (Ministry of Regional Development and Infrastructure). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| **Zana** | Zana | Landslide | **H** | • Arrange drainage systems on landslide slopes<br>• Implement large-scale landslide prevention engineering activities;<br>• Stabilize landslide slope using | 50,000 – 100,000 | **LT** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.); |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | bioengineering methods if possible;<br>• Move population from th landslide territory based on conclusions by specialists<br>• Permanently monitor the landslide | | | Infrastructure; NEA). | • NGOs. |
| | Etseri | Floods / Washing of river banks | **L** | • Bank protection activities on the Zana river.<br>• Restore the bridge on the Zana-Etseri road . | < 50,000 | **ST** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Satkebuchao | Landslide | **M** | • Arrange drainage systems on landslide slopes;<br>• Implement engineering activities;<br>• Stabilize the landslide slope using bioengineering methods if possible. | < 50,000 | **MT** | • Municipal government;<br>• Central government (Ministry of Environment Protection; NEA). | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| Khorshi | Shua Khorshi | Landslide | M→H | • Implement engineering bank-strengthening activities on the Tsivi river banks (bank protection wall, gabions, etc)<br>• Arrange drainage systems on the landslide slopes;<br>• Apply landslide protection bioengineering activities<br>• Implement a detailed survey of landslide processes on the Khorshi community territory. | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Tsizeti | Floods | M→H | • Implement of engineering bank-protection activities on the Khobiswkali river | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment protection; Ministry of Regional Development And Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Landslide | M | • Arrangedrainage systems on the landslide slopes<br>• Implement river protection | < 50,000 | ST | • Municipal government;<br>• Regional government; | • Local budget;<br>• Central budget; |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | bioengineering activities. | | | • Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Patara Zana | Floods | M | • Implementriver-protection engineering activities on the Zana river | 50,000 – 100,000 | ST | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure<br>• ; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Saadanaio | Landslide | L | • Arrange drainage systems on landslide slopes<br>• Stabiliz the landslide slope using bioengineering methods | < 50,000 | ST | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| Menji | Bataria | Landslide | L | • Arrange drainage systems on landslide slopes | < 50,000 | ST | • Municipal government; | • Local budget; |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | • Stabilize landslide slope using bioengineering methods<br>• Restore the damaged section of the road<br>• Constructi bank protection building from the Tsivi river side.<br>• Survey the landslide to prove suffusion process<br>• In case suffusion is proved, fill the section with inert material and align | | | • Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Floods / Washing of river banks | M→H | • Lengthen the existing bank protection building along the populated territory. | < 50,000 | ST | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Sakharbedio | Landslide | M | • Arrange drainage systems on | < 50,000 | ST | • Municipal government. | • Local budget; |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | landslide slopes;<br>• Stabilize the landslide slope using bioengineering methods | | | | • Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Floods / Washing of river banks | L→M | • Build a bank protection work on the Tsivi river<br>• Stabilize the landslide slope using bioengineering methods if possible | < 50,000 | ST | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Satsuleiskiro | Landslide | L→M | • Arrange drainage systems on landslide slopes;<br>• Stabilize the landslide slope using bioengineering methods. | < 50,000 | ST | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Mudflow | L | • Clean/deepen the Eki mountain mudflow channel bed;<br>• Permanently monito the bed's condition;<br>• Protect logging of the forest | < 50,000 | MT | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.); |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | close to the channel;. | | | | • NGOs. |
| **Teklati** | Teklati | Floods / Washing of river banks | **M** | • Restore the damaged bank protection building (dam) on the Rioni river. | < 50,000 | **ST** | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| **Nokalakevi** | Lebaghaturi e | Landslide | **L→M** | • Drain and dry landslide slopes- by making open drainage channels;<br>• Remove and dispose of the landslide ground shaft along the unnamed stream in the landslide zone;<br>• Permanently monitori the landslide | < 50,000 | **ST** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | | Floods / Washing of river banks | **M** | • Implement bank protection engineering activities on the Abashistskali river;<br>• Rehabilitate the Tarcheni river | < 50,000 | **ST** | • Municipal government;<br>• Regional government;<br>• Central government | • Local budget;<br>• Central budget;<br>• Development agencies |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | bridge. | | | (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Jikha | Landslide | **L** | • Arrange drainage systems on landslide slopes;<br>• Stabilize the landslide slope using bioengineering methods | < 50,000 | **ST** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Gakhomela | Floods / Washing of river banks | **L** | • Implement engineering bank-protection activities on the Tekhura river in the Sabeselio neighborhood; | < 50,000 | **ST** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Dzigideri | Floods / Washing of river banks | **L** | • Implement engineering bank-protection activities on the Tekhura river. | < 50,000 | **ST** | • Municipal government. | • Local budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| **Gejeti** | Gejeti | Floods | **M** | • Clean and deepen the village channel;<br>• Arrange tube-bridges on the channel;<br>• Implement engineering bank-protection activities on the Tekhura River. | < 50,000 | **ST** | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| **Dzveli Senaki** | Dzveli Senaki | Landslide | **H** | • Implement bioengineering activities such as afforestation on the landslide surface;<br>• Regulate surface runoff streams;<br>• Temporarily prohibiti cattle grazing on the landslide area.<br>• Implement palliative bank protection activities;<br>• Widen and deepenithe Nakhuri stream bed. Regularly clean the bed. | < 50,000 | **ST** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Sachikobao | Landslide | **H** | • Arrange drainage systems on | < 50,000 | **ST** | • Municipal government. | • Local budget; |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | landslide slopes;<br>• Implement the landslide protection engineering activities;<br>• Stabilize the landslide slope using bioengineering methods<br>• Move population from the landslide territory based on the conclusions by specialists | | | | • Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Meore Nosiri | Floods / Washing of river banks | M→H | • Implement bank protection engineering activities on the Tekhura river<br>• Rehabilitate the Tekhura river bridge (on Senaki-Martvili road) | 50,000 – 100,000 | ST | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| Akhalsopeli | Akhalsopeli | Floods / Washing of river banks | H | • Conduct a detailed study of hazardous sections by specialists<br>• Implement large scale bank-protection engineering activities | 100,000 – 1,000,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, |
| | Isula | Floods / Washing of | H | | | | | |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | river banks | | on the Rioni and Tekhura rivers<br>• Restore the existing bank protection dams | | | Protection; Ministry of Regional Development and Infrastructure; NEA). | etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| Zemo Tchaladidi | Mukhuri | Floods / Washing of river banks | H | • Restore, rehabilitate damaged bank protection dams on the Tsivi river.<br>• Implement bioengineering activities on restored dams. | 50,000 – 100,000 | ST | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| | Siriachkoni | Floods / Washing of river banks | H | • Rehabilitate the bank protection dams on the Rioni river.<br>• Rehabilitat the ferry exit;<br>• Restore/strengthen the damaged dams in the upper neighborhood of Siraichkoni<br>• Implement bioengineering activities on restored dams. | 100,000 – 1,000,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development<br>• and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW); |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | • NGOs. |
| Senaki | | Landslide | H | • Implement intense landslide-protection engineering activities on the landslide area;<br>• Permanently monitor the landslide process;<br>• Move population from the high threat territory in case as recommended by specialists | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| | | Floods | M | • Extend flow directing facilities in the concrete bed of the stream on the territory of the city.<br>• Regularly clean sediments from the channel. | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | Washing of river banks | M | • Implement bank-protection engineering activities on the Tekhura river | 50,000 – 100,000 | ST | • Municipal government;<br>• Regional government. | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• NGOs. |
| Sagvichio | Sagvichio | Floods / Washing of river banks | H | • Detailed study of the Rioni river bank protection dams' condition to check their sustainability;<br>• Restore/rehabilitate damaged sections of the dam;<br>• Implement bioengineering activities on restored dams;<br>• Implement additional bank protection activities if necessary | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| Tchaladidi | Saghvamichao | Floods / Washing of river banks | H | • Detailed study of the Rioni river bank protection dams' condition to check their sustainability;<br>• Restore/rehabilitate damaged | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | sections of the dam;<br>• Implement bioengineering activities on restored dams;<br>• Implementadditional bank protection activities if necessary. | | | Protection; Ministry of Regional Development and Infrastructure; NEA). | etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| | Sabazho | Floods / Washing of river banks | H | • Detailed study of the Rioni river bank protection dams' condition to check their sustainability;<br>• Restore/rehabilitate damaged sections of the dam;<br>• Implement bioengineering activities on restored dams;<br>• Implement additional bank protection activities if necessary | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure; NEA). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| **Patara Poti** | Patara Poti | Floods / Washing of river banks | H | • Detailed study of the Rioni river bank protection dams' condition to check their sustainability<br>• Restore/rehabilitate damaged sections of the dam; | 50,000 – 100,000 | MT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, |

| Community | Village | Problem | Problem Level (L; M; H) | Executive Measures[3] | Cost Range (USD) | Timeline[4] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|---|---|
| | | | | • Implement bioengineering activities on restored dams;<br>• Implement additional bank protection activities if necessary. | | | Regional Development and Infrastructure; NEA). | etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |

### *3.9.Lower Rioni Pilot Watershed - Climate Change Mitigation Activities*

### *3.9.1.Senaki Municipality*

Within the program, greenhouse gas emission analysis for different sectors was conducted. The sectors that emit greenhouse gases into the atmosphere were identified and the volume of emitted gases in Senaki Municipality was calculated.

The obtained results by sector are presented in a generalized manner in Table 3.3.

***Table 3.3. – Emission of greenhouse gases into the atmosphere from the territory of Senaki Municipality***

| Sector | | Tons $CO_2$ eq / Year |
|---|---|---|
| Agriculture | Enteric Fermentation | 21,792.60 |
| | Soil Management | 18,302.4 |
| | Manure Management | 4,568.39 |
| **Total agricultural emissions** | | **44,663.39** |
| **Landfill** | | **22,335.9** |
| **Pipelines** | | **4,855.2** |
| **Residential / Stationary** | | **2,402.63** |
| **Transport** | | **11,651.19** |
| **Total** | | **85,908.31** |

Based on the performed analysis, a list of mitigation activities is recommended. Specifically:

**Recommendations**

To reduce the quantity of GHG Emissions from the municipality of Senaki, the following activities are recommended:

Senaki is characterised by a high level of emissions from landfill sites, an average quantity of degraded soils and an average quantity of agricultural emissions. Bearing this in mind the following activities are advised:

- Management of landfill sites (covering, composting practices);
- Workshops on manure management techniques (storage and application practices).

The activity plan is presented in Table 3.4.

***Table 3.4. – The concluding list of mitigation activities that must be performed in Senaki Municipality***

| Objectives | Measures | Scale of the measure | Cost Range (USD) | Time line[5] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|
| **Reduction in greenhouse gas emissions from landfill sites** | Management of landfill sites (covering, composting practices) | Senaki Municipality | 10,000 - 50,000 | **LT** | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| **Reduction in greenhouse gas emissions from agricultural/land use sources** | Workshops on manure management techniques (storage and application practices) | Senaki Municipality | 5,000 - 20,000 | **ST** | • Smallholder farmers;<br>• Farming cooperatives;<br>• Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, ACF, GIZ, Sida, etc.);<br>• NGOs. |
| | Reforestation program on degraded land | Senaki Municipality | 10,000 - 100,000 | **LT** | • Smallholder farmers;<br>• Farming cooperatives;<br>• Municipal government;<br>• Regional | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development |

[5] "Short-term"(ST) implying the period of time up to 1 year; "midterm" (MT) – 1-5 years; "long-term" (LT) – > 5 years.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | government;<br>• Central government (Ministry of Environment Protection). | banks (ADB, EBRD, WB, KfW);<br>• NGOs. |

### *3.9.2.Khobi municipality*

Within the program, greenhouse gas emission analysis for different sectors was conducted. The sectors that emit greenhouse gases into the atmosphere were identified and the volume of emitted gases in Khobi municipality was calculated.

The obtained results by sector are presented in a generalized manner in Table 3.5.

***Table 3.5. – Emission of greenhouse gases into the atmosphere from the territory of Khobi Municipality***

| Sector | | Tons $CO_2$ eq / Year |
|---|---|---|
| Agriculture | Enteric Fermentation | 31,308.9 |
| | Soil Management | 22,871.8 |
| | Manure Management | 7,015.75 |
| **Total agricultural emissions** | | **61,196.45** |
| **Landfill** | | **17,749.82** |
| **Pipelines** | | **3,498.6** |
| **Residential / Stationary** | | **1,043.14** |
| **Transport** | | **22,861.7** |
| **Total** | | **106,349.71** |

Based on the performed analysis, a list of mitigation activities is recommended, specifically:

**Recommendations**

To reduce the quantity of GHG emissions from the municipality of Khobi, the following activities are recommended:

Khobi municipality is characterised by a high level of agricultural and stationary emissions. It also has a high number of transport vehicles.

Bearing this in mind the following activities are recommended:

- Workshops on manure management techniques (storage and application practices)
- Insulation of public and municipal buildings
- Exchanging public transport and municipal vehicles for new, more efficient replacements

The activity plan is presented in Table 3.6.

***Table 3.6. – The concluding list of mitigation activities that must be performed in Khobi Municipality***

| Objectives | Measures | Scale of the measure | Cost Range (USD) | Time line[6] (ST; MT; LT) | Responsible Agent | Potential Source of Funding |
|---|---|---|---|---|---|---|
| Reduction in greenhouse gas emissions from agricultural/ land use sources | Workshops on manure management techniques (storage and application practices) | Khobi municipality | 5,000 - 10,000 | ST | • Smallholder farmers;<br>• Farming cooperatives;<br>• Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, ACF, GIZ, Sida, etc.);<br>• NGOs. |
| Reduction in greenhouse gas emissions from residential / stationary sources | Insulation of public and municipal buildings | Khobi municipality | 10,000 - 50,000 | ST | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; Ministry of Regional Development and Infrastructure). | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, ACF, GIZ, Sida, etc.);<br>• Development banks (ADB, EBRD, WB, KfW);<br>• NGOs. |
| Reduction in greenhouse gas emissions from transportation sources | Exchanging public transport and municipal vehicles for new, more efficient replacements | Khobi municipality | 50,000 - 100,000 | LT | • Municipal government;<br>• Regional government;<br>• Central government (Ministry of Environment Protection; | • Local budget;<br>• Central budget;<br>• Development agencies (USAID, UNDP, EU, GIZ, Sida, etc.);<br>• Development |

[6] "Short-term"(ST) implying the period of time up to 1 year; "midterm" (MT) – 1-5 years; "long-term" (LT) – > 5 years.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | Ministry of Regional Development and Infrastructure). | banks (ADB, EBRD, WB, KfW);<br>• NGOs. |

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