Climate Change and Agriculture in Kakheti

Tbilisi, 2014

The present report is drafted in the process of preparation of Georgia's Third National Communication to the UNFCCC. The preparation process involved a large group of specialists, representing: the Ministry of Environment and National Resources of Georgia, the Ministry of Agriculture of Georgia, the Ministry of Energy of Georgia, the Ministry of Economy and Sustainable Development of Georgia, the Ministry of Labor, Health and Social Affairs of Georgia, the Ministry of Regional Development and Infrastructure of Georgia, the Ministry of Education and Science of Georgia, individual academic institutes; representatives of self-governing bodies of all eight municipalities of Kakheti and local consultants engaged in agriculture, independent experts and NGOs. UNDP Georgia made special contribution to the implementation of the work, supporting the government of Georgia in the preparation of this document.

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Abbreviations

ADA - Austrian Development Agency
AL - Agricultural lands
CDM - Clean Development Mechanism
CTI - Climate Tourism Index
CVD- Cardiovascular Diseases
ENVSEC -Environmental Security Initiative
EU –European Union
FAO - Food and Agriculture Organization
GCF - Green Climate Fund
GEF - Global Environment Facility
GIZ -German Agency for International Cooperation
GoG – Government of Georgia
HCC – Hail, Suppression, Service
IFAD - International Fund for Agricultural Development
IOM -International Organization for Migration
IPCC -Intergovernmental Panel on Climate Change
LEPL -Legal Entity of Public Law
MENRPG - Ministry of Environment and Natural Resources Protection of Georgia
MLHSAG- Ministry of Labour Health and Social Affairs of Georgia
MoA - Ministry of Agriculture
NEA - National Environmental Agency
PHCU - Primary Health Care Unit
SPI - Standardized Precipitation index
UNDP - United Nations Development Programme
UNFCCC- United Nations Framework Convention on Climate Change
USAID - United States Agency for International Development
WHO - World Health Organization
WMO – World Meteorological Organization

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Introduction

In compliance with the rules of the United Nations Framework Convention on Climate Change, activities implemented on climate change in the country are periodically summarized in National Communications. In 2012 Georgia started to work on the Third National Communication, in which an important place is given to the impact of climate change underway in Kakheti – one of unique regions – on the economy of region and natural ecosystems. A particular goal of this research was to study the impact of climate change on agricultural sector of Kakheti.

All eight municipalities of Kakheti were involved in the research. The project with the help of locally mobilized consultants, collected primary and secondary information, based on which the problems were analyzed and recommendations were prepared. Besides, the project proposals were selected and prepared as a result of discussing ideas developed in the municipalities, which will facilitate balancing the risks associated with the climate change.

According to the volume of agricultural production, Kakheti historically has a leading position among the regions of Georgia, which preconditions high vulnerability of its economy to climate change and weather conditions. This circumstance provided grounds for the implementation of a large irrigation project – construction of Alazani irrigation system in Shida Kakheti in XII century. Since 30's of the last century large-scale works had been implemented to combat drought in Gare Kakheti as well, however, in 1990 - s, the irrigation systems, as well as windbreaks were mostly exterminated and Kakheti has faced great challenges, the climate change poses to the rural-agricultural regions all over the world.

In Georgia's Second National Communication, the impact of climate change on economy and natural ecosystems was analyzed as a case study for one part of Kakheti – Dedoplistskaro municipality, together with other vulnerable regions of Georgia. However, taking into consideration, that the territory of municipality compiles only 22% and population – 8% of Kakheti region, the results provided in the previous report do not reflect the problems facing the whole region

According to the territory (11.04 thousand km^2) Kakheti exceeds twice average value of the areas of other regions. Its relief and climate conditions are also diverse, proportionally to the area. According to hypsometric characteristics it is almost comparable to Zemo Svaneti – the lowest point is at 90 meters above sea level – near Mingechauri Reservoir, while the highest point Mt. Tebulosmta is at 4 492 meters. According to modern classification, 9 climate zones are presented on the territory of Kakheti, started with warm, humid climate of Alazani floodplain and separate locations of Lagodekhi and ended with high mountain climate of Greater Caucasus watershed with permanent snow and glaciers. Temperate humid climate zone of dry subtropics (Shida Kakheti) and temperate dry steppes climate zone (Gare Kakheti) are spread on the most of the territory. In conditions of forecasted warming of the climate, the latter zone will be especially vulnerable against expected aridization.

Diversity of the climate preconditions multi sector structure of agriculture in Kakheti. Viticulture, horticulture, gardening, melon and gourd growing, common for lowland areas of Shida Kakheti, are substituted by grain farming and sunflower plantations in steppes and mountains of Gare Kakheti.

Animal husbandry and been keeping are developed on Tsivi - Gombori Range and southern slopes of Greater Caucasus, while lowlands of Iori Plateau are used as winter pastures.

Besides agricultural production, significant part of Kakheti territory is occupied by protected areas, out of which the most important are Mtatusheti, Lagodekhi and Vashlovani reserves, Ilto and Chachuna protected areas and so on. High land zone of Mtatusheti has great potential for the development of mountain ski sports and mountain tourism. Besides, having rich historical past the region has great potential for the development of cultural tourism. Davit Gareji and Bodbe monastery complexes, Alaverdi Cathedral; churches and chapels of X-XII centuries, located around Ikalto, Shuamta, Gremi, Nekresi, Gurjaani and Sagarejo make the whole territory of Kakheti more attractive for the tourists of this category. Unique nature and architecture of Mtatusheti – distinguished with its ethnographic peculiarities, similarly to Zemo Svaneti - really add value to future importance of tourism potential in Kakheti, which mostly is related to the problem of constructing a road to Tusheti. It is to be mentioned that thanks to relatively mild and dry climate, characterized with less snow in winter, except for highland areas, tourism in Kakheti is possible all the year round.

The calculations conducted with climate models, demonstrated that compared to the average of 2010, the average annual temperature in Kakheti will be increased by 1.1^{0}C, to 2050 and by 3.5^{0}C by 2100. Besides, in the beginning precipitations will be insignificantly changed within the range of ±5%, but to 2100 supposedly will be decreased by 10-20%. Despite the fact that this forecast basically is favorable for the tourism sector, it will be associated with many challenges for the main sector of the economy – agriculture, especially in the second half of this century. In particular, the demand for irrigation water will be increased in Kakheti, which will require important improvement and optimization of irrigation systems as well as recovery expansion of windbreaks. Expected transformation of agro climate zones requires introduction of new species and technologies in agriculture. Increase of temperature and water shortage will cause problems in health care sector as well.

As mentioned above, in Georgia's Second National Communication, these issues were partially viewed just for Dedoplistskaro municipality. Discussion of the climate change problem in the present report, to the extent of the whole Kakheti, presents the ways and opportunities to be realized in the respective adaptation projects. Within the framework of the Second National Communication 2 proposals out of those prepared for Dedoplistskaro municipality, already are under implementation. 10 project proposals are presented in this report, which in case of implementation will demonstrate adaptation measures to climate change in different agricultural sub-sectors.

1. Climate and Agro Climate Characteristics of Kakheti Region

1.1. General Information

Kakheti region, the area of which compiles 11 040.6 km^2, covers the extreme eastern part of the territory of Georgia. From the north it is bounded by the Greater Caucasus watershed, from the west – by the Kakheti Ridge and western end of the Iori Upland, and from south-east it is bordering with Azerbaijan. Taking into consideration physical and geographic conditions, Kakheti could be divided into three climate districts: Gare Kakheti, which includes: Sagarejo, Signangi (central and southern parts) and Dedoplistskaro municipalities; Shida Kakheti, which includes Akhmeta (low zone), Telavi, Gurjaani, Kvareli and Lagodekhi municipalities, as well as west part of Signangi municipality; highlands of Kakheti, which includes upper zone of Akhmeta municipality (Mtatusheti) and mountain zone of Caucasus slopes.

The relief of the region is diverse. The lowest point (90m above sea level) is close to Mingechauri Reservoir, close to estuary of the river Iori, and the highest peaks are Mt. Tebulo (4 492 m) and Mt. Diklosmta (4 285 m). Shida (inner) and Gare (outer) Kakheti regions are divided by Tsivi - Gombori Range (the highest peak – Mt. Tsivi 1991 m). In the north of the Range up to southern slopes of the Caucasus – Alazani valley is spread, and in south and east – the Iori upland, with average heights 500 – 800 m, above the sea level. Alazani floodplain, located alongside east border of Shiraki valley in the low part of the river Alazani – 100–300 meters, is distinguished with specific landscape and climate. Due to diversity of the relief, many different climate zones are identified in Kakheti, location of which according to the data[1] of 1980s is given on Fig. 1.1. According to general classification of climate zones, Kakheti belongs to temperate humid, subtropical continental climate district, in which in compliance with vertical zoning, rich spectrum of zones is presented, from semi-arid steppes (2, 3) to nival zone covered with permanent snow and glaciers (9).

In climate zones given in the Figure, average values of basic meteorological elements according to the data available to 1980s are given in Table 1.1. Since then during recent decades, climate elements influenced by global warming were somewhat changed. However the extent of these changes has not gone beyond natural variations and at the moment does not change configuration of climate zones.

1 The SSR resorts and resources. Moscow, 1989

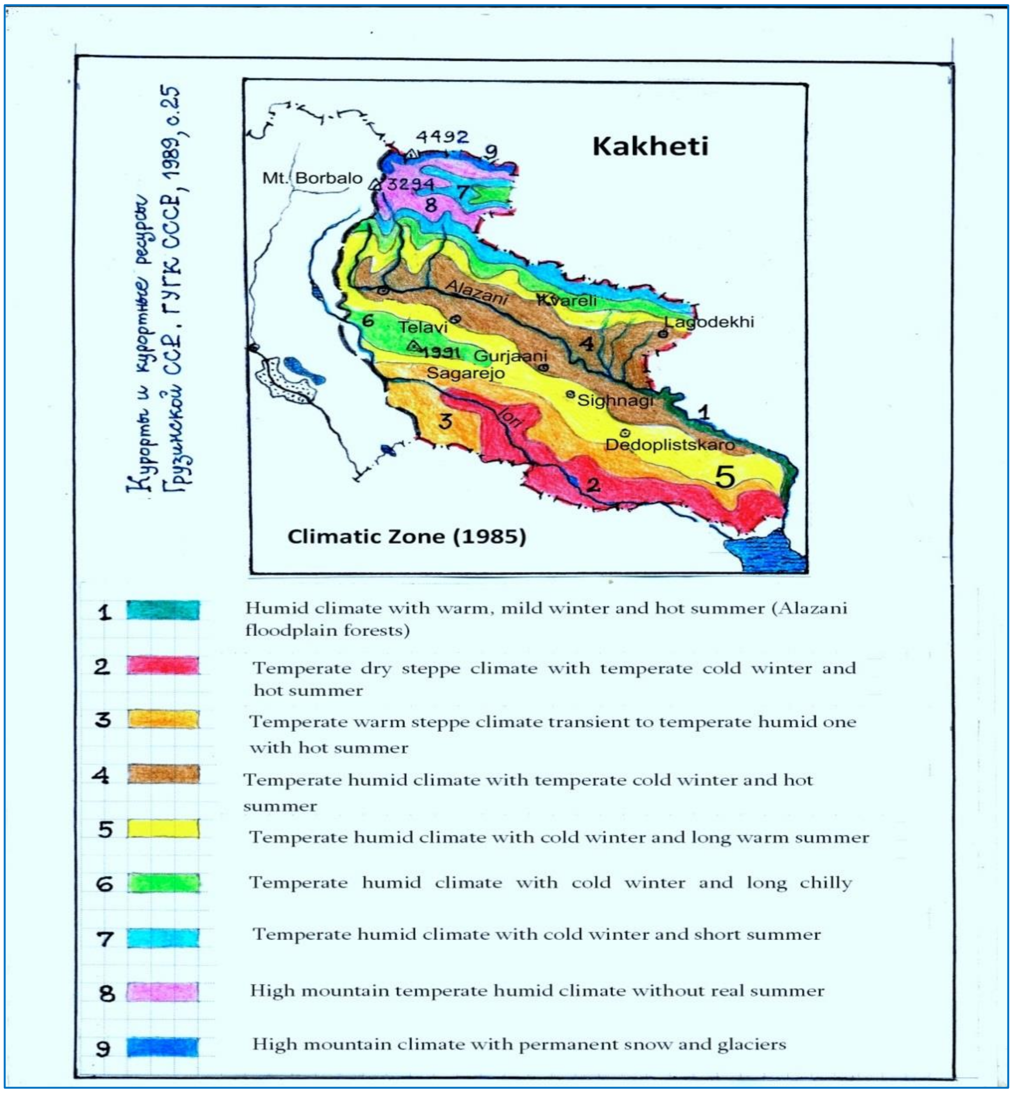


Figure 1.1.Location of climate zones in Kakheti region

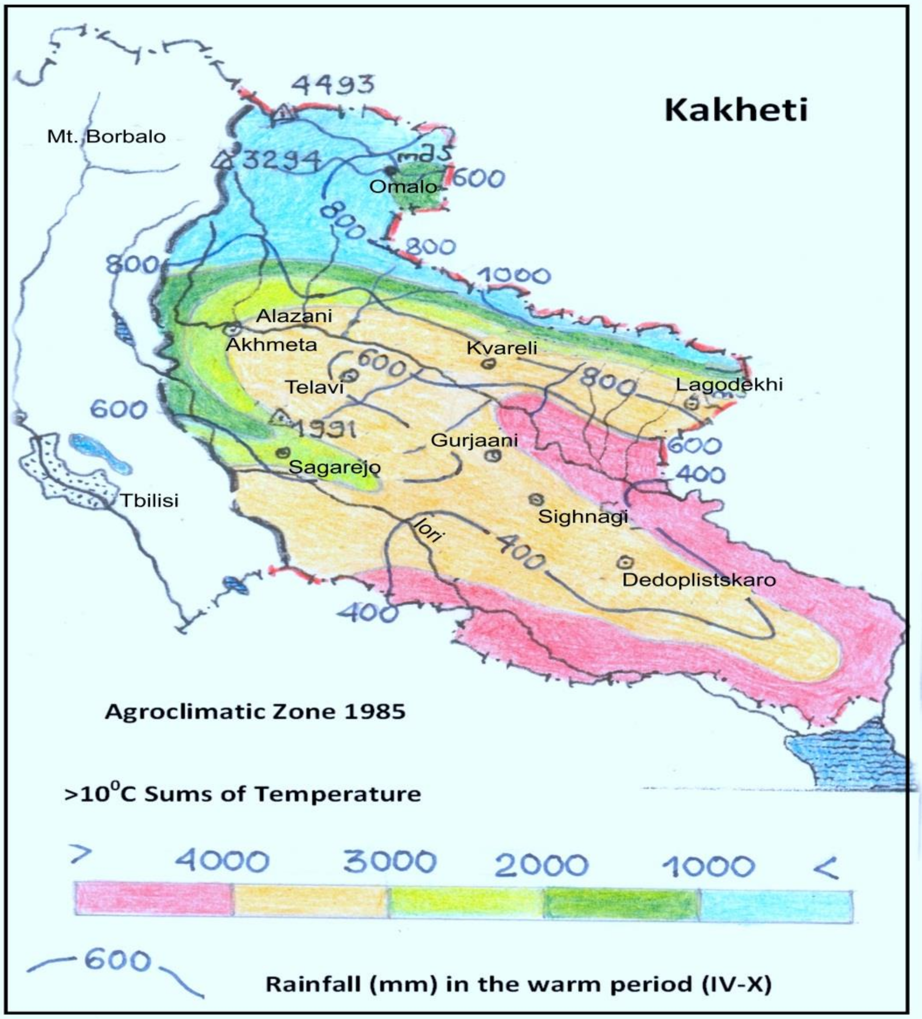
Table 1.1 Climate data of basic weather stations in the Kakheti region (according to 1980s state)

Climate district	Weather station	Height above sea level, m	Year of starting observation	Average annual temperature, ^0C	Annual sum of precipitation's, mm	Climate zone
Gare Kakheti	Eldari	500	1950	11.6	470	2
	Sagarejo	802	1916	11.0	768	3
	Udabno	750	1951	10.4	430	3
	Sighnagi	795	1950	11.0	735	5
	Dedoplistskaro	800	1951	10.1	585	5
	Shiraki	550	1931	10.3	501	5
	Gombori	1 085	1940	8.1	730	6
Average		755		10.4	603	
Shida	Akhmeta	567	1928	11.6	788	4

Kakheti	Telavi	568	1932	11.8	770	4
	Gurjaani	415	1915	12.4	741	4
	Kvareli	449	1936	12.5	991	4
	Lagodekhi	435	1930	12.6	1 004	4
	Alazani	290	1933	13.3	617	4
Average		454		12.4	818	
Highland zone	Omalo	1 880	1950	3.5	658	7

In this table weather stations are ordered in accordance with the climate districts. The Table demonstrates that in Gare Kakheti temperature on the average is by 2 ^{0}C lower than in Shida Kakheti. Besides, rainfall is approximately in 200 mm less as well. According to indirect assessments, up to approximately 2 400 m height average annual temperature was positive in high land zone. According to the calculations of different authors, in this zone annual totals of rainfall compile 1 000 mm. In this regard Omalo is not representative station, since it is located in cavity and is influenced by downward air flows, that conditions the reduction of rainfall. Situation is similar in Adjara (Shuakhevi Hollow) and in Zemo Svaneti (Mestia cavity). As for climate zone 1, according to landscape assessments it could be considered similar to humid subtropical conditions, with average temperature 14^{0}C and total rainfall 600mm.

Agriculture is leading sector in Kakheti region, one of main factors of development of which is climate together with peculiarities of relief and soils. Taking into consideration distribution of temperature and rainfall, 5 climate zones are identified in the region, location of which according to the data available for 1985 is given in Fig. 1.2.



Source: Meladze G., Meladze M. Agroclimatic Resources of Eastern Regions of Georgia. "Universal", Tbiliai, 2010 (in Georgia)

Figure 1.2 Agro Climate Zones of Kakheti

Aiming to characterize climate change in different municipalities located in this region, in different periods of the last century and projected changes until the middle of this century, following weather stations were selected for the analysis:

- **Sagarejo** which characterizes agroclimate conditions on the territory of municipality with sufficient approximation (western part of Gare Kakheti);
- **Akhmeta**, which characterizes southern – low part of the municipality, located in extreme North West section of Alazani Plain. The data of Omalo weather station could also be used for characterizing highland zone of the municipality (northern part), but due to its closure in 1992, recent change of climate could not be assessed in this zone.
- **Telavi**, which well characterizes agroclimate conditions of the territory of municipality

(north - western parts of Alazani Valley);

- **Gurjaani**, which characterizes agroclimate conditions in the middle of Alazani Plain and in the middle of the foothills of Tsivi - Gombori Ridge;
- **Kvareli**, which characterizes agro climate conditions of northern part of central section of Alazani Valley;
- **Tsnori**, which characterizes agroclimate conditions in eastern low zone of Sighnagi municipality, in southern part of Alazani Plain. Central, mountainous part of Sighnagi municipality, where city of Sighnagi is located, basically is covered with forests, and southern part includes arid steppes of Iori upland, with no settlements and basically used for winter pastures;
- **Dedoplistskaro**, which quite well describes agroclimate conditions of the territory of municipality (upper part of Iori upland, including Shiraki and Eldari Valleys);
- **Lagodekhi**, which is representative for agroclimate conditions in northern section of extreme eastern part of Alazani Valley (territory of historical Hereti).

1.2. Climate change in Kakheti region (1961-2010)

In 1970s global warming became obvious in different regions of the world. In Georgia this trend was revealed clearly by 1990s. According to the results presented in Georgia's Initial National Communication, by this time centennial increase of temperature reached 0.5 ^{0}C in East Georgia, in particular in Kakheti. With this regard, quantitative assessment of the data provided in Table 1.1 during last half a century becomes topical.

Aiming to clarify this matter, 8 distinctive weather stations were selected in all 8 municipalities of Kakheti, which are located in respective administrative centers. Sighnagi municipality is an exception. The observations at Sighnaghi weather station were terminated in 1977. Consequently, Sighnagi municipality was characterized by Tsnori weather station.

The database and methodology for climate change assessment

The present report assesses the trends of changes of temperature and rainfall, as well as of wind speed and relative humidity of air. The data collected in 1961 – 2010 were used for this purpose. Used database (1961 – 2010: temperature, rainfall, wind speed, relative humidity) is presented in electronic format (excel), which was developed as a result of processing materials of hydrometeorological network observations[2]. Data quality control and assurance procedure[3], implemented in compliance with the recommendations of the World Meteorological Organization, was used in the process of compiling the database.

For detecting change of climate parameters in the region, annual and seasonal values of following parameters were assessed:

[2] National Environmental Agency of the Ministry of Environment and Natural Resources Prorection

3 Guide to Climatological Practices WMO-No. 100

- Average air temperature;
- Average minimum and maximum of temperature (seasonal and annual average of daily maxima and minima);
- Absolute minimum and maximum of temperature (one number is selected from annual maxima of 25 year period);
- The average daily temperature amplitude (seasonal and annual average of the differences between daily maxima and minima);
- Total precipitation;
- Daily maximum of precipitation (intensity);
- Average and maximal speed of wind;
- Average relative humidity;
- Extreme climate indexes of temperature and rainfall;
- Drought Index (SPI, standardized precipitation index).

Aiming to increase reliability of obtained results, time series of mentioned parameters were checked for homogeneity[4], and changes were assessed with two methods: the trends were revealed for each parameters, for which statistical reliability was assessed (Mann Kendall method), medium values of two 25 year period (1961-1985 and 1986-2010) were also compared.

Since extreme values of climate parameters are more sensitive to climate change, than their average values, different climate characteristics (indexes) are used for climate change assessment, the methodology for their calculation is elaborated under IPCC recommendations[5]. Description of these indexes and values of their changes are given in Annex 1, Tables 1.1 – 1.2.

Extreme climate and evapotranspiration indexes[6] were calculated for selected weather stations (see Annex 1, Tables 1.1.-1.3.), and by means of them were identified the regularities of the changes of daily minimal and maximal air temperature and extreme values, frequency and intensity of precipitation, as well as rainfall deficit.

1.2.1. Akhmeta Municipality

As it was mentioned above, the territory of municipality could be divided in two zones. Lower zone climate could be characterized by the data of Akhmeta weather station, and highland zone – by Omalo weather station. However, as a result of closure of this station in 1991 since 1992 assessment of climate change became impossible in upper zone (Mtatusheti district).

Thus, the territory was described by Akhmeta weather station, which is located at 567 meters above the sea level. In city of Akhmeta climate is temperate humid, with hot summer and temperately cold winter. Based on the data available for 1928-1960, average annual temperature of this territory was +11.6 ^{0}C, average temperature of the coldest month (January) was +0.5 ^{0}C, while of the hottest period (July – August) - +22.4 ^{0}C, absolute minimum -23 ^{0}C, and absolute maximum +38 ^{0}C. Total of

[4] Albert M.G. Klein Tank, Francis W. Zwiers* and Xuebin Zhang, 2009: Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation. *Climate* Data and Monitoring. WCDMP-No. 72, WMO-TD No. 1500

[5] http://cccma.seos.uvic.ca/ETCCDI

[6] http://ulysses.atmos.colostate.edu/SPI.html

temperatures (+10^{0}C and above) was 3 655 ^{0}C. Average annual relative humidity compiled 69%. Sums of annual precipitations was 788mm, maximum monthly total of which as a rule came in May and compiled 115mm, while minimum – in December (34 mm). Average annual wind speed was 1.7m/sec. Western and North Western winds were prevailing on surrounding area.

Temperature -Analyses of changes of climate elements between the periods 1961-1985 and 1986-2010 in lower zone of Akhmeta municipality has shown the increase of mean annual temperature by 0.5 ^{0}C, and compared with the period of 1928-1960 by - 1.2 ^{0}C. Warming takes place in all seasons is being the highest in summer (+1.0 ^{0}C). In other seasons increases of temperature are nearly the same and are within 0.3-0.4 ^{0}C. Detected warming is sustainable and confirmed by the trends in summer and winter, as well as by average annual value. In 1961-2010 the rate of average temperature change made 0.26 ^{0}C/10. Absolute maximum is excessive in all seasons, except for winter. The increment is highest in summer (+3 ^{0}C), and in transition seasons is the same (+2 ^{0}C). Positive increases of absolute minima are highest in winter and summer (+4.6 and +2.3 ^{0}C respectively). Average maximum of temperature between two examined periods is significantly increased (+0.8 ^{0}C), while annual value of average minimum showed smaller increase (+0.4 ^{0}C). Average daily amplitude of temperature is increased in all seasons by 0.2-0.5 ^{0}C.

Precipitation. Between two mentioned periods annual total precipitation has reduced by 41mm or by 5%, and compared with period between 1928-1960, it has decreased in 62mm, which compiles 8% of the average of starting period. As for daily maximums of precipitation, reduction of their absolute values within the range of 8-15mm was identified in all seasons, except for winter, while in winter the increment in 10mm was identified.

Annual and seasonal values of relative **humidity of air** are not in fact changed between two periods and make 69% annually.

Average wind speed has increased in all seasons between the periods and average annual increase made 0.8m/sec.

In lower zone of Akhmeta municipality **winter** became relatively milder during last 25 years. The difference between two periods is about +0.5^{0}C for all average characteristics. Consequently, winter frost risk is reduced. The amount of precipitation is increased by 7%. In spring the picture of the change of temperature parameters is similar; however the value of increment is lower and varies within 0.2-0.4 ^{0}C. Seasonal sums of precipitation were also decreased insignificantly (-4%). Temperature is considerably increased (+1.0 ^{0}C) between two examined periods, both maxima (+1.4 ^{0}C) and minima are increased (+0.9 ^{0}C). Seasonal sums of precipitation has decreased by 18%, also the repetition of extreme 1 month (agricultural) draughts has increased twice. Finally summer in lower zone of Akhmeta became considerably hotter and relatively drier. Similar to other seasons, autumn became also warmer (+0.4 ^{0}C). Warming basically took place after the increase of maximal temperatures (+0.7 ^{0}C). Precipitation also increased insignificantly on this season (+6%), similarly to winter, which could increase, that could increase the risk of flash floods and mudflows for this season.

Thus, between the two discussed periods in lower zone of Akhmeta temperature increased the most in summer (+1.0 ^{0}C) and the least – in spring (+0.3 ^{0}C). Precipitation significantly reduced in summer (-18%), however insignificantly increased in autumn and winter (+6, +7%).

Duration of vegetation period for threshold temperature 8 ^{0}C has increased by 5 days between the examined periods and its average temperature got increased by 0.4 ^{0}C. Consequently sums of active temperatures were increased by 190 ^{0}C. In vegetation period total of precipitation on the average was reduced by 47mm. For threshold temperature of 10 ^{0}C the duration of vegetation period and its average temperature were increased by 4 days and 0.5 ^{0}C-; total of active temperatures has increased by 180 ^{0}C, and total of precipitation has grown by 53mm. Duration of the frost free periods was reduced by 4 days between the periods.

Reduction of the number of months without draughts was identified between the periods, which did not apply to 1 month agricultural draughts, frequency of which has increased twice.

Duration of the period with optimal temperature (16-25 ^{0}C) for bee keeping was reduced by 7 days in lower part of the municipality between there viewed periods. According to basic data the value of average relative humidity of air compiled 67% by this period.

1.2.2. Gurjaani Municipality

Territory of the municipality covers central part of Alazani Valley and low and medium mountain zone of Tsivi - Gombori Ridge, due to which it is not distinguished with diversity of climate zones. The territory is characterized by Gurjaani meteorological station, which is located at 415 m above the sea level. In city of Gurjaani the climate is temperate humid, with hot summer and moderately cold winter, with double maxima of precipitation in a year. Based on observations carried out before 1925-1960, average annual temperature of this territory was +12.4 ^{0}C, average of the coldest month (January) was 0.9 ^{0}C, and the hottest month (August) +23.6 ^{0}C, absolute minimum -22 ^{0}C, and absolute maximum +38 ^{0}C. The total of active temperatures (above +10 ^{0}C) was 3 924 ^{0}C. Average annual relative humidity of the air compiled 72%. Annual total of precipitation was 741mm, monthly total maximum of which as a rule fell in May and made 117mm, and minimum – in January (28 mm). Average annual wind speed was 1.7 m/sec. Western and South - Western winds were prevailing on surrounding area.

Temperature . The analyses of climate elements changes in two periods between 1961-1985 and 1986-2010 demonstrated that in Gurjaani municipality annual temperature has increased by 0.4 ^{0}C, and compared with 1925-1960 - by 0.7 ^{0}C. Warming is ongoing in all seasons, except spring, it is highest in summer (+0.6 ^{0}C), and in spring seasonal temperature has not changed. Revealed warming is sustainable and confirmed by the trends in summer and spring, as well as by the annual value. In 1961-2010 the rate of change of average annual temperature made 0.14 ^{0}C /10 years. Annual absolute maximum of temperature has increased in all seasons between the periods, with highest value in autumn (+2.1 ^{0}C). Absolute minima are significantly warmer in winter and summer (+3 ^{0}C). Average maximum of temperature between two examined periods has increased significantly (+0.5 ^{0}C), while annual value of average minimum was increased insignificantly (+0.1 ^{0}C). Annual daily amplitude of temperature has increased in all seasons up to 0.5 ^{0}C.

Precipitation – Total precipitation has decreased between two mentioned periods by 18mm or 2% and compared with the level existing in the period between 1925 and 1960 has increased by 4%. As for maxima of daily precipitation, their absolute values were increased by 6-24 mm for all seasons, except summer, in which the decrease by 54 mm took place.

Relative humidity of air in fact has not changed between the periods and remained within the range of 72%.

Average wind speed was reduced equally in all seasons between two periods by 0.3-0.4 m/sec.

Winter on the territory of Gurjaani municipality became relatively milder. Almost all temperature parameters are increased (warmer) by 0.3-0.4 ^{0}C, except average minimum, due to which freezing nights are more frequent and the risk of frost in winter is maintained. Seasonal totals of precipitation have increased by 9%. **In spring** picture of temperature alteration is different. On the background of constant average temperature between the periods, small increase of maxima (+0.2 ^{0}C) is compensated by cooler minima (-0.3 ^{0}C). Average daily amplitude of temperature has increased by 0.5 ^{0}C, due to which the threat of frosts is still maintained. Insignificant increase of precipitation (+3%) is followed by the reduction of average wind speed. **Summer** is the warmest compared with other seasons (+0.6 ^{0}C). Both maxima (+0.8 ^{0}C) and minima (+0.4 ^{0}C) have increased. Seasonal totals of precipitation are reduced significantly (average 20%). In summer one month agricultural moderate as well as severe and extreme droughts have increased. Recurrence of heat waves has also increased. Thus, summer in Gurjaani became considerably hotter and relatively drier. Autumn, similar to summer, became warmer, however relatively less (+0.4 ^{0}C). Absolute maximum is increased by +2.1 ^{0}C and absolute minimum is reduced by 0.4 ^{0}C. Seasonal totals of precipitation on the average have increased by 11%, which could be resulted by increase of the risk of flash floods and mudflows in this season.

Thus, between the two reviewed periods in Gurjaani municipality temperature has increased most of all in summer (+0.6 ^{0}C) and the least – in spring (+0.0 ^{0}C). Precipitation has significantly reduced in summer (-20%), while noticeably increased in autumn (+11%).

Duration of vegetation period for the threshold temperature12 ^{0}C has increased by 3 days, between the reviewed periods and its average temperature has increased by 0.4 ^{0}C. Consequently sums of active temperatures have increased as well. In vegetation period totals of precipitation on the average have reduced by 31 mm. Duration of frostless period between two examined periods in average was reduced by 7 days. The period of temperatures optimal for bee keeping (16-25 ^{0}C) was also reduced by 7 days, at the background of actually unchangeable relative humidity (average 68%).

As for extreme events, the increase of recurrence of one month agricultural draughts was identified; however the frequency of draughts for longer periods (3 – 6 months) was reduced.

1.2.3. Dedoplistskaro Municipality

The territory of municipality covers 4 climate zones, from semi-arid steppes (Iori Upland, heights 300 – 700 m above sea level) to moderately humid climate of Alazani Valley (heights 200 – 600 above sea level).

The territory is characterized by Dedoplistskaro weather station, located at 800 m above the sea level. In Dedoplistskaro town the climate is dry subtropical transitional to temperate subtropical, with hot summer and temperate cold winter. Based on the observations carried out in 1951-1960, average annual temperature of this territory was +10.1 ^{0}C, average for the coldest month (January) was - 1.5 ^{0}C, and for the hottest period (July – August) - +21.7 ^{0}C, absolute minimum -26^{0}C, and absolute maximum +35 ^{0}C. Total of active temperatures (above +10 ^{0}C) was 3 234 ^{0}C. Average annual relative humidity compiled 76%. Annual sum of precipitation was 585 mm, maximum of monthly totals of which usually came in May and compiled 102mm, and minimum – in January (20mm). Average annual wind speed was 2.1 m/sec. In the cold period of year basically western winds were prevailing on surrounding territory, while in warm period – north - eastern winds.

Temperature. The analyses of climate change between the periods 1961-1985 and 1986-2010 demonstrated that average annual temperature in Dedoplistskaro is increased by 0.7 ^{0}C, and compared with the period of 1951-1960- by 1.2 ^{0}C. Warming is ongoing in all seasons, it is highest in summer (+1.4 ^{0}C), and lowest in spring (+0.1 ^{0}C). In all the rest of the seasons the increase is 0.4-0.8 ^{0}C. Revealed warming is sustainable; it is confirmed by the trends in spring and summer as well as by average annual value. In the period between 1961 -2010 the rate of change of average temperature made 0.33 ^{0}C/10 in year. Absolute maximum of temperature has increased in all seasons. In winter and spring deviations do not exceed +1.0 ^{0}C; and in summer - autumn the increase is within the range of 2.0-3.0 ^{0}C. Absolute minimum has increased in all seasons by about 0.8-1.0 ^{0}C, except autumn where there is decrease in 1.0 ^{0}C .Annual value of average maximum has increased by +0.7 ^{0}C, and of minimum by +0.5 ^{0}C. Average daily amplitude of the temperature in all seasons has increased insignificantly and average increment made 0.2 ^{0}C.

Precipitation. Annual total precipitation has insignificantly decreased between the mentioned periods (5 mm, -1%), and compared with the level of the period of 1951-1960– is increased by 27mm, which amounts to 5% of basic average. Absolute values of daily precipitation are reduced by 25mm in summer and their maximum moved to spring (+34 mm).

Seasonal and annual values of relative **humidity of air**, have increased by 2-3% between the periods. Average speed of **wind** was reduced by 0.2-05 m/ in all seasons between the periods and annual average has dropped from 1.7 m/sec to 1.3 m/sec.

Winter on the territory of Dedoplistskaro municipality became milder. All temperature parameters are increased, especially absolute minimum, which has increased by almost 7 ^{0}C. Average maxima are increased by 0.3 ^{0}C, and minima – by +0.6 ^{0}C. Due to that the risk of winter frost was reduced. Precipitation sums have increase by 9%. In **spring** the pattern of temperature change is different. Average air temperature between two periods in fact is not changed (+0.1 ^{0}C). Insignificant increase of maximum (+0.1 ^{0}C) is covered by cooling of minimum (-0.2 ^{0}C). Absolute minimum is warmer by +4.0 ^{0}C, thus the risk of freezing is reduced. The quantity of precipitation is increased. In the second period in spring a case of extremely heavy precipitation (≥90 mm) was detected, which was not observed before. Average temperature of **summer** is significantly increased between the periods (+1.4 ^{0}C). Maxima (+1.7 ^{0}C) as well as minima (+1.0 ^{0}C) are increased significantly. Seasonal sums of precipitation are decreased by 22%, on the background of which frequency of one month agricultural draughts has increased 3 times and of 3 - months drought – 2 times. At the same time the recurrence of heat waves has increased. Thus, summer in Dedoplistskaro becomes considerably hotter and relatively drier. Similar to summer, **autumn** also became warmer, however maxima of temperature are increased less considerably (+0.8 ^{0}C). Maxima (+0.7 ^{0}C) and minima (+0.5 ^{0}C) of temperature are increased significantly. In contrast to summer, the quantity of precipitation has increased (+20%), which should be reflected positively on the productivity of winter pastures.

Hence, between the discussed two periods in Dedoplistskaro the temperature mostly has increased in summer (+1.4 ^{0}C), and the least - in spring (+0.1^{0}C). Precipitation has significantly reduced in summer (-22%), however significantly increased in autumn (+20%).

As for agroclimate characteristics, duration of vegetation period and other parameters were assessed for different threshold temperatures, which are related to production of different agricultural crops and availability of pastures on the territory of the municipality. For the marginal temperature 3 ^{0}C – the duration of vegetation period between there viewed periods has increased by 5 days. Consequently, the total of active temperatures has increased by 218 ^{0}C. In vegetation period the sums of precipitation were insignificantly reduced by 3mm. For threshold temperature 50C duration and mean temperature of vegetation period has increased by 3 days and 0.6 ^{0}C respectively, while the total of active temperatures has increased by 213 ^{0}C, and sums of precipitation were not changed. For marginal temperature 14 ^{0}C vegetation period and average temperature increased by 3 days and 0.9 ^{0}C respectively, total of active temperatures was increased by 260 ^{0}C, and precipitations remained unchanged. For threshold temperature 17 ^{0}C, vegetation period and its average temperature increased by 12 days and 0.9 ^{0}C respectively. The total of active temperatures has increased by 355^{0}C, and precipitation was reduced by 7mm; between two examined periods the duration of frost free period was reduced by 2 days.

As for extreme events, agricultural (1 - and 3 – month duration) moderate as well as severe and extreme draughts became more frequent, which is harmful for agricultural sector and requires implementation of respective adaptation measures. Increase of the frequency of extreme precipitation events (≥50 mm) was also revealed (0.1 day per year), however on territory of Dedoplistskaro municipality, which does not belong to flashflood and landslide risk zone, this should not have destructive result.

1.2.4. Telavi Municipality

In terms of climate the territory of municipality belongs to temperate subtropical continental climate district, however on its territory different climate zones are identified on different elevations (Fig 1.1).

The territory is characterized by Telavi meteorological station, which is located at 568 meters above the sea level. In city of Telavi climate is temperate humid, with hot summer and moderately cold winter. Based on the observations carried out in 1932 – 1960, annual average temperature of this territory was +11.8 ^{0}C, average of the coldest month (January) was +0.5 ^{0}C, and of the hottest month (August) +23.0 ^{0}C, absolute minimum -23 ^{0}C, and absolute maximum +38 ^{0}C. Total of active temperatures (above +10 ^{0}C) was 3727 ^{0}C. Average relative humidity of air compiled 69%. Annual total of precipitations was 770 mm, maximum of monthly total of which usually came in May and compiled 134 mm, and minimum – in January (26mm). Average annual wind speed was 2.4 m/sec. South - western and western winds were basically prevailing on surrounding territory.

Temperature. According to the analyses of changes of climate elements between the periods 1961-1985 and 1986-2010, in Telavi municipality average annual temperature has increased by +0.4 ^{0}C, and compared to the period of 1932-1960 – by 0.7 ^{0}C. Warming is ongoing in all seasons, it is highest in summer (+0.8 ^{0}C), the lowest–in spring (+0.1^{0}C). Revealed warming is sustainable and confirmed by the trends in summer and autumn as well as according to average annual values. In 1961-2010 the rate of the change of average temperature made 0.19^{0}C/10 years. Absolute maximum of temperature has increased in all seasons, except winter. Increments are equal and in summer – autumn season reach +2.2 ^{0}C. Absolute minima in winter and summer are significantly warmer (+3, +4 ^{0}C). Average maximum between two reviewed periods significantly increased (+0.6 ^{0}C), while annual value of average minimum increased relatively less (+0.2 ^{0}C). Average daily amplitude of temperature has increased in all seasons within the range of 0.3-0.5 ^{0}C.

Precipitation. Between two mentioned periods, in Telavi annual total precipitation were reduced by 91mm, which makes 3% of the first period. Precipitation also insignificantly decreased (-1%), compared with average in 1932-1960. As for maxima of daily precipitation, in all seasons except autumn, their absolute values were decreased within the limits of 3-15mm, and in autumn – increased by 42 mm.

Annual and seasonal values of air relative **humidity a**ctually did not change two periods and were ranking within 70%.

Between the periods, average speed of **wind** has decreased equally in all seasons and with annual average, by 0.6-0.7 m/sec.

On the territory of Telavi municipality **winter** became relatively milder. Almost all temperature parameters are increased (warmer), the most of all maximum (on the average by +5.0 ^{0}C). Average minima are not changed in this season, which means that there is still risk of winter frost. Seasonal totals of precipitation have increased in value (+6%). The picture of change of temperature in **spring** is similar to winter, however the nature of change is less contrasting and does not exceed +0.1 ^{0}C. Average daily amplitude of temperature is increased by 1.9 ^{0}C, which caused the increase of the frost risks. On the background of insignificant increase of precipitations (+2%) average speed of wind is reduced. Summer is different of other seasons with significant increase of average temperature (+0.8 ^{0}C). Maxima (+1.1 ^{0}C) as well as minima (+0.6 ^{0}C) are significantly increased. Seasonal totals of precipitation reduced by 17%. Besides, the recurrence of extreme one month agricultural draughts increased 3 times. Thus, **summer** on the territory of Telavi municipality became significantly hotter and relatively drier. Similar to other seasons, in Telavi **autumn** also became warmer (+0.3 ^{0}C), which basically was conditioned by the increase of maximal temperature (+0.7 ^{0}C). In contrast to summer, precipitations on this season were increased significantly (+12%). At the same time, number of days with heavy precipitation (≥50 mm) has increased 3 fold during the periods, which points to the increase of the risks of flash floods and landslides on this season.

Thus, between 2 examined periods, on the territory of Telavi municipality temperature the most increased in summer (+0.8 ^{0}C). The precipitation has significantly decreased in summer (-17%), and significantly increased in autumn (+12%).

As for agro-climatic characteristics, duration of vegetation period for threshold temperature 12 ^{0}C between two reviewed periods has increased by 2 days and its average temperature has risen by 0.4 ^{0}C. Consequently, the sum of active temperatures was increased. In the vegetation period total of precipitation was increased by 115 ^{0}C. In vegetation period total precipitation has in average decreased by 46mm. For marginal temperature 13 ^{0}C duration of vegetation period and its temperature were reduced by 1 day and 0.5 ^{0}C respectively. Total of active temperatures increased by 101 ^{0}C and total precipitation decreased by 54 mm. Duration of frost free period has decreased in average by 9 days, between the periods.

As for extreme events, between the periods the increase of the number of days with heavy precipitation (≥50mm) per year by 0.1 day and 3 times increase of one - month agricultural draughts were revealed.

1.2.5. Lagodekhi Municipality

The territory of Lagodekhi municipality basically covers temperate humid subtropical continental climate zone, which form the north on the southern slopes of Greater Caucasus is bordering with relatively narrow zones characteristic for mountain and highland areas. On mentioned territory the elevations are increasing from 200 above the sea level (Alazani banks) to 3 400 meters (Greater Caucasus watershed).

The territory is characterized by Lagodekhi weather station, which is located at 435 meters from sea level. In town of Lagodekhi the climate is temperate humid, with hot summer and temperate cold winter. Based on observations carried out in 1930-1960, average temperature at this territory was +12.6 ^{0}C. Average of the coldest month (January) was +0.9 ^{0}C, and of the hottest period (July – August) - +24.1 ^{0}C. Absolute minimum was -23 ^{0}C, and absolute maximum +38 ^{0}C. Total of active temperatures (above +10 ^{0}C) was 3 975 ^{0}C. Average annual relative humidity was equal to 72%, annual total of precipitation was 1 004 mm, maximum of monthly totals of which usually fell in May and made 143 mm, and the minimum – in January (36mm). Average annual wind speed was 1.1 m/. North eastern and northern winds were basically prevailing on surrounding territory.

Temperature. The analyses of changes of climate elements between the periods 1961-1985 and 1986-2010 demonstrated that average annual temperature on the territory of Lagodekhi municipality has increased by 0.4 ^{0}C, and compared to 1930-1960 period– by 0.9 ^{0}C. Warming, except spring, is ongoing in all seasons and is highest in summer (+0.6 ^{0}C), and in spring insignificant cooling takes place (+0.1 ^{0}C). Revealed warming is sustainable and confirmed by the trends in summer and autumn, as well as according to average annual value. In the period of 1961-2010 the rate of change of average annual temperature made 0.18 ^{0}C/10 yr. Absolute maximum of temperature has increased only in autumn (+3.5 ^{0}C), and the highest increment of absolute minimum is in summer (+5.6 ^{0}C). Annual value of average maxima is almost unchanged (+0.1 ^{0}C), while the increment of minima made +0.9 ^{0}C.

As a result of mentioned, average daily amplitude of temperature in all seasons has decreased by 0.6-1.0 ^{0}C.

Precipitation. Annual total precipitation has increased by 81 mm (+8%) between two mentioned periods, and compared with average of 1930 – 1960 period by 56mm, which equals to 6% of basic value. Absolute values of daily maxima changed within ±5mm in transitional seasons, however in summer this value was significantly decreased (-18 mm). Precipitation has increased in all seasons, maximal increase was indicated in spring (32 mm, +11%).

According to restored data, relative **humidity** of air has increased within 2 - 4%, and average wind speed by 0.5-0.8 m/.

Winter in studied zone of Lagodekhi became significantly milder during last 25 years. Average temperature of the season has increased by 0.4 ^{0}C. Particularly increased the absolute minimum, which became warmer almost by 5 ^{0}C. Average minimum has increased by 0.9 ^{0}C. Consequently the risk of winter frosts is reduced. Seasonal precipitation increased by 13%. In **spring** average temperature between two periods is almost unchanged. Decrease of maxima (-0.4 ^{0}C) is leveled by the warming of minima at the same order, due to which winter frosts are reduced. Seasonal totals of precipitation are significantly increased (+11%). **Summer** average temperature has increased by 0.6 ^{0}C between two periods. On the background of relatively small increase of maxima (+0.4 ^{0}C) average minimum is dramatically increased (+1.3 ^{0}C). Unlike other municipalities in Kakheti, in Lagodekhi summer precipitation has increased, which preconditioned the reduction of draught recurrence of all time scales, the exception being just extreme one month agricultural draughts, frequency of which between mentioned periods has increased by 40%. Thus, winter in Lagodekhi became significantly hotter with relatively more precipitation. Recurrence of hot waves has also increased. Like other seasons **autumn** also became warmer (+0.4 ^{0}C), which basically was due to the increase of minima by 1.0^{0}C. Absolute maximum of temperature has increased by 3.5^{0}C and absolute minimum – by +1.2 ^{0}C, which reduces the risk of autumn frosts. Seasonal precipitation also increased by 6%. Prolonged rainfalls increase the risk of flash floods and mudflows in the season.

Thus, between two reviewed periods in Lagodekhi municipality temperature most of all increased in summer (+0.6 ^{0}C), spring became insignificantly cooler (-0.1 ^{0}C). Precipitation increased in all seasons, especially in spring (+11%). Recurrence of the number of days with heavy precipitation (≥50 mm) increased by 20% in a year, that increases flash flood risks in highland area of municipality.

As for agroclimate characteristics, duration of vegetation period for threshold temperature 10 ^{0}C, between two periods has increased by 4 days and its average temperature was risen by 0.2 ^{0}C. Consequently, the total of active temperatures has increased by 106 ^{0}C. In vegetation period sums of precipitation increased by 65 mm. For threshold temperature 12 ^{0}C, duration of vegetation period and its average temperature were increased by 2 days and +0.3 ^{0}C respectively, total of active temperatures has grown by 89 ^{0}C and sums of precipitation increased by 64mm. For marginal temperature 15 ^{0}C, duration of vegetation period and average temperature is increased by 3 days and +0.4 ^{0}C, total of average temperatures – by 63 ^{0}C and precipitation – by 26 mm. The period without frosts has increased by 7 days.

In mentioned zone of the municipality, between two periods the duration of period optimal for bee keeping (16-25 ^{0}C) has increased by 2 days, relative humidity of air also increased by 2% in this zone, which on the average in this period made 60%.

As for extreme events, in conditions of reduction of recurrence of different draughts, the frequency of one month extreme draughts has increased by 40%, recurrence of the days with heavy precipitation (≥50 mm) has increased by 20%.

Part of above mentioned data on changes of average air temperature, humidity, totals of precipitation and different extreme indexes between two selected periods are provided in the Table 2, which demonstrates that sustainable trends of changes are mainly revealed for indexes of average temperature, hot days SU25 and tropical nights TR20, total differences comply with 25 years period and for calculating average for 1 season/year given values should be divided by 25.

1.2.6. Sagarejo Municipality

Territory of the municipality is characterized by Sagarejo weather station, located at 802 meters above the sea level. In the town of Sagarejo climate is temperate subtropical, with cold winter and hot summer, with two maxima of precipitation a year. Based on the observations carried out in 1923-1960, average annual temperature of this territory was +11.0 ^{0}C, average temperature of the coldest month (January) was -0.1 ^{0}C, average of the hottest month (July) -+22.0 ^{0}C, absolute minimum -24 ^{0}C, and absolute maximum +38 ^{0}C. Total of active temperatures (above +10 ^{0}C) was 3 423 ^{0}C. Average annual relative humidity of air made 69%. Annual sum of precipitation was 768 mm, average monthly maximum of which usually fell in May and equaled to 123 mm, and minimum – in January (28 mm). Average annual wind speed was 2.2 m/sec. north – western and northern winds were usually prevailing on surrounding territory.

Temperature. The analyses of the changes of climate elements between the periods 1961-1985 and 1986-2010 demonstrated that average annual temperature in Sagarejo municipality has increased by +0.5 ^{0}C, and compared with the period of 1923-1960 – by +1.7 ^{0}C. Warming is ongoing in all seasons, being the highest in summer (+0.9 ^{0}C). In other seasons the increments of temperature are nearly equal and are within +0.5^{0}C. Parameters are relatively less changed in spring (+0.3 ^{0}C). Revealed warming is sustainable and confirmed by the trends in summer and autumn, also according to average annual minima. In 1961-2010 the rate of change of average temperature is 0.2 ^{0}C/10yr. Absolute maximum of temperature has changed insignificantly, however absolute minima became significantly warmer (by 2-5 ^{0}C). Average maximum of temperature is slightly increased between two reviewed periods (+0.2 ^{0}C), while the value of average annual minimum is increased significantly (+0.6 ^{0}C). Average daily amplitude of temperature is reduced in all seasons within 0.2-0.5 ^{0}C.

Precipitation. In mentioned two periods, annual precipitation has decreased by 82 mm, or by 10% and almost got back to the level existed in 1923 – 1960.

Annual and seasonal values of relative **humidity** of air are decreased by 2-3%, and annual total precipitation is reduced by 82mm or 10%. As for maxima of daily precipitation, the cases of excess of their absolute values were recorded in all seasons,

Average speed of **wind** is reduced equally by 0.4-0.5 m/. In all seasons between two periods, maximal speeds of wind were also reduced.

On the territory of Sagarejo municipality **winter** became relatively milder during last 25 years. Absolute minimum got warmer by 5 ^{0}C. Temperature in **spring** has changed similar to winter; however the warming of minima is relatively small. Average increments of temperature parameters are approximately equal and do not exceed 0.3 ^{0}C. In the second period a case of 90 mm daily precipitation was recorded, which was not observed in the first period. Average temperature of summer has significantly increased between two reviewed periods (+0.9 ^{0}C), which basically is preconditioned by the increase of night temperatures. Seasonal total of precipitation is reduced by 25%, and the draught periods also became more frequent. Finally, **summer** in Sagarejo zone became significantly hotter and relatively drier. Similar to other seasons **autumn** also became warmer. Average temperature has increased by 0.5 ^{0}C. Warming in this season is caused just by the increase of minimum, and average maximum has not changed between two periods. Autumn is the only season when amount of precipitation increased. Increment between two periods compiled 9%, which to some extent increases the risk of flash floods and mudflows on small rivers existing on this territory.

The analyses of summary data demonstrated that between two examined periods in Sagarejo the temperature has increased most of all in summer (+0.9 ^{0}C), and least of all spring (+0.3 ^{0}C). The most precipitation mostly grew in autumn (increment 16 mm), and most of all decreased in summer (-68mm). As for agroclimate characteristics, the duration of vegetation period for the threshold temperature grows 10 ^{0}C has increased by 7 days and its average temperature was increased by 0.4 ^{0}C. Consequently, the total of active temperatures has increased by 186 ^{0}C. In vegetation period sums of precipitation decreased by 68 mm, and the duration of frost free period was reduced by 6 days. This incompliance of warming patterns between two periods is associated with anomalously cold November in 1993, when 18 freezing nights and 7 freezing days were recorded. This anomaly caused respective reduction of average duration of non-freezing period in the second period. For threshold temperature 150 ^{0}C duration of vegetation period and its average temperature have increased by 6 days and 0.5 ^{0}C. Total of active temperatures increased by 193 ^{0}C, and total precipitation were reduced by 58 mm.

Between the periods all types of draught became more frequent, especially in summer. In particular 2 times and more has increased recurrence of one month extreme (agricultural) draughts.

1.2.7. Sighnagi Municipality

The municipality covers fairly extensive area, from the River Iori to the River Alazani and includes 4 climate zones (see Fig 1.1). Southern part of the territory belongs to the Iori upland covered by arid steppes, with heights 300-700 m above the sea level. Relatively small area of central part covers the slopes of Tsivi - Gombori Ridge at 800-1 000 m, where the town of Sighnagi is located, and eastern part is spread on Alazani Plain at 200-500 m. Taking into consideration that the most of the municipality belongs to plains and foothills, for its description weather station Tsnori was selected representative for whole area, having full spectrum of observations, located at 293 m a.s.l. In the town of Tsnori the climate is temperate humid, with hot summer and moderately cold winter, with two maxima of precipitation per year. Based on the observations carried out in 1950-1960, average annual temperature on this territory was +12.6 ^{0}C, average of the coldest month (January) was +0.1 ^{0}C, of the hottest month (July) -+24.4 ^{0}C, absolute minimum -25 ^{0}C, and absolute maximum +40 ^{0}C. Total of active temperatures (above +10 ^{0}C) was 4 100 ^{0}C. Average annual relative humidity compiled 76%. Total of precipitations compiled 568 mm, maximum of monthly totals of which, usually came in May and made 99 mm, and minimum – in December – January (22 mm). Average speed of wind was 1.0 m/. North Westerly winds were basically prevailing on surrounding area.

According to the analyses of the variability of climate elements, **temperature** between the periods of 1961 1985 and 1986 2010 in the lower zone of Sighnagi municipality increased by 0.5 ^{0}C and in comparison with the period from 1950 to 1960 - by 0.8 ^{0}C. Warming is characterized by an increment of 0.6-0.7 ^{0}C during all seasons, except for spring, which became slightly cooler (-0.2 ^{0}C). The observed warming is stable and is confirmed by the trend in summer, autumn and winter, as well as with the average annual value. In the period between1961and 2010, the rate of average annual temperature change reached 0.23 ^{0}C/10 yr. The absolute maximum of temperature increased in each season, except for spring. The increment is the largest in summer (+3.4 ^{0}C). The absolute minima also became significantly warmer (3-4 ^{0}C). The average maximum, except for spring, has increased significantly during each season (0.7-0.9 ^{0}C), while the average minimum increments vary between +0.5 ^{0}C and 0.3 ^{0}C. The average daily temperature amplitude in all seasons between these two periods increased within the range of 0.2-0.5 ^{0}C.

Precipitation. The total annual precipitation decreased insignificantly between the two periods (5 mm, -1%) and in comparison to the level of the period from 1950 to 1960 increased by 27 mm (+5%). As for the maximum daily precipitation, its absolute values lowered by 9-11 mm in winter and spring and increased by 4-9 mm in summer and autumn.

Relative air humidity, the average annual value of which for the period of 1950-1960 was 76%, remained virtually unchanged during the last two periods.

The average **wind** speed between the periods in all seasons has reduced by 0.1-0.2m/ and the average annual velocity has also decreased by 1.0 m/s-0.8 m/s.

In the lower zone of Sighnagi municipality, **winter** has become significantly milder for the last 25 years. The difference between the two periods in regards to the average temperature is nearly equal and varies from+0.6 ^{0}C to +0.8 ^{0}C. Consequently, the risk of winter frosts is reduced. The amount of precipitation has increased by 14%. The pattern of temperature change in **spring** is different from other seasons. The average temperature between the two periods decreased (-0.2 ^{0}C), which is determined by lowering of the minima (-0.3 ^{0}C). As a result, the risk of spring night frosts in this zone remains. The sums of seasonal precipitation remained practically unchanged and were preserved at the 200 mm level. The average **summer** temperature between the two periods has increased by +0.6

^{0}C. Both the maxima (+0.9 ^{0}C), and the minima (+0.5 ^{0}C) have increased. The sum of the seasonal precipitation decreased by 15%, although the daily maximum of precipitation increased in the second period (+9 mm) and the number of days with heavy precipitation (≥50mm) increased (0.1 per year). Amid virtually unchanged extreme droughts frequency of severe month-long drought nearly doubled. Recurrence of heat waves also increased. Thus, summer became evidently hot and relatively dry. Autumn has become warmer in this zone of Sighnagi (+0.7 ^{0}C). Both the average maxima (+0.7 ^{0}C), and the minima (+0.6) were increased. Precipitation at this season, like in winter, significantly increased (+11%). The number of days with heavy precipitation also increased or the **autumn** became considerably warmer and relatively more rainy.

Consequently, between the two abovementioned periods, fall and winter became the warmest in the lower zone of Sighnagi municipality (+0.7 ^{0}C), while spring became cooler (-0.2 ^{0}C). Precipitation significantly decreased in summer (-15%), but increased in autumn and winter (+11, +14%, respectively).From agroclimate characteristics, the duration of the vegetation period for the threshold temperature of 5 ^{0}C between the two periods increased by 4 days and its average temperature grew up by 0.2 ^{0}C. Consequently, the sum of active temperatures increased by 126 ^{0}C. The sum of the precipitation during the vegetation period decreased by an average of 21 mm. Thus, the length of the vegetation period for the threshold temperature of 10 ^{0}C and its average temperature again increased as well by 4 days and 0.2 ^{0}C. The sum of active temperatures has risen by 118 ^{0}C, while the amount of precipitation decreased by 22 mm. The length of frost-free periods between the periods increased by 2 days.

Between the reviewed spaces of time, the decrease in the number of the drought months of all time scales was revealed with the exception of just one month-long extreme agricultural draughts, the repetition of which almost doubled.

The number of extreme droughts of the similar durations also increased. In addition, the increase in the number of days with heavy precipitation (≥ 50 mm) to some extent demonstrates that the mudflow risk in Sighnagi municipality increased. The central part of Sighnagi municipality belongs to the very high-risk mudslide hazard zone.

1.2.8. Kvareli Municipality

The vertical zoning of the climate in Kvareli municipality is very clearly demonstrated. According to the Fig. 1.1, it includes 4 climate zones, the height of which varies within 300 m- 3 100 m above the sea level. The territory is described by Kvareli weather station, which is located at an altitude of 449 meters above the sea level. In Kvareli town, the climate is temperate humid with hot summer and mild winter.

Based on observations carried out in 1936 1960, the average annual temperature in this area was +12.5 ^{0}C, the coldest month (January) average was +1.0 ^{0}C, the hottest month (July - August) average was +23.6 ^{0}C, the absolute minimum was -23 ^{0}C, while the absolute maximum was +38^{0}C.The sum of active temperatures (+10 ^{0}C and above) was 3 960 ^{0}C. The average annual relative humidity of air was 72%, the annual total precipitation 991 mm, the maximum monthly sum of which fell usually in May and equaled to 172 mm and the minimum - in January (34 mm). The average annual wind speed equaled to 1.2 m/. Mainly northern direction was prevailing in the surrounding areas.

The analyses of the variation of climate elements between the periods of 1961 1985 and 1986 2010 indicated that the annual average **temperature** in the lower zone of Kvareli municipality increased by 0.5 ^{0}C and by 0.7 ^{0}C in comparison with the period from 1936 to 1960. Warming is prevalent in all seasons, but reaches the maximum in summer (+0.8 ^{0}C) and is the lowest in spring (+0.2 ^{0}C). The observed warming is stable and is confirmed by the trend in summer and autumn, as well as with the average annual value. In the period from 1961 to 2010, the rate of average annual temperature change reached 0.25 ^{0}C/10yr. The absolute maximum of temperature increased every season, except for winter. The increment is the largest in autumn (3-4 ^{0}C). The absolute minima, except for autumn, also became significantly warmer in the range of 2.0-4.5 ^{0}C. The average maximum temperature between the two reviewed periods increased significantly (+0.6 ^{0}C), while the increment of average annual minimum appeared smaller (+0.3 ^{0}C).The average daily temperature amplitude in all seasons between these two periods increased within the range of 0.2-0.5 ^{0}C.

Precipitation. The total annual precipitation decreased insignificantly between the two periods (5 mm, -1%) and in comparison to the level of the period from 1936 to 1960 increased by 30 mm (+5%). As for the maximum daily precipitation, its absolute value increased during all seasons, except for spring, the increase in the absolute values was maximum in spring (+15 mm), but were decreased in summer by 12 mm.

Relative air humidity, the average annual value of which for the period of 1936-1960 was 72%,during the last 25 years increased by 4-6 %.

The average **wind** speed between the two periods is reduced equally in all seasons by 0.3-0.4 m/s.

In the lower zone of Sighnagi municipality, **winter** has become significantly milder for the last 25 years. The difference between the two periods in regards to the average temperature is approximately in the range of +0.5 ^{0}C. Consequently, the risk of winter frosts is reduced. The amount of precipitation has increased by 7%. The pattern of temperature change in **spring** is analogous, although the increase is lower and changes are in the range of 0.2-0.4 ^{0}C. The exception is the minima, which between the two periods became cooler (-0.2 ^{0}C) and keeps the danger of frosts. The total of the seasonal precipitations decreased slightly (-3%).The average **summer** temperature between the two periods has significantly increased by +0.8 ^{0}C. Both the maxima (+1.1 ^{0}C), and the minima (+0.6 ^{0}C) increased significantly. The sum of the seasonal precipitation decreased by 7%, although the daily maximum precipitation or their intensity increased. Along with the decrease of precipitation, the recurrence of droughts of all time scales doubled, that endangers the agricultural production. The repetitions of heat waves also increased. Thus, summer in the lower zone of Kvareli municipality became noticeably hot and relatively dry. Similar to other seasons, **autumn** in Kvareli also became warmer (+0.5 ^{0}C). Warming mainly occurred as a result of the maximum temperature rise (+0.5 ^{0}C). Precipitation in this season in contrast with summer increased slightly (+4%), which in case of heavy precipitation ($\geq$ 50 mm) may cause the risk of floods and landslides at the season. Consequently, between the two abovementioned periods, in the lower zone of Kvareli municipality, summer became the most of all (+0.8 ^{0}C), while spring became least of all warmer (+0.2 ^{0}C). Precipitation significantly decreased in summer (-7%), but increased slightly in autumn and winter (+4, +7%, respectively).

From agroclimate characteristics, the duration of the vegetation period for the threshold temperature of 10 ^{0}C between the two periods increased by 4 days and its average temperature increased by 0.3 ^{0}C.

Consequently, the total of active temperatures increased by 152 ^{0}C. The total of the precipitation during the vegetation period decreased by an average of 11 mm. The length of the vegetation period for the threshold temperature of 15 ^{0}C and its average temperature increased by 1 day and 0.5 ^{0}C. The sum of active temperatures increased by 112 ^{0}C, while the sums of precipitation decreased by 22 mm. The length of frost-free span between the periods has increased by one day. Between the reviewed periods, the sharp increase of 1 month-long all-type agricultural draughts, among them of extreme severity was revealed.

The number of days with heavy precipitation (≥ 50 mm) decreased slightly (by 0.2 day annually), although the increase of indices related to daily maxima demonstrate that in this municipality, the highland part of which belongs to the very high-risk mudslide hazard zone, the risk of the given phenomenon remains.

1.2.9. General Description of Weather Stations in Kakheti Region

The data discussed above for the periods of 1961-1985 and 1986-2010are presented in Tables 1.2 and 1.3 in the form of the average values of climate indices of Kakheti region.

Table 2.1. Average values of climate indices in 1961-1985 (I) According to the data of 8 weather stations of Kakheti [7]

Climate indexes		T	FD0	ID0	SU30	TR20	P	Rx1day	Rx5day	R50	R90	CDD	CWD
Winter	Akhmeta	2.4	49.6	5.8	_	_	97.6	25.7	81.3	_	_	_	_
	Gurjaani	2.5	45.3	6.0	_	_	97.8	32.9	75.4	_	_	_	_
	Dedoplistskaro	0.6	67.7	11.6	_	_	75.9	28.2	56.0	_	_	_	_
	Telavi	2.1	53.2	7.4	_	_	88.9	43.6	82.4	_	_	_	_
	Lagodekhi	2.8	45.6	4.8	_	_	123.4	43.0	95.2	_	_	_	_
	Sagarejo	1.5	58.5	9.9	_	_	102.8	25.3	59.4	_	_	_	_
	Kvareli	2.6	50.1	5.1	_	_	121.6	40.5	91.5	_	_	_	_
	Tsnori	1.9	61.6	5.0	_	_	78.6	39.9	71.3	_	_	_	_
Spring	Akhmeta	11.7	6.4	0.2	0.1	_	240.5	62.6	107.0	0.1	_	_	_
	Gurjaani	12.3	6.0	0.2	0.5	_	253.3	69.0	102.5	0.2	_	_	_
	Dedoplistskaro	9.8	15.6	1.1	_	_	191.6	59.3	84.4	0.04	_	_	_
	Telavi	11.6	7.8	0.5	0.4	_	244.5	61.5	97.1	0.2	_	_	_
	Lagodekhi	12.7	5.3	0.1	1.0	_	300.1	87.9	118.6	0.3	_	_	_
	Sagarejo	10.3	11.5	1.0	0.3	_	264.7	82.0	110.9	0.2	_	_	_

[7]Names of extreme parameters are explained in the Annex 1

	Kvareli	12.2	6.2	0.2	0.6	_	306.2	70.5	104.6	0.3	_	_	_
	Tsnori	12.8	8.8	0.1	2.0	_	200.5	65.1	122.2	0.1	_	_	_
Summer	Akhmeta	21.9	_	_	25.8	12.1	261.2	79.2	101.3	0.4	_	_	_
	Gurjaani	22.7	_	_	35.2	14.6	259.3	123.0	211.4	0.6	0.04	_	_
	Dedoplistskaro	20.7	_	_	16.1	3.4	211.6	96.6	168.0	0.4	0.04	_	_
	Telavi	21.9	_	_	25.5	12.2	282.2	100.0	115.0	0.6	0.04	_	_
	Lagodekhi	23.2	_	_	43.0	18.0	298.7	131.6	223.1	0.8	0.2	_	_
	Sagarejo	20.8	_	_	21.6	4.9	265.7	80.2	144.4	0.6	_	_	_
	Kvareli	22.6	_	_	37.3	9.8	311.3	130.6	160.5	0.7	0.1	_	_
	Tsnori	23.5	_	_	54.4	13.6	188.5	61.0	121.5	0.3	_	_	_
Autumn	Akhmeta	13.2	2.6	_	2.0	0.2	167.1	96.8	110.2	0.2	0.04	_	_
	Gurjaani	13.4	1.7	_	3.0	0.2	181.4	59.1	98.8	0.1	_	_	_
	Dedoplistskaro	11.4	7.3	0.1	0.8	_	127.9	55.2	78.9	0.04	_	_	_
	Telavi	12.9	2.9	_	1.6	0.1	163.6	66.9	100.0	0.1	_	_	_
	Lagodekhi	13.9	2.5	_	3.8	0.2	257.2	81.9	177.4	0.6	_	_	_
	Sagarejo	12.0	4.6	_	1.3	_	175.6	54.9	135.7	0.1	_	_	_
	Kvareli	13.5	2.9	_	3.4	0.2	237.1	87.5	170.2	0.8	_	_	_
	Tsnori	13.5	9.3	_	6.4	0.4	132.6	49.9	85.1	_	_	_	_
Annual	Akhmeta	12.3	58.6	5.9	27.9	12.3	767.2	96.8	110.2	0.7	0.04	29.9	5.8
	Gurjaani	12.7	53.0	6.0	38.7	14.8	792.1	123.0	211.4	0.9	0.04	28.9	7.0
	Dedoplistskaro	10.6	90.8	12.6	17.0	3.4	607.1	96.6	168.0	0.4	0.04	29.8	5.6
	Telavi	12.1	64.2	7.7	27.5	12.3	781.0	100.0	115.0	0.9	0.04	30.5	5.4
	Lagodekhi	13.1	53.6	4.8	47.8	18.2	979.6	131.6	223.1	1.7	0.2	26.2	6.5
	Sagarejo	11.2	74.6	10.6	23.2	4.9	808.9	82.0	144.4	0.9	_	28.9	7.0
	Kvareli	12.7	59.2	5.1	41.3	10.0	978.1	130.6	170.2	1.8	0.1	26.3	7.0
	Tsnori	12.9	79.9	5.0	62.8	14.0	600.2	65.1	122.2	0.4	_	31.2	5.2

Table 2.2 Average values of climate indices in 1986-2010 (II) according to the data of 8 weather stations of Kakheti

Climate index		T	FD0	ID0	SU30	TR20	P	Rx1day	Rx5day	R50	R90	CDD	CWD
Winter	Akhmeta	2.8	48.7	2.7	_	_	104.6	35.6	66.1	_	_	_	_
	Gurjaani	2.8	47.9	3.5	_	_	106.5	39.0	62.4	_	_	_	_
	Dedoplistskaro	1.0	65.8	10.6	_	_	83.1	35.0	61.6	_	_	_	_
	Telavi	2.4	54.0	4.2	_	_	93.8	41.2	80.0	_	_	_	_
	Lagodekhi	3.2	39.5	2.9	_	_	139.0	45.2	70.5	_	_	_	_
	Sagarejo	1.9	55.7	7.3	_	_	93.9	41.5	73.1	_	_	_	_
	Kvareli	3.1	47.0	1.8	_	_	130.6	50.4	78.7	0.04	_	_	_
	Tsnori	2.6	58.9	2.2	_	_	89.7	28.5	52.1	_	_	_	_
Spring	Akhmeta	12.0	5.5	_	0.7	_	231.0	47.3	79.2	_	_	_	_
	Gurjaani	12.3	6.1	_	0.7	_	261.6	92.7	134.7	0.2	0.04	_	_
	Dedoplistskaro	9.9	13.5	0.3	0.2	_	211.6	93.2	100.7	0.1	0.04	_	_
	Telavi	11.7	7.2	0.1	0.6	_	250.6	58.1	97.2	0.2	_	_	_
	Lagodekhi	12.6	3.6	_	0.9	0.1	331.8	82.7	138.0	0.4	_	_	_
	Sagarejo	10.6	10.0	0.2	0.3	_	244.5	103.9	184.6	0.2	0.04	_	_

	Kvareli	12.4	5.7	_	0.9	_	296.8	84.9	122.9	0.2	_	_	_
	Tsnori	12.6	8.6	_	2.6	_	198.9	56.0	104.7	0.04	_	_	_
Summer	Akhmeta	22.9	_	_	39.2	20.0	213.4	70.7	123.8	0.2	_	_	_
	Gurjaani	23.3	_	_	43.6	18.1	206.5	68.5	123.2	0.3	_	_	_
	Dedoplistskaro	22.1	_	_	31.1	7.8	165.6	71.6	136.9	0.4	_	_	_
	Telavi	22.7	_	_	35.9	17.0	232.9	85.4	145.6	0.4	_	_	_
	Lagodekhi	23.8	_	_	45.2	33.2	318.5	114.0	288.0	0.8	0.04	_	_
	Sagarejo	21.7	_	_	24.4	9.3	198.1	88.2	108.7	0.3	_	_	_
	Kvareli	23.4	_	_	47.2	15.6	289.6	118.9	220.6	0.8	0.04	_	_
	Tsnori	24.1	_	_	61.2	20.2	159.9	70.0	113.7	0.3	_	_	_
Autumn	Akhmeta	13.6	2.9	_	4.0	0.8	177.3	89.0	106.3	0.2	_	_	_
	Gurjaani	13.8	2.9	_	4.3	0.4	200.5	66.1	121.8	0.2	_	_	_
	Dedoplistskaro	12.2	7.2	0.3	2.2	0.2	152.9	64.2	119.2	0.1	_	_	_
	Telavi	13.2	4.1	_	3.0	0.5	184.0	109.3	123.8	0.4	_	_	_
	Lagodekhi	14.3	1.4	_	4.6	1.8	273.3	87.5	193.0	0.8	_	_	_
	Sagarejo	12.5	5.0	0.3	1.9	0.4	191.4	72.8	96.5	0.3	_	_	_
	Kvareli	14.0	2.9	_	4.8	0.8	246.2	89.4	147.8	0.5	_	_	_
	Tsnori	14.2	6.2	_	9.0	0.7	148.0	53.5	100.0	0.1	_	_	_
Annual	Akhmeta	12.8	56.4	2.8	43.8	20.8	725.6	89.0	123.8	0.3	_	29.1	7.3
	Gurjaani	13.1	56.2	3.5	48.6	18.5	773.6	92.7	134.7	0.7	0.04	29.8	6.5
	Dedoplistskaro	11.3	85.9	11.2	33.6	8.0	612.2	93.2	136.9	0.5	0.04	30.4	5.7
	Telavi	12.5	64.9	4.2	39.5	17.6	759.7	109.3	145.6	1.0	0.04	32.0	6.9
	Lagodekhi	13.5	43.7	2.9	50.6	35.0	1060.5	114.0	288.0	2.0	0.04	26.2	7.0
	Sagarejo	11.7	70.0	7.8	26.5	9.7	726.7	103.9	184.6	0.8	0.04	29.8	6.5
	Kvareli	13.2	55.0	1.8	53.0	16.5	961.0	118.9	220.6	1.6	0.04	27.5	7.0
	Tsnori	13.4	73.3	2.2	72.8	20.9	595.4	70.0	113.7	0.4	_	30.6	6.1

As it could be seen from these Tables, Lagodekhi is the hottest station according to the average annual temperature, followed by Tsnori and then Kvareli and Gurjaani. Dedoplistskaro is the coldest weather station.

According to the **summer temperature** Tsnori and then Lagodekhi are the hottest stations while, Dedoplistskaro and Sagarejo are the coolest. Their summer temperatures are almost the same as in the first period, but Sagarejo becomes cooler than Dedoplistskaro in the second period.

Lagodekhi is the richest in the **annual precipitation** followed by Kvareli, while Tsnori and then Dedoplistskaro are characterized with the least precipitation. According to the observations of Tsnori weather station, precipitation was further reduced in the second period.

During the first examined period, Kvareli and then Lagodekhi were the richest in **summer precipitation,** although the difference was small. In the second period, precipitation increased significantly in Lagodekhi. In comparison to other stations, it is the characterized with the most precipitation in summer and significantly outran Kvareli.

Tsnori and Lagodekhi were characterized in the first period by the large number of **hottest days** (SU30). Tsnori remains on the first place in the second period, while Lagodekhi has outran Kvareli. Dedoplistskaro took the last place according to the number of the hot days, while Sagarejo has become the best in the second period.

Lagodekhi and the Tsnori were leading by the number of **tropical nights** (TR20) and Tsnori still remains the same in the second period. The number of the tropical nights was the lowest and remained the same in the second period in Dedoplistskaro and Sagarejo.

Changes in the aridity index were also evaluated for all eight municipalities (as presented in Table 1.4.)

Table 2.3.Values of aridity index and its change between the periods of 1986-2010 (II) and 1961-1985 (I)

Municipality	AKhmeta		Gurjaani		Dedoplistskaro		Lagodekhi		Telavi		Sagarejo		Sighnaghi		Kvareli	
Periods	I[8]	II[9]	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Sums of precipitation in the vegetation period (mm)	560	507	570	553	400	379	717	782	573	545	542	474	438	416	707	696
Aridity index	0.78	0.81	0.95	0.95	0.74	0.76	1.23	1.35	0.88	0.92	0.91	0.85	0.73	0.69	1.18	1.21

On the basis of the limits of aridity index, it becomes clear that Lagodekhi moved from semi-humid climate to the category of humid climate as shown in Table 1.5.

Table 2.4 Limits of aridity index

Super-arid	Hyper-arid	Arid	Semi-arid	Semi-humid	Humid	Hyper-humid	Super-humid
<0.03	0.03-0.08	0.08-0.20	0.20-0.50	0.5-1.33	1.33-2.67	2.67-5.33	>5.33

Table 1.4 demonstrates that Sighnagi is the driest municipality in Kakheti region, followed by Dedoplistskaro. Lagodekhi and then Kvareli are the most humid municipalities. According to the data of the meteorological stations, none of the municipalities are in the semi-arid zone, but it is known that territories such as Eldari and Udabno are sufficiently arid. Previously, there were weather stations here, which are no longer functioning.

To avoid the risk of desertification caused by climate change it is necessary to constantly monitor the processes, for which an establishment of at least an automatic weather station on areas with

[8]http://www.fao.org/docrep/t0122e/t0122e03.htm#3. arid zone climate
[9] http://www.fao.org/docrep/t0122e/t0122e03.htm#3. arid zone climate

desertification elements is required. Only Dedoplistskaro and Tsnori weather stations are complying with showing the semi-aridity and only during the summer.

Based on the change of the reviewed parameters, the following is established:
In winter: From 8 studied weather stations between the two compared periods warming is observed at all stations. The average temperature increment varies in the range between 0.3-0.7 ^{0}C and on the average makes 0.4 ^{0}C. The maximum warming is observed in Tsnori (+0.7 ^{0}C). Precipitation increased at 7 stations and decreased at one (Sagarejo). The average precipitation increment is 9%. The average wind speed decreased at all stations.

In **spring** temperatures increased on the average by 0.2 ^{0}C at 5 stations and remained unchanged at one station and were lowered slightly at 2 stations in the range between 0.1 ^{0}C and -0.2 ^{0}C. The maximum warming does not exceed +0.3 ^{0}C. Precipitation increased on the average by 6% at 4 stations and decreased the average by lowered on average with 5% at 3 stations. The average wind speed decreased at all stations.

Summer was marked by significant warming at all stations. The average increment amounted to +0.8 ^{0}C and the maximum to +1.4 ^{0}C (Dedoplistskaro). The total of precipitations at 7 stations decreased on the average by 18% and increased at 1 station by +7% (Lagodekhi). The total seasonal precipitation decreased significantly in Sagarejo (-25%), Dedoplistskaro (-22%) and Gurjaani (-20%). The average wind speed decreased at all stations.

Autumn also became extremely warm at all the stations with the average temperature increment of +0.5 ^{0}C. Warming reached the maximum in Dedoplistskaro (+0.8 ^{0}C). The total seasonal precipitation increased at all stations by the average 10%. The increment turned out to be the largest in Dedoplistskaro (+20%). The average wind speed decreased at all stations.

In terms of the **annual** changes, temperature at all stations increased on the by average 0.5 ^{0}C. Maximum increment was revealed in Dedoplistskaro (+0.7 ^{0}C). The precipitations decreased at 5 stations by an average of 4% and increased at 2 stations by the average of +4%. The decrease in annual precipitation reached the maximum in Sagarejo (-10%), while the maximum growth was revealed in Lagodekhi (+8%), where the increase in precipitation was observed within 6-13% in all seasons.

Thus, the presented data demonstrates that climate change in Kakheti region was most of all manifested during the summer season - the average of the summer temperature increased by +0.8 ^{0}C, while the precipitation has reduced by 18%. The most drastic changes between the stations were observed in Dedoplistskaro, where summer temperatures increased by +1.4 and the precipitation decreased by 22%. Drastic changes were also observed in Sagarejo, where summer became warmer by +0.9 ^{0}C, while precipitation decreased by 25%. A trend of the summer temperature increase and precipitation decrease is also quite clearly outlined at all other stations of Kakheti region except for Lagodekhi, where precipitation increased in all seasons.

From the seasons, quite sensitive to climate change turned out to be autumn as well. Dedoplistskaro again took a special place in this season with the largest rise in temperature and precipitation (+0.8 ^{0}C, +20%), followed by Tsnori (+0.7 ^{0}C, +11%). This station also detected the most dramatic warming in winter (+0.7 ^{0}C).

The weakest response to climate change was detected in spring. The seasonal change in temperature at the majority of stations was ±0.2 ^{0}C, although precipitation increased by 10-11% in Dedoplistskaro and Lagodekhi. Therefore, it could be said that Dedoplistskaro again turned out to be in the outstanding position. In addition, at this station, except during the summer, all seasons were marked by strong wind frequency and speed increase, giving a reason to conclude that the most severe response of climate elements to ongoing global warming processes in Kakheti region is detected in Dedoplistskaro. Sagarejo and Akhmeta also proved to be quite sensitive, Gurjaani and Lagodekhi demonstrated to be the least sensitive, although at this last station the increase in precipitation in all seasons was detected.

As for the **vegetation period**, the changes in transition periods to various temperatures, starting from the transition of 5^0 and ending with 20^0, was assessed for each municipality. The results are presented in Annex 2. The Annex demonstrates that in the second period, the longest vegetation period and the sums of active temperatures are maintained for all temperature transitions in Lagodekhi municipality. As for the shortest vegetation period, with all transition temperatures, again Dedoplistskaro is leading, followed by Sagarejo.

The same Tables demonstrate that **precipitation in the vegetation period** is the highest in Lagodekhi, while the smallest is in Dedoplistskaro, followed by Sagarejo. Precipitation in the vegetation period between the two periods increased only in Lagodekhi and decreased the mostly in Akhmeta (remaining unchanged in Dedoplistskaro).

The number of **droughts** and changes in their numbers were calculated using SPI[10] index. 1, 3, 6, 9 and 12 months-long droughts were analyzed. For agriculture, even one month-long droughts are dangerous, this is why Table 1.6 presents the changes in the number of the month-long droughts.

Table 2.5. Changes in the number of one month-long droughts between the periods of 1986-2010 (II) and 1961-1985 (I)

Municipality	Akhmeta	Gurjaani	Dedoplistskaro	Lagodekhi	Telavi	Sagarejo	Sighnaghi	Kvareli
All (SPI<-1.0)	-3	+1	+7	-11	+5	+14	-4	+6
Severe (-2.0<SPI<-1.5)	-5	+7	+3	0	+1	-2	+9	+5
Extreme (SPI<-2.0)	+7	+2	+11	+3	+8	+6	+1	+8

[10] http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html

The Table clearly demonstrates that number of all types of one month-long droughts increased most of all in Sagarejo, the number of the extreme droughts also significantly increasing in this municipality. The extreme droughts increased most of all in Dedoplistskaro, Telavi and Kvareli. Extreme droughts increased everywhere, but the number of relatively mild droughts decreased slightly in Lagodekhi, Sighnagi and Akhmeta.

1.3. The climate change forecast for Kakheti Region to 2050

Till the end of the current century, the expected change scenarios for Kakheti region were assessed with the regional RegCM4[11] model, which uses ECHOM5[12] global model and the socio-economic development A1B scenario[13]. The calculations were carried out for the period of 2021-2050 according to the data from real observations of 8 regional weather stations discussed above[14]. The observation data for the period of 1991-2010 were used for testing the model results. The forecast scenarios were constructed separately for each weather station. Main results of the calculations are presented as the difference between projected for 2021 – 2050 values and observed values for the period of 1986-2010 (Annex 1, Table 1.2). For comparison, the data on the changes in the previous periods are given in the Table 1.1 of the Annex. For the temperature and precipitation, the differences between the averages of the periods are given, and for the remaining 4 values - the differences between the totals of the numbers (days) of the cases.

The presented data demonstrates that in comparison to 2010, for 2050, the average annual temperature increase of 1.0-1.2 ^{0}C is expected at all stations of Kakheti region, while the seasonal temperature increase is expected to be from 0.7 to 1.4 ^{0}C. The seasonal and annual average temperature increment for each station amounts to 1.1-1.2 ^{0}C. Different result is obtained in the projected changes in precipitations. The significant increase at each station is expected in winter (+22% on the average), while noticeable decrease is anticipated in spring (17% on the average). The sums of mean precipitation may be left unchanged. An interesting picture is revealed when comparing the changes of the previous two periods (1961-1985 and 1986-2010). In particular, the temperature increment in the last century reached its maximum in summer (0.8 ^{0}C on the average), while the minimum increase was observed in spring (+0.2 ^{0}C on the average). Also, during the previous years, the maximum increase in precipitation was observed in autumn (+10% on the average) and the decrease in summer (-15%).

Thus, according to the forecast, during the coming decades, till 2050, the average temperature in Kakheti region is expected to increase evenly in all seasons by 1.1-1.2 ^{0}C. The substantial shift of the maximum of precipitation substantial is expected from autumn to winter, while the deficit will be replaced from summer to spring. The greatest annual precipitations increase is expected in Sagarejo (+8%), while the maximum reduction is possible in Lagodekhi (6%).

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[11] http://www.ictp.it/research/esp/models/regcm4.aspx

[12] http://www.mpimet.mpg.de/fileadmin/publikationen/Reports/max_scirep_349.pdf

[13] http://www.ipcc.ch/ipccreports/tar/wg1/029.htm

[14] http://www.mssanz.org.au/modsim09/I13/sennikovs.pdf;http://www.ipcc.ch/ipccreports/tar/wg1/380.htm

Table 1.3. of the Annex 1 demonstrate that none of the weather stations will be transferred to the semi-arid zone in the future. Consequently, the aridity index is not dropping down below 0.6, i.e. the climate in all eight municipalities (presumably, except for specific local areas) will remain semi - humid and from the humid zone Lagodekhi again returns to the semi-humid zone. Unlike previous periods, almost every weather station displays aridity during the summer period.

Changes in **vegetation periods** are presented in Annex 2.

Expected Changes in **drought** events for 2021-2050 are presented in Table 1.7. According to the Table number of, extreme (the most hazardous for agriculture) droughts may be reduced in all municipalities; The decrease will be largest in Dedoplistkaro. However, the number of severe droughts will be increased the most again in Dedoplistskaro and slightly in Akhmeta.

Table 2.6. Changes in the month-long droughts in the period of 2021-2050 (III) compared to the period of 1986-2010 (II)

Municipality	Akhmeta	Gurjaani	Dedoplistskaro	Lagodekhi	Telavi	Sagarejo	Sighnaghi	Kvareli
Severe (-2.0 <SPI<-1.5)	+1	-7	+6	-5	-8	-1	-3	-3
Extreme (SPI<-2.0)	-7	-6	-16	-5	-6	-7	-6	-9

Thus, it could be concluded that the agricultural risks in 2021-2050 in the majority of municipalities will be reduced, because of the expected reduction in severe droughts, the increase of the vegetation period and the growth of sums of active temperatures. However, the problem of hail (Gurjaani, Telavi, Kvareli) and high strong spring winds (Dedopjlistskaro and Sighnagi) again remains. The risk of aridity increases in Lagodekhi area. As for the years 2070-2100, during this period, according to the forecasts, all types of droughts are expected to grow in number.

2. Impact of Climate Change on Agriculture in the Kakheti Region and Adaptation Strategies

2.1. Agriculture in the Kakheti Region: General Overview

Natural Resources and Climate Risks. 38% of Georgia's agricultural lands are located in the Kakheti Region. Arable and grassland-pasture land areas are especially large in this region. Kakheti is leading among the regions of Georgia by these land categories - this is why it is considered to be the top crop growing and livestock production region. Among the districts of the Kakheti Region, Dedoplistskaro municipality is distinguished with the size of its agricultural lands, followed by Sighnagi, Sagarejo and Akhmeta. Only 20-25% of landowners throughout the country have registered their agricultural lands at the National Agency of Public Registry, the rest does not possess means to pay the required registration fee. Disputes among citizens or between the citizens and the state over the land ownership are frequent. In general, farmers are not in a position to properly cultivate soil, they do not sufficiently enrich soil with mineral or organic fertilizers and lands are polluted with weeds due to inappropriate care. The process of pasture desertification due to overgrazing, especially in Sagarejo and Dedoplitskaro districts, are common. Most agricultural lands are affected by wind and water erosion.

R. Alazani at the Georgia-Azerbaijan border area especially endangers the agricultural fields in the Kakheti Region. In the last 15 years, the river washed off more than 100 ha arable land and pastures. This type of loss is increasing annually, as a result of which, the local population loses an important source of income from the production of livestock and agricultural crops. The spread of underground pests in soils (that damage new vineyards) has reached dangerous levels in the Kakheti Region (especially Polyphylla olivieri Castelnau). As a consequence, efforts to develop this sector turn out to be unsuccessful. Although the National Food Agency took active measures in 2009-2012 to prevent the spread of locusts, the risk of their migration from the neighbouring countries remains high.

The risk of natural hazards due to various factors ranging from climate change to incorrect agricultural practices has in general significantly increased in Georgia. In particular, it is a serious problem in the Kakheti Region. Losses from natural disasters are increasing annually. Droughts in spring, rains at harvests, hailing may take place at any time of a year, the wind intensity has also increased. A cycle of these climatic phenomena has dramatically changed, they pose a serious threat to agriculture and cause great losses to farmers.

Losses caused by hail and strong wind that took place on 19 July 2012 were unprecedented. In April and May 2013, hail in Telavi and Gurjaani municipalities inflicted enormous loss on agriculture. Seasonal floods and droughts and the natural phenomena extended in time, such as waterlogging, shall be also mentioned. Today, the entire Kakheti Region faces a threat of various natural hazards.

Along with the drought, hail is one of the most hazardous phenomena for the agriculture in Kakheti (Fig. 2.1). In 1960-1990 about 650 000 ha of agricultural lands were protected from the hail by the specialized Hail Suppression Service here. The efficiency of the Service amounted to about 70% on the average. After the breakdown of the Soviet Union hail suppression work have seased, but in recent years it has been decided to restore these activities in Kakheti using modern technologies if cloud seeding[15].

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[15] Tsintsadze T., Beritashvili B., Kapanadze N. On the restoration of hail suppression and avti-avalanche activities in Georgia. Inst. of Hydrometeorology, Tbilisi, 2013 (in Georgia). http://dspace.nplg.gov.ge/handle/1234/26844

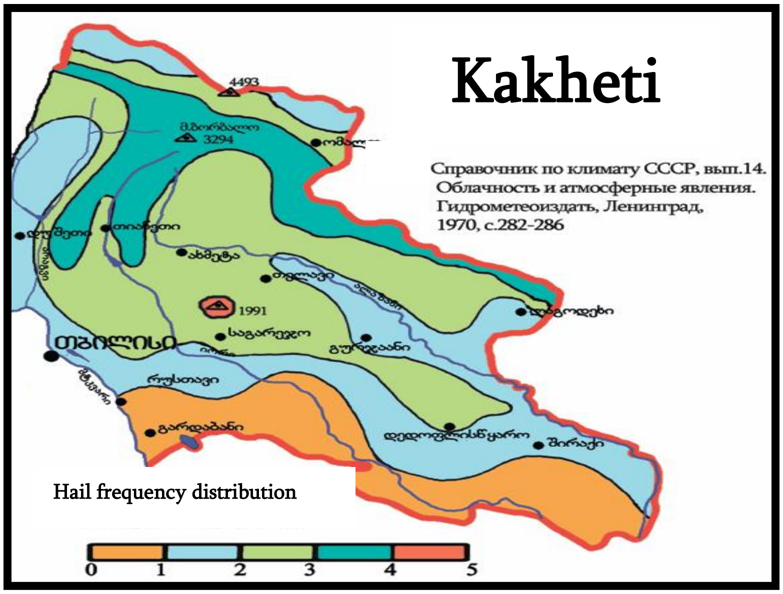

Figure 2.1. Hail frequency distribution on the territory of the Kakheti Region (1970)

Production of cereals. Wheat crops originate from Georgia. From 24 wheat species 5 are endemic to Georgia. Although the endemic wheat varieties do not have a mass production importance today, they have valuable biological characteristics which are necessary to use for growing intensive, high-yielding varieties. These are: immunity, tolerance and high bread-baking characteristics. The endemic species are the best genetic material for improving selective, agricultural and biological wheat elements.

Kakheti is rightly called as a barn of Georgia, because it is the largest wheat producer region in the country. 50% of wheat crops and more than half of wheat produced in the whole Georgia originate from Kakheti. On the background of the recent year's overall reduction of wheat production in Georgia, Kakheti's share increased. In comparison to this region, the level of wheat production fell more in other regions. The districts of Dedoplistskaro and Sighnagi, which are known for an abundance of non-irrigated arable lands, are the leading wheat-producing regions in Georgia.

Traditionally, Kakheti was considered as the major producing region of wheat, barley and other cereals. Wheat productivity was quite low (0.7 t/ha) in the 1960s, which was determined by a lack of agriculture equipment, seed materials and other auxiliary means. Wheat per hectare yield increased dramatically at the end of 1980s (2.9 t/ha). The success was determined by the refinement of technologies and zoning of modern varieties throughout Georgia, including Kakheti. For obvious reasons, wheat production began to decline from the beginning of 1990s.

This trend was mainly determined by the fall of the Soviet Union and the consequent derangement of production chain. It shall be noted that in 2001, Georgia had unprecedented wheat harvest that was determined by good climatic conditions, as well as using high-quality materials. This period coincides with the import of the high-quality seed materials from the United States. Exactly at this time, jagger and cooper seed varieties that were distinguished by the disease and drought resistance were imported to Georgia. Taking into account that the active functioning of the research institutes and the seed testing stations practically stopped in Georgia from the beginning of 1990s, the high-quality seed imports played a positive role in raising the average wheat productivity level. Fundamental changes in the Statistics Service and its methodologies, which were implemented in 2004, make it difficult to compare the data of the past 14 years, especially the data before and after 2004.

Table 2.1.1. Areas under cereal crops (ha) in the municipalities of Kakheti

Municipality	1980s	2012-2013
Akhmeta	5 500	8 200
Gurjaani	3 100	2 686
Dedoplistskaro	39 600	34 873
Telavi	2 200	8 500
Lagodekhi	6 600	8 000
Sagarejo	11 500	2 300
Sighnagi	39 000	25 000
Kvareli	15 200	15 200

Barley is the second most important grain crop mainly used for animal nutrition. The interest in it is determined by the trend of livestock development and profitability. Barley is a significant food in the cattle-farming sector. Farmers in Dedoplistskaro and Sighnagi produce relatively more barley. As for the other regional municipalities of Kakheti, the farmers produce it for feeding their livestock.

The barley production levels are increasing together with the development of livestock farming. As for the barley production and the hectare yield, similar to the wheat varieties, it also dramatically increased at the end of 1980s as a result of introducing new varieties and technologies. Taking into account that the high-quality seed production declined in Georgia from the beginning of 1990s, the average barley productivity also decreased. The average hectare yield for barley is 1.5-2.5 tons today. The climate is one of the factors determining productivity, particularly, the duration of droughts and the required amount of precipitation during the vegetation period.

Corn is the third most important crop in Kakheti. Imereti and Samegrelo-Zemo Svaneti are the leading corn-producing regions of Georgia, although it is also important for Kakheti both in terms of the crop area and the number of producers. Corn in Eastern Georgia needs watering. Therefore, corn is more widely produced in the municipalities of the region, where the irrigation infrastructure is available and precipitation is relatively high. Such municipalities are: Lagodekhi, Akhmeta, Telavi and Kvareli.

The most successful and productive in this regard is Lagodekhi district, where the productivity of corn increased from 3.5 tons to 7-9 tons per ha as a result of using new varieties and modern production technologies. At the same time, the areas under corn crops increased (tripled in some regions) as compared to other grain crops, which is a result of their high profitability. Taking into account that modern corn hybrids require humid climate and irrigation, Lagodekhi district leads in terms of the corn productivity. The high zoning rate of new hybrids in Lagodekhi shall be also highlighted. As for other places, it is necessary to test the varieties and the hybrids aimed at of their further zoning, which will allow obtaining high corn yields in the case of irrigation. However, the replacement of existing wheat and barley cultivation areas with corn (non-irrigated plots) is only possible after the rehabilitation of the irrigation systems or the arrangement of the new irrigation systems.

Sunflower is another important commercial crop for the Kakheti Region. The advantage of sunflower is a possibility of its production in non-irrigated areas and the need for crop rotation. As for the productivity, it did not exceed 0.25-0.45 tons per hectare in early 20th century, but increased to 1.2-1.6 tons as a result of developing new varieties and technologies in late 1960s.

The main sunflower-producing municipality in the Kakheti Region is Dedoplistskaro. 47% of sunflower crops in Kakheti are in Dedoplistskaro. Though, the area used for sunflower production is larger in Gurjaani and Telavi municipalities where the annual precipitation rates are higher.

As for the near past, an absence of the high-quality seed materials resulted in the sharp decline of the productivity rate and the sown areas from the 1990s. This trend to some extent was also determined by the fact that because of the low yield and, consequently, high production costs, the demand for local products declined and oil refineries plants preferred to import raw material from countries such as Russia and Ukraine. Generally it is known that wheat, barley and sunflower production is less cost-effective in comparison to the corn production. However, the frequency of droughts and a lack of the irrigation systems does not allow to replace cereals by corn.

Environmental problems associated with the production of grain crops in Kakheti are determined by the lack of windbreaks, that leads to soil erosion by wind. The droughts and a lack of precipitation negatively impact the crop productivity and in many cases lead to a reduction in crop areas.

Melons. Kakheti is the leading region of Georgia in the production of the melon crops (watermelons, melons and pumpkin). 70-80% of the melon crops grown in Georgia originate from Kakheti. In recent years, the production scale of the melon crops has dramatically increased, which is determined by a number of factors: In particular, vineyards and other perennial plants (especially after Russian embargo) were replaced by new high-yielding varieties and hybrids. The average hectare yield of the melon crops reached 25-30 tons (melon and watermelon). The number exceeds the profitability of not only cereal crops, but in some cases of fruits too. This is why we have seen a massive increase in the production of the melon crops. The high profitability of the melon crops is the reason why the melon crops are produced on the irrigable lands. Lagodekhi, Sagarejo, Kvareli and Sighnagi are the leading municipalities producing the melon crops.

The melon crops are mainly damaged by drought and hail. At the same time, we shall take into account the fact that a lack of agricultural insurance (especially for climate-related disasters) makes it difficult for farmers to reimburse the damage and maintain the production scale. In this regard, the upper zone of Gurjaani, the Sagarejo and the Kvareli districts represent high-risk areas.

Vegetables. In Kakheti, Lagodekhi and Kvareli municipalities are particularly distinguished by the agriculture production. Because of the similar conditions to the subtropical climate, the Lagodekhi District is the leader in the vegetable production, in particular, for cucumber produced in closed ground (without greenhouse heating). The harvest season starts from April. This direction developed from the end of the 1990s and today, Lagodekhi cucumbers account for 40-50% market share in April-June. The open ground vegetable production is also developed in Kvareli district.

Drought and hail are the main problems for the vegetable crops. At the same time, it should be noted that Lagodekhi District, where large quantities of early closed ground cucumbers are produced, often suffers from floods and mudflow attacks, which damage crops in the greenhouses.

Gardening. Kakheti produces a large variety of fruits. The districts of Gurjaani and Telavi are famous for commercial fruit-growing, where drupe production, particularly peach and nectarine production is well-developed. Gurjaani is the top peach and nectarine producing district in Georgia. Peach and nectarine are sold at the local, as well as export markets. In terms of nectarine yield, Gurjaani district and partly, Telavi are outrunning all other regions of Georgia.

According to information received from the municipality, from 1970s, the area with drupe fruit orchards in Gurjaani increased by approximately four fold (from 900 ha to 4 300 ha), which happened at the expense of reduction in vineyard areas (from 13 200 ha to 7 000 ha) and cereal crop production. Market diversification is named as one of the factors for such decline. This issue became relevant after the 2006 Russian embargo on Georgian food production. Weather conditions facilitate early drupe production in Kakheti and enable to sell products quickly and with a high price at the local, as well as export markets.

Orchards and especially peach producing regions are mainly damaged by hail. For example, in 2012, hail and subsequent storms destroyed not only the year's harvest, but 50% of the plants. In this regard, the risks associated with the production of perennial crops are high.

Table 2.1.2. Fruit orchard areas according to the municipalities of the Kakheti Region (ha)

Municipality	1970s	2013
Akhmeta	780	542
Gurjaani	930	4 385
Dedoplistskaro	21	110
Telavi	604	1 500
Lagodekhi	2 445	3 845
Sagarejo	2 550	1 676
Sighnagi	160	220
Kvareli	2 800	3 460

Animal Husbandry. Animal husbandry has traditionally been an important component of the agricultural industry in Kakheti. In addition, Kakheti plays one of the leading roles in the animal husbandry subsector of Georgia. Large areas of pastures and grasslands, favourable agricultural and climate conditions are major factors contributing to the development of this sector. At the same time, it shall be noted that factors such as frequent droughts, pasture erosion and productivity decline which are the results of the climate change in many cases prevent the development of this sector and forces the livestock owners to reduce the number of cattle. On the other hand, it is important to take into account that in the Soviet Union some animals, in particular, sheep, were wintering in Kizlyar pastures of Dagestan, where the mountain regions' population of Georgia had access to approximately 60 000 ha of pasture. Since 1994, Georgia no longer uses these sheep pastures and almost 100% of the total number of sheep winter in Kakheti and Kvemo Kartli (in Kakheti mainly on the territories of the Dedoplistskaro and Sagarejo municipalities). The excessive grazing is exactly one of the important stimulating factors for erosion.

Cattle breeding. Kakheti ranks fourth in cattle breeding among the regions of Georgia after Imereti, Samegrelo and Kvemo Kartli. Sagarejo, Akhmeta and Lagodekhi are leading in cattle-farming among other municipalities of Kakheti (see Table 2.1.3).

Table 2.1.3. Number of cattle according to the municipalities

Municipality	1980s	2012-2013
Akhmeta	16 800	20 000
Gurjaani	13 700	9 200
Dedoplistskaro	18 600	15 300
Telavi	13 000	15 300
Lagodekhi	21 300	18 200
Sagarejo	22 000	28 000
Sighnagi	42 500	13 200
Kvareli	10 600	12 300

According to beef production, together with the above-mentioned municipalities, Sighnagi municipality is leading. The large areas of pasture and grassland, also the existence of the cereal waste, facilitate the development of the cattle-farming. Milk production is gaining growing significance. An increase in price on the world market resulted in the increase of the demand on local pastures.

Increase of the price on milk powder consequently augmented demand of milk production enterprises for healthy local milk.

This was followed by the expansion of the milk collection center networks in Kakheti and Kvemo Kartli. Lagodekhi, Sagarejo and Akhmeta are the leading milk producing municipalities, although a growing trend is also noticeable in other municipalities. But the milking capacity is still low and equals to 1.2 tons per year. In order to increase cattle productivity, it is necessary to improve food and veterinary services, livestock breeds and cattle calving for increasing milk quantities in winter.

Pig-farming. Samegrelo, Imereti and Kakheti are the leading growing regions of Georgia. Pork is produced in all municipalities of Kakheti, but Kvareli, Telavi, Akhmeta and Lagodekhi are the leading districts, where the forest resources are used for feeding pigs. On the one hand this indicates that there is huge demand for the product and on the other hand, about the significant contribution of pig-farming to the regional economy, especially for small family farms. A significant reduction in the number of pigs in Kakheti is a result of the spread of the African swine fever virus in the region (2007).

Sheep-breeding. Kakheti has a long history of sheep-farming. According to the number of sheep, Kakheti is outrunning all other regions of Georgia. An existence of the summer and winter pastures contributes to the development of this field. Among other municipalities of Kakheti, Akhmeta and Sagarejo are the leaders in sheep production. In these districts the number of sheep exceeds the number of pigs. Sagarejo and Akhmeta are also the leaders of lamb, wool and sheep milk production, which makes sheep-farming especially significant in the mentioned municipalities. Georgian sheep has an export potential, although a number of issues, namely, pasture erosion, disease control/vaccination, selection and an improvement of infrastructure related to sheep herding trails need to be addressed for boosting this potential.

Table 2.1.4. Number of sheep according to the municipalities

Municipality	1980s	2012-2013
Akhmeta	98 770	41 855
Gurjaani	21 523	19 261
Dedoplistskaro	200 000	44 000
Telavi	37 000	44 700
Lagodekhi	40 700	31 950
Sagarejo	120 000	120 000
Sighnagi	265 000	35 000
Kvareli	25 683	25 444

Poultry farming. Samegrelo, Imereti, Kvemo Kartli and Kakheti are the leading poultry producing regions in Georgia according to the number of the poultry. The large cereal production levels contribute to the development of poultry production here. Sagarejo and Lagodekhi are the top poultry meat producing districts among the municipalities of the region. Patardzeuli poultry farm (Sagarejo municipality) is a large-scale enterprise, but operates with a small capacity.

Apiculture. Imereti, Kakheti and Samtkhe-Javakheti are the leading beekeeping regions of Georgia. Kakheti accounts for one fifth of the country's total hones production. According to this produce, Kakheti and Imereti are the leading regions of Georgia. Apiculture shall be considered as one of the Kakheti's priority directions, as the region is rich in forests, flowery meadows and crops, which are a natural food for bees. According to the number of bee hives, Kvareli and Gurjaani municipalities are leading in Kakheti, where we observe a trend of the increased production. The similar trends are mentioned in other municipalities, although, the decline trends are noticeable in Telavi, Sighnagi and Akhmeta.

Winemaking. Kakheti is the most important Georgian winemaking region. The best vineyards producing premium-quality wines are located in the Alazani and Iori basins, at 400-700 meters above sea level, on humus-carbonate, black and alluvial soils. This region can be divided into 4 main parts: the right bank of R. Alazani, the left bank of the Alazani, Kiziki and Gare Kakheti. Out of 18 registered wines originated in Georgia, 14 belong to Kakheti, such as Tsinandali, Gurjaani, Vazisubani, Manavi, Kardenakhi, Tibaani, Kakheti, Kotekhi, Napareuli, Mukuzani, Teliani, Kindzmarauli, Akhasheni and Kvareli.

The following grape sorts shall be mentioned: Rkatsiteli, Green Kakhetian, Kisi, Khikhvi, Budeshuri, Mtsvivana, Safena, Kumsi, Saperavi, Cabernet Sauvignon, Tavkveri, Ikalto Red, and others. The Kakhetian wine expresses soil properties more than other Georgian wines. The Kakhetian grape sorts give quite high quality European, as well as traditional wines.

Gurjaani municipality is the leader among other districts of Kakheti according to the vineyard areas (Table 2.1.5) which occupy 7 000 ha. Kvareli municipality ranks the second (5 700 ha), followed by Telavi (4 000 ha). Dedophlistskaro (1 500 ha) and Akhmeta (2 072 ha) have the least vineyard areas. Kratsiteli is prevalent in the vineyards of Kakheti. Saperavi is the most prevalent in Kvareli municipality (2 316 ha), that is determined by high demand on Saperavi grapes produced in Kindzmarauli micro-zone.

Today, Kakheti wine-making is represented by the vineyards planted in the 60-70s of the last century (85-90% of the total vineyard area) and new vineyards (10-15% of the total vineyard area).

Table 2.1.5.Vineyard areas in Kakheti according to municipalities (ha)

Municipality	1980s	2012-2013
Akhmeta	3 570	2 072
Gurjaani	13 200	7 000
Dedoplistskaro	8 200	1 500
Telavi	10 300	4 000
Lagodekhi	1 600	1 500
Sagarejo	4 720	3 600
Sighnagi	4 500	3 140
Kvareli	7 000	5 700

Rkatsiteli and Saperavi prevailed in the wineyeards planted during the Soviet era. Winemaking at that time was focused on the grape quantity and other Georgian grape varieties, such as Kisi, Khikhvi, Mtsvane, Mtsvivana and others were almost forgotten.

Today, the old vineyards are almost amortized. Sparsity is high and the hectare yield is low (2-2.5 t/ha). In order to increase profitability and improve grape quality, these vineyards require rehabilitation. Planting of new vineyards in Kakheti started very intensively in the second half of the 1990s, the process being implemented especially quickly in Telavi, Kvareli and Gurjaani municipalities, as the world-famous winemaking zones are located here, namely: Kindzmarauli, Akhasheni, Mukuzani, Tsinandali, Vazisubani and Napareuli. The interests of the investors are also quite high. According to the operative information, 5 000 ha of new vineyards are planted in Kakheti. If we take into account that the investment in the amount of 8 000 -11 000 USD is necessary for planting one ha of vineyard, we can conclude that 40-55 million USD were invested in growing new vineyards in Kakheti. Akhmeta, Sighnagi, Sagarejo, Lagodekhi and Dedoplistskaro municipalities were less affected by this process as winemaking is not the leading sector of economy here.

In new vineyards, the wine varieties are represented according to the following ratio: Saperavi – 96%, French red grape sorts: Cabernet Franc, Cabernet Sauvignon, Merlo and Malbec (1.8-2%). Old Georgian white grape sorts: Kisi, Khikhvi and Kakhetian Green (Kakhuri Mtsvane) – 2-2.2%.

Georgian and foreign businessmen established a grape nursery in Telavi municipality - Arivie-Georgia, which produces Georgian and foreign grape saplings in line with European standards. A part of the saplings produced here is exported and the rest is sold locally. This is the only modern plant nursery not only in Georgia, but in the whole South Caucasus. That is why its capacity is not enough for satisfying the existing needs. Two-three additional large plant nurseries are functioning in Kakheti. In general, it could be said that the full technological production cycle in this respect is virtually broken here and the high-quality vine production is thus hindered due to this reason. Hence, this is the most severe and serious problem for Kakheti viticulture. Without this the development of viticulture in Kakheti is hard to imagine.

2.2. Description of Agricultural Sector in Municipalities of Kakheti Region

2.2.1. Akhmeta Municipality

Location and borders. Akhmeta municipality covers an area of 220 700 ha, including 80 266 ha of agricultural land. 91 200 ha is covered with forests. Akhmeta borders Dusheti municipality and Tianeti municipality in the west, Chechen Republic of the Russian Federation in the north, Telavi municipality and the Autonomous Republic of Dagestan of the Russian Federation in the east, and Sagarejo municipality in the south.

Relief. The territory of Akhmeta municipality is rich in the geomorphological contrasts. The largest part is surrounded by high ridges and mountains. Relatively low parts are located in the southern part of the municipality in the form of Alazani Plain.

Soils. The territory of Akhmeta municipality and the relevant soil types can be divided into three zones: a lower zone (500-800 meters above sea level), where small areas of forest brown, meadow brown and brown soils are found. Alluvial soil and alluvial-carbonate soils are dominant in Alazani Plain and Pankisi Gorge, humus-carbonate soil is developed on the weathering crust of carbonate rocks, which is good for cereal crops (including stubble crops), all grape varieties (early, late), fruit, essential oil and vegetable production.

In the transitional zone (800-1 500 meters above sea level) and in general, in Akhmeta municipality, brown mountain-meadow turfy soil is found, which is developed in the subalpine and alpine zones of the municipality. Grey forest soil is found here, which is mainly represented in the historical region of Tusheti, in the mountainous pine forests, along the both shores of Alazani River and the downstream and upstream shores of Alazani River. It is possible to use these areas for livestock forage, grassland-pastures and partly, for cereal crops.

In the mountainous zone (1 500-3 000 meters above sea level), in Mtatusheti, grey forest podzolic, mountain-meadow turfy and primitive soils are found, which are mainly used for grassland-pasture and forage root crops.

Rivers and irrigation systems. The hydrological network is sufficiently dense on the territory of the municipality. The terrain here is full of rapid rivers and in general, of internal waters. In the northern, mountainous part of Tusheti, two rivers have to be mentioned: Pirikiti Alazani and Tusheti Alazani with its many tributaries. Pirikiti Alazani (length 49 km) originates in the southern slopes of the mountain range at an altitude of 3 195 meters above sea level. It is nurtured by glacier, snow, rain and groundwater. From the right it is joined by one of the most important rivers - Larovani Tskali. At the south-eastern end of Atsunta Ridge, at an altitude of 2 840 meters above sea level, Tusheti Alazani River is born (length 59 km) and flows in Gometsari Valley at the considerable distance. Also, R. Alazani originates within the abovementioned district, on the eastern slope of Mt. Borbalo Mountain at an altitude of 2 750 meters above sea level. It is characterized by rapid flow and turns into a plain river on Alazani Plain characterized by the relatively quiet flow. Alazani flows at more than 50 km on the territory of Akhmeta municipality. Within te territory of the municipality, Alazani is joined by many rivers, especially from the right side. River Ilto (length 43 km) on the territory of the municipality shall be separately mentioned, which originates from the junction of Kartli and Kakheti ridges. The river mostly has the South-West direction, it turns sharply to the east in the village of Naduknari and connects to Alazani in the north of Akhmeta town. Andi Koysu River flows in the north of the municipality, which is formed as a result of joining Pirikiti Alazani River and Tusheti Alazani River at the absolute height of 1 535 m. The length of the river within Georgia is 14.6 km. Andi Koysu is a typical mountain river with well-marked stepwise flow and a narrow and deep valley.

Approximately 6 200 ha of arable lands in Akhmeta municipality require watering, but due to a lack of the irrigation systems and their poor condition, the municipality lacks irrigation water. The upper Alazani irrigation system originates in Akhmeta district. The main source premise was built in the upper part of Alazani River, in Pankisi Gorge, near Duisi Village. From the upper right water intake system of the premise, the main channel of Zemo Alazani irrigation system starts, which flows from the river source to the right side of the river, at a distance of 18 km follows the south branch of the Caucasus, the eastern slope of Tbatani Ridge. After crossing Ilto, the river bends south-eastward, passing partly inclined Alazani plains. From here, it flows along the Tsiv-Gombori slope until the Papriskhevi River. The length of the main channel from the source to Papriskhevi is 18 km, the water capacity is 24 m^3/s. Irrigation of 41 000 ha in inner Kakheti, namely in Akhmeta, Telavi and Gurjaani districts is possible with the inner and distribution channels of Alazani main channel.

For the irrigation of agricultural crops in Alvani, #1 and #2 irrigation canals are nourished from the right bank of Alazani River. Their length is 6 and 8 km respectively. They irrigate 1 200 ha. The Ilto canal is cut from the left bank of R. Ilto, which starts below Naduknari Village and irrigates 480 ha land plots in Matani. During summer water shallows, water is dramatically decreasing in the Ilto River Valley. Therefore, during summer, it almost is not used for agricultural irrigation plots located at the right side of Alazani, which often led to the loss of the entire harvest crops here.

In addition, mudflows formed as a result of spring floods filled up the channel bed with solid materials, which made the water flow impossible through the channel. The channel bed has not been cleaned since the 1980s of the last century. This circumstance makes it impossible to properly operate the irrigation system. A similar situation is at the Alazani-Ilto connecting irrigation main channel. Here, damages to the connecting sections of the channel tunnels are added to a lack of cleaning. During the previous winter, the tunnel ceiling collapsed in several places, and the water does not flow here. As a result, lands in Matani Village are not irrigated. In the upper part of River Ilto, in the village Naduknari, the construction of the water reservoir was planned in the late 1980s, which would supply the irrigation system in summer with water accumulated in spring. The tunnels with the length of more than half a kilometer were built on both sides of the river. Currently they are broken. The goal of building the reservoir was to regulate water freshets and floods in Ilto Basin, which until today still represents an unsolved problem for Akhmeta district. Construction was stopped for no apparent reason, thus the system lost its major water supply and the possibility to reduce risks.

In terms of amelioration, Akhmeta district was one of the leading municipalities in the Kakheti Region. Currently the irrigation system of Zemo Alazani and the source premise of the Ilto irrigation channel is not functioning. The internal irrigation network is also damaged, which in the past played a great role in producing abandant corn harvest.

In recent years, the Ministry of Agriculture initiated the ongoing rehabilitation of the main channels, but rehabilitation of the internal network or water tax system optimization cannot be yet achieved. For instance, for the time being the following facilities are rehabilitated: The main channel of the Zemo (Upper) Alazani irrigation system on the territory of Akhmeta municipality (I line). The reclamation system in the Zemo (Upper) Alazani irrigation system zone from the source premise to the Valley of Orvili River on the territory of Akhmeta municipality (I line). The reclamation system in the Zemo (Upper) Alazani irrigation system zone from the valley of Orvila River to the Khodasheni Valley on the territory of Akhmeta municipality (II line). A certain amount of wetlands are also accounted for in the administrative unit, which are mainly located in the floodplain. 2 500 ha of agricultural lands require drainage. The drainage systems exist, but they are depreciated, this is why they are unable to ensure proper drainage.

Overview of Agricultural Sector

The main economic activity of the municipality is agriculture. The total area of agricultural lands of the municipality occupies 80 266 ha, of which agricultural land area is 16 354 ha, 799 ha - perennial crops and grasslands-pastures - 62 113 ha.

According to information provided by local authorities, the agricultural land fund of the municipality, namely arable and pasture lands degraded in the last ten years, including 1 500 ha arable and 10 000 ha grassland-pasture lands. Swamps (500 ha), excessive grazing (10 000 ha) and land depletion (1 000 ha) are named as the reasons. According to the same source, the agricultural land loss amounts to 400 ha, including 100 ha arable land, 300 ha grassland-pasture land. The fertility loss (100 ha), mudflows (100 ha) and river bank washing (200 ha) are named as the reason for it.

Animal husbandry. Akhmeta municipality is reach in grassland-pastures, their total area amounting to 62 113 ha, which is 77% of agricultural lands. Cattle-farming is well developed in the municipality.

According to 2012 data, the number of the livestock in the administrative units amounted to 32 500, their number has increased with 15 000 in the last decade.

Sheep farming is the priority field in the municipality. The number of sheep amounted to 50 000 in 2012, their number has increased by 10 000 over the last 10 years. The cattle from the neighboring municipalities is not brought to the pastures of Akhemta municipality. According to local experts, the grassland-pastures in the municipality are insufficient for cattle feeding because of their degradation.

Based on available data and calculations of livestock and sheep in the municipality, 0.5 livestock and 0.8 sheep per hectaree are observed. Despite ample pasture resources, the cattle-breeders suffer from the lack of pasture. Excessive grazing, waterlogging and drought are named as the reasons. No measures for maintaining and caring grasslands-pastures are taken by the municipality, the grazing norms for pastures are not assessed.

Plant-growing. Arable lands occupy 20% of the agricultural lands in Akhmeta municipality. According to the Akhmeta municipality, horticulture is not widespread in the district. Grape is a priority agricultural crop. Its productivity has not changed in recent years. A decrease in the vegetable crop productivity is observed, the main reasons of which are named: low-productivity seed material, insufficient irrigation and adverse weather conditions (drought), ineffective means for combating pests, weeds and diseases, land depletion, excessive grazing and swamping.

Observations at the Akhmeta meteorological station demonstrated that the beginning of the vegetation period (10 ^{0}C) in spring was postponed by 10 days to late spring (from 03.04 to 13.04) in the period from 1986-2010, and the end was extended by 15 days to winter (from 02.11 to 16.11). Such change will have an impact on the demand for water by plants, because during this period the temperature rise is accompanied by a decrease in precipitation by 10%.

Data on the scale of agricultural production and productivity changes in the municipality is presented in Tables 2.2.1. and 2.2.2.

Table 2.2.1. Various agricultural production yield rates, (t/ha) in Akhmeta municipality

Product Name	1980s	2012-2013
Grapes	6.7	4.35
Fruits	6.0	3.55
Grains	3.1	3.00
Melons	5.0	12.9
Vegetables	7.0	3.63

Table 2.2.2. Indices of various animal husbandry fields in Akhmeta municipality

Animal category	1980s	2012-2013
Livestock (head)	16 800	19 980
Pig (head)	30 380	7 515
Sheep (head)	98 770	41 855
Poultry (wing)	68 300	106 620
Meat production (ton)	5 200	1 199
Bee (live)	4 220	6 385

Expected impact of climate change on Agriculture

According to information of the municipality administration, natural hazards harming the population of Akhmeta municipality the most, are mudflows and floods, that seriously damage agricultural plots, houses, irrigation systems and other public infrastructure significantly affecting agriculture.

Overflown Ilto and Alazani during excessive precipitation threaten and significantly harm the local population, as the main agricultural lands are located on the banks of Ilto and Alazani rivers. Floods are recurring with different intensity every year and wash off arable lands of the population. During the droughts, on the contrary, there is a shortage of irrigation water. In such cases, a malfunctioning irrigation-drainage system cannot compensate for water loss.

As a result of washing Ilto and Alazani river banks, already 200 ha of arable lands were washed off and approximately the same land area is at risk.

Flooding and wash-out on the left bank of R. Orvila affected 150 families. River bank erosion, the river bed gully erosion and forest degradation are taking place near the hydro reservoirs. River bank erosion damages engineering constructions. From the ongoing projects that have a goal to eredicate these events, the gabion bank protection projects and the projects for cleaning the river bed from inert materials are being implemented in the district.

From the climate threats, the district is characterized by strong winds and drought.

According to data obtained from Akhmeta weather station, the number of harsh and extreme agricultural droughts in the period of 1986-2010 increased by 9 in comparison with the 1961-1985 period.

The annual number of hot days (SU30) has also significantly (16 days) increased, as well as the number of tropical nights (TR 20), (9 days). These parameters are projected to increase even more in the coming decades, which will be a significant blow to the agriculture sector of the district.

Except the cereal crops, apiculture is also at risk. As mentioned above, honey production in Akhmeta district decreased significantly. The reasons of such decrease supposedly are an increase in hot days and droughts (when bee working capacity falls significantly), increase in heavy rains (during which the plant nectar is washed off and bee forage is reduced) and strong winds (during which the honey nectar-producing plants are also damaged). In addition, strong spring winds (which reaches 40 m/s in the last 20 years) deplete pastures and seriously degrade them against the background of increases in droughts and high temperature and decreasing the occurrence of precipitation during the vegetation period.

Recommendations

In order to avoid problems anticipated by climate change, it is necessary to implement the following activities in the municipality:

- Protection of agricultural lands and household plots from the development of washing and erosion processes of rivers. To achieve this objective, it is necessary to strengthen the river banks with gabions and other modern technologies and implement anti-erosion phytoreclamation measures;
- The rehabilitation of irrigation systems existing on the territory of Akhmeta municipality and their relevant broadening by introducing modern water saving, high-efficiency technologies for refreshing atmosphere (fertigation, mulching, drip irrigation, artificial rain irrigation) and ensuring their proper operation.
- Usage of ground water and wells and the arrangement of new ones for the irrigation of agricultural crops and livestock drinking initially on the territories away from irrigation channels and grassland-pastures.
- Control plans for wells, groundwater and leachate;
- Promotion of the development of cattle-farming as a priority high-profitable sector. Organizing of the genetic center and breeding farm for the development of the sheep farming, where a selection of Georgian sheep varieties will be performed using modern technologies, their regular monitoring for assessing the impact of changes in environmental conditions;
- Restoration of windbreaks and planting of new ones for preventing soil erosion by wind (mainly on pastures) and for maintaining moisture during severe droughts;
- Elaboration of the pasture management plan for the municipality. (In particular, banning grazing in grasslands in early spring and late autumn, a time-limits shall be established for grazing and 15-20 days shall be left until the preparation for winter herbage; use of special hummock chisels and rollers against hummocks; Sowing on unaffected and bare soils. The regulation of standards for pasture loads with the adherence to the necessary interval of 20-30 days so that the plant cover survives well during the winter period. Arrangement of the infrastructure on cattle herding routes (resting places, shady, drinking and washing places, etc.).
- Introduction of modern environmentally feasible technologies (chisels, combined aggregates, uncultivated arable land plots);
- Establishment early warning systems for forecasting extreme hydrometeorological events in the municipality, on vulnerable areas. The introduction of a mechanism for reducing damage caused by hydrometeorological risks, including hail;

- Increasing the potential of the information-consultation services that were established in the municipalities by the Ministry of Agriculture (information, methodologies, availability of laboratories, learning materials, videos, demonstration projects, etc.) to effectively serve the cattle-breeding and plant growing sectors.

2.2.2. Gurjaani Municipality

Location and borders. Gurjaani municipality is bordered by 5 administrative municipalities. In the west, it is bordered by Sagarejo municipality, in the south-east by Sighnagi municipality, in the north-west by Telavi municipality, in the north by Kvareli municipality and in the east by Lagodekhi municipality. Gurjaani municipality occupies the smallest area within the borders of Kakheti (846 km^2).

Relief. Relief in the greatest part of Gurjaani municipality is low-mountainous and medium mountainous at some places. The elevation of the territory varies from 300-450 meters to 850-100 meters. The municipality is spread in the Alazani River basin. Its southern part is occupied by Tsiv-Gombori medium-mountainous ridge. The Gombori Ridge is gradually decreasing outside Gurjaani municipality, turns into the hill and connects to Iori Highland.

Soils. On the slopes of Gombori Ridge at the territory of the municipality (400-500 meters above sea level) brown forest soils are developed, which are especially suited to all grape varieties, fruit and melon crops.

In the mountainous zone (500-800 meters above sea level), gray forest soils of medium and small thickness are prevalent. Black earth of small and medium-thickness are met on the Outer Kakheti Plateau. Alluvial carbon-free soils are widespread in Alazani Plain. The territories of the mountainous zone are mainly covered with forests.

Rivers and irrigation systems. The hydrological network of the municipality is not quite tight. The area is mostly bisected with the network of narrow and dry gorges and ravines. The major part of them is waterless and dry. The main river artery is R. Alazani and its short low-water tributaries, from which R. Chermiskhevi (length 35 km) and R. Lakbe (length 32 km) are relatively important. Both rivers originate from the Gombori Ridge.

Gurjaani municipality is included in the service zone of Alazani lower irrigation system, which irrigated 10 325 ha agricultural land. The Georgian United Land Reclamation Systems Company supplies the municipalities with water.

Kakheti Region in general and Gurjaani municipality in particular still faces serious problems in the land reclamation field: A large part of the irrigation networks in the so-called Gurjaani zone was constructed during the Soviet era with metal tubes that are already corroded and can no longer perform their functions. They need to be rehabilitated as soon as possible, that is connected with a substantial financial investments. Nevertheless, some drainage rehabilitation processes are still ongoing. For instance, in 2013, 9 km long drainage channel was constructed on the territory of village Bakurtsihe. This saved 350 ha of arable land from degradation. According to the information provided by the Reclamation Division "Alazani-M", the land drainage work will continue in 2014 and will include the territories from the village of Kitaani to Kardenakhi. In this zone, on the Vejini area, the relevant works are still in progress and upon their completion 500 ha land area will be rehabilitated.

Despite already implemented certain works, the situation in the Kakheti Region in terms of land reclamation is still grim. According to information provided by the Land Reclamation Division "Alazani-M", 7 300 ha land are located in the irrigation area, but the population is often unable to use irrigation water due to the malfunction of the internal networks. But, sometimes, irrigation water flows uncontrolled and floods and damages the lands and plantation routes.

More difficult is the situation in Kachreti zone. A large part of the internal network of the irrigation system is plundered and destroyed, this is why it is still impossible to channel irrigation water to the land plots of all villages. Often, during droughts, there is a water shortage, which is likely to adversely affect a variety of agricultural crop growth-development, productivity and quality. Although some preventive measures, namely, periodical removal, cleaning and replacement of open channels are going on, but the process is still insufficient. The full implementation of the measures will allow irrigation of about 3 000-4 000 ha in this area, which will increase the hectare, as well as the total yield. All these measures will increase the financial income of the local population.

Overview of Agricultural Sector

Gurjaani municipality in the Soviet period was and still is of rural orientation. According to the priority, viticulture has always been on the first place. Table 2.2.4 below shows the change in agricultural areas for leading agricultural crops, while Table 2.2.5 demonstrates the corresponding cattle-breeding figures.

Table 2.2.3. Various agricultural production yield rates (t/ha) in Gurjaani municipality

Product Name	1980s	2012-2013
Grapes	5.9	4.7
Fruits	2.0	6.0
Grains	2.6	2.4
Melons	1.2	12.4
Vegetables	6.0	5.4

Table 2.2.4. Areas under various crops in Gurjaani municipality (ha)

Crop Name	1980s	2012-2013
Grapes	13 100	7 000
Fruits	700	4 400
Grains	2 973	2 800
Melons	1400	706
Vegetables	555	295

Table 2.6. Indices of various animal husbandry categories in Gurjaani municipality

Animal category	1980s	2012-2013
Livestock (head)	13 691	9 181
Pig (head)	20 975	5 042
Sheep (head)	21 523	19 261
Meat production (ton)	2 812	2 199
Milk production (ton)	5 147	9 002
Wool production (ton)	34	36

As the Table 2.2.4 demonstrates, in the 1980s, grape production was the primary direction for the municipality.

During the abovementioned period, cattle-breeding ranked second, even though Gurjaani municipality in general is scarce in land. For that period cattle-farming was presented quite extensively. This was determined by the fact that based on the relevant governmental resolution, the municipality used winter and summer pastures in Dedoplistskaro, in so called "Taribana" and Mtatusheti summer pastures in Akhmeta district.

Soviet-era statistics demonstrate the development of viticulture. It was expressed in an increase in vineyards areas, as well as in the average productivity (Table 2.2.6).

Table 2.7. Viticulture development trend in Gurjaani municipality in 1970s

Product Name	1976	1977	1978
Grapes (t/ha)	3.2	5.0	5.9
Vineyards (ha)	10 663	11 848	13 087

In the same period, the cattle-farming industry was more or less stable as according to the amount of livestock head, as well as in terms of production.

Although presently the volume of these directions is somewhat reduced, but their priority is still relevant. However, fruit production, particularly peach production is strongly competing with this sector.

Fruit production statistics for the years of 2011-2013 are summarized in Table 2.2.7.

Table 2.8. Fruit production trend in Gurjaani municipality

Product Name	2011	2012	2013
Peach (t/ha)	6.3	6.0	6.0
Peach orchards (ha)	3 752	3 756	4 385

As mentioned above, with its volume and income, fruit production moved to the second position, among which the peach plantation dominates. Cattle-farming moved to the third place with its status.

As can be seen from information given above, both in the Soviet period and now, the same agricultural directions maintain priorities, albeit with the changed order, but for various reasons the majority of their quantitative values are decreased. The year of 2012, when a strong natural disaster (hail, storm) destroyed the harvest, shall be mentioned separately.

The situation is similar in the sphere of livestock-farming. As the data demonstrates, according to the number of animals, the indicators are stable in cattle-farming and pig breeding spheres, as for the sheep farming, the indicator has deteriorated. This is mainly caused by the fact that in so called "Gujaani Zone", collective farms and state farms were mainly focused on viticulture, they had less material-technical and forage base for sheep farming, so they were forced to minimize or completely rejected this field.

Recently, in Gurjaani municipality, one of the priority areas and a source of income became peach production, the total area and yield of which have increased significantly. This is due to its demand on the foreign market, particularly its large part is exported to the Russian market through Azerbaijan. Since the opening of the Russian market in 2013 a further increase in the peach production scale has been observed. All these will greatly increase the income of peasants and farmers.

The data clearly shows changes in peach production in not only total production, but also in the hectare yield. The productivity growth in fruit production is particularly eye-catching: If in 1976-78 it varied from 1.6 to 3.0 tons, in 2011-2013 it amounted to 6.0-6.3 tons. This was mainly caused by the fact that in the first period the fruit production received less attention. The main focus was on viticulture, cattle farming, cereal production, etc. Hence, fruit production was almost ignored, which meant that soil cultivation and the use of fertilizers did not meet the agricultural standards, treatment of plants with chemicals was performed with old, so-called ancestors methods, also, new high-yielding varieties were not planted. All of the above had a direct negative effect on the hectare, as well as the overall yield.

As mentioned above, lately, fruit production, and in particular peach production has sparked great interest in Georgia and beyond. The population reacted instantly to the emergence of a new market. Cultivation of peach plants started immediately. One of the hindering factors in this process is an absence of the nursery in the district. The population tries to select relatively high-yielding varieties and cultivate them by means of grafting independently, based on knowledge available to them at this stage, also they try to more accurately follow to agricultural rules and moderately use chemicals and fertilizers.

The interest of the population is also determined by the fact that in comparison with the vineyard, the peach orchard is less laborious and requires less expenditures, but revenues in some years exceeds revenues received from grape production.

However, there is always a risk related to peach sales. The risk is determined by the volatility of the external market. There were cases when the export to Republic of Azerbaijan became a problem and the price in that period fell catastrophically. Also, peach production, as other agricultural sectors, is associated with certain risks. For reducing the risk, in addition to regulating the market, it is desirable to establish and operate peach fruit processing plants and cold storage infrastructure, which will contribute to the reduction of dependence on the time of selling.

There is a significant difference between the total productivity of melons, as well as the average hectaree yield. Presumably, this is mainly due to the demand in watermelons, melons and pumpkin on the domestic market. These are highly productive crops and amount to 70-80% of the total produced melons. In addition to the abovementioned detail, in case of taking the right measures, which implies the use of modern methods, the given agricultural crops give a higher hectaree yield. The population quickly understood this and consequently, their source of income began to rise.

Table 2.2.3 demonstrates that the average hectaree yield at viticulture, especially in 2012, decreased in comparison to the previous period. One of the reasons for this is heavy hail and storm of 19 July 2012, which almost completely destroyed arable lands in 8 villages, including vineyards. The natural disaster that happened on 30 August 2013 seriously damaged 4 villages in so called Kachreti zone. All these has significantly reduced the total harvest, as well as the average hectare yield.

Generally, the viticulture yield in Georgia is low. In the leading European countries, the average hectare yield for different grape varieties amounts to 5-8 tons. In Gurjaani municipality, this figure varies in an average of 4.5-6 t. However, in some areas it exceeds 10-15 tons. In this regard, there is a real potential to improve the grape productivity with the use of correct agricultural measures and modern technologies.

As of today, there are 7 000 ha vineyard areas in Gurjaani municipality. According to the local authorities, it is possible to plant grapes on additional 3 000 ha in a way that is does not affect other branches of agriculture. The municipality has suitable soil for this.

The decline of animals in the cattle farming sector is mainly determined by the fact that the largest part of the sector during the Soviet period was mainly concentrated in collective and Soviet farms. Only its small part was owned by the population. The above mentioned organizations had better material-technical and forage bases. After their elimination, the cattle farming was transferred to the private sector and the population, who actually did not have such bases. All these, of course, led to a reduction in the number of cattle. Milk production is an exception in Gurjaani municipality, which in comparison to the Soviet period has significantly increased. There are the following reasons for this: As it was said above, the great majority of cattle was concentrated in the collective and public farms, where so called Zootechnical norms of that time were operating. According to these norms, the livestock herd on every 100 cattle had to have 25-30% cows, and the rest of the repair teenage according to sex and age groups.

Therefore, the number of cows in that period did not exceed 3 500 cattle in the municipality. Now the given rules are no longer applicable. In parallel to increasing the demand for milk and dairy products in recent years, the population sharply increased the number of cows, which currently amounts to 6 200 cattle. All these influenced the dairy industry.

The situation is undesirable in terms of the unit production. In particular, in Gurjaani, the daily weight gain per animal in the meat industry amounts to the average of 250-300 g., while in developed countries, the rate amounts to 700-800 g. and sometimes even exceeds 1 kg. The annual milk production in forage cows varies between 1 300 and 1 500 kg, while in the leading European countries it is more than 4 000 kg.

All these are directly reflected in the low productivity of livestock, which in turn is determined by the absence of breeding nurseries, low quality veterinary services (animal death and compulsory slaughter are frequent because of this), low qualifications of the cattle breeding specialists and the lack and imperfectness of forage bases (concentrated, as well as grassland forage is meant here).

There are sharp changes on agricultural lands. The comparison of the periods discussed in the Tables reveal significant changes in the areas. It basically refers to the areas of vineyards and pastures. The reason for the decline in area of vineyards has already been discussed above. As for the pastures, their decline is determined by several reasons: According to the Presidential Decree №166 of 11 February 1996, 4 000 ha pastures were transferred outside the boundaries of Gurjaani municipality. Today, these pastures are managed by the neighboring Sagarejo, Kvareli and Lagodekhi municipalities. A large part of the remaining pastures, approximately 6 000 ha was transformed into arable land. A part, which was located on the territories of surrounding mountainous villages, were covered by plant trees because of the neglect and gradually became less suitable for cattle farming.

Impact of Climate Change on Agriculture

The most serious threat caused by climate change and its extreme manifestations (hail, heavy rains) observed in Gurjaani municipality is land degradation (secondary bogging) and hail.

The sums of annual precipitation on the territory of Gurjaani municipality during 1986-2010 were reduced in comparison with the previous 1961-1985 period, although total precipitation, except in the summer, increased during all other seasons, especially in fall (by 11%). On the other hand, summer precipitation and precipitation during the vegetation period declined by 20 mm or 6% respectively. It is accompanied by the increase in severe droughts, which generates the need for the additional irrigation. The maximum daily rainfall in spring increased by 34%, which is accompanied by floods and waterlogging of soils. If heavy rainfall (more than 90 mm/day) were common in summer, now it comes in the same amount, but in spring, which is harmful to wheat crops. The amount of precipitation during 5 consecutive days increased in spring and autumn, by 31% and 23% respectively.

As grapes and peaches are two leading crops in Gurjaani municipality, hail is the greatest risk for this municipality. Especially in case of grapes, 2-3 years are necessary for the rehabilitation after hail, until the vineyards again produce harvest. Despite the fact that after the 1990s, Kakheti did not suffer from hail for a long period of time, during the last three years, this event has become more frequent and especially intensive. As it was mentioned above, strong hail and storm shattered Gurjaani municipality in 2012 and destroyed rural lands and vineyards in 8 villages. Hail in 2013 damaged 4 villages in Kachreti zone. These events significantly reduced the hectare yield of the damaged areas.

The second major problem for Gurjaani municipality is land. For this time, soil waterlogging is the most acute problem caused by heavy rains and the seizure of agricultural areas by Alazani River. Because of these developments, 1 000 ha of arable land and pasture in the municipality face threats of loss. Rehabilitation works are ongoing in these areas, but the pace is unsatisfactory. For the small-land district such is Gurjaani municipality, the loss of agricultural land is a serious risk.

In Gurjaani municipality, as well as in several other municipalities of Kakheti, maximum wind speed in spring has increased by 6 m/s in the second period. Windbreaks play an important role in the production of agricultural crops. In the Soviet period, they covered about 550-600 ha in the district. In the following period, they too were chaotically hewed and currently only about 50-60 ha are left, which is actually amortized and can no longer perform its functions. All these had devastating impact for so-called Kachreti zone, where annual grain crops - wheat and barley are sown on relatively massive areas. There were instances when strong winds uprooted and carried away plants on dozens of hectarees, consequently peasants and farmers suffered serious losses.

In pastures, the majority of which were transferred in the disposal of other municipalities, grazing standards are observed, because the remaining pasture areas are insufficient for the existing number of cattle. The number of livestock per hectaree has significantly increased (if according to the zoological-technical norms, 1 ha pasture is a norm for 1 cattle head, the number of cattle heads in Gurjaani is 10 and sometimes more. In case of sheep, 10 sheep per hectare is a grazing norm, but in Gurjaani, 50 sheep and more graze on 1 hectare), that leads to pasture degradation and deterioration of food quality. In addition, there are no irrigation systems, pasture improvement does not take place. Furthermore, an increase in summer droughts is also added to the factors. As a result, the pasture gradually loses its function.

Recommendations

In order to avoid problems anticipated in relation with climate change, it is necessary to implement the following activities in the municipality:

- Adoption of modern hail suppression measures and introduction of other preventive measures; a state intervention is especially important in this area;
- Rehabilitation of irrigation and drainage systems existing on the territory of Gurjaani municipality by introducing modern technologies (new water saving, high-efficiency technologies for refreshing atmosphere, such as fertigation, mulching, drip irrigation, artificial rain irrigation, etc.) and ensuring their proper operation;
- Implementation of bank-protective works on the sections of R. Alazani Rivers threatened with a seizure of agricultural land plots and pastures and their monitoring is necessary by mobilizing local communities;

- Arrangement of plant nurseries equipped with modern technologies for the development of fruit production, which first of all will provide Gurjaani district with virus-free, high-quality and certified plants;
- Restoration of windbreaks and construction of new ones for preventing soil erosion by wind (mainly on pastures) and cultivation of forest groves for the rehabilitation of salinized soils;
- Capacity building of the personnel at the Information-Consultation Centers established in the municipalities by providing them with the information on modern achievements.

2.2.3. Dedoplistskaro Municipality

Location and borders. Dedoplistskaro municipality is located in the extreme eastern part of Georgia, at the border with Azerbaijan, on the lofty plateau between Alazani and Iori river beds. The area of the territory is 2 532 km^2. From the north-west and the north-east it is bordered by Sighnagi district and from the south-east by the Republic of Azerbaijan. The northen part of the municipality is in fact the extreme southern section of Gombori Ridge that connectes to Shiraki Plain.

Vashlovani National Park with an area of 25 114 ha is located in the southern part of the municipality.

Relief. The largest part of Dedoplistskaro municipality is covered by Iori (Outer Kakheti) Plain. The major part of the given territory is located at an altitude of 400-600 meters from sea level, and individual sections are located at 800-900 meters above sea level. The lowest point is located at 90 meters above sea level at Mingechauri Reservoir, near the confluence of R. Iori, while the highest point is Mt. Nikorastsikhe (1 001 m ASL) located to the south of Dedoplistskaro.

Soils. Mainly the following soil types are met at different elevations above sea level:

Low zone (100-500 m ASL) - gray - brown, brown carbonate, alluvial carbonate (Alazani and Iori Groves), alkaline soils. Cereals (wheat, sunflower) are mainly produced here and used for winter grazing. Grape is also cultivated in this zone.

High zone (500-800 m ASL)- Black, black carbonate, highly erosive and at some places exposed soils are prevalent here. Mainly used for cereal crops and pastures, as well as for grapes and fruit trees.

Land can be divided into three categories according to the fertility: Good - 45% (Shiraki, Patara Shiraki); Medium - 30% (Vake, Telatskali, Mtsaretskali, Dilicha); Poor - 25% (Kargho, Burdo Mountain, Taribana - mainly used for pasture and sheep wintering).

Rivers and irrigation systems. Two rivers are flowing through the territory of the municipality - Alazani and Iori (Table 2.2.8). R. Alazani flows in the north-east of the municipalities along the following villages: Samtatskaro, Pirosmani and Sabatlo representing the state border. R. Alazani tries to cut a linear bed on many sections (Village Sabatlo is one of such places) in a way as it happened in Village Erisimedi in Sighnagi municipality. In such a case, hundreds (250-300) of hectarees will be added to the non-irrigated territories.

R. Iori flows in south-east of the municipality and partly represents the state border. The Dali Reservoir is located on this river.

Water from Alazani and Iori rivers has been traditionally used for the irrigation of surrounding areas, although these are very small territories. The territory of the municipality is bisected with the ravine beds and gullies of small, seasonal rivers (Leki Tskali, Mlashe Tskali, Pantrishara Tskali, Didi Ru, Qushi, Brotseula, Kumuro).

Table 2.9. Indices of Rivers in Dedoplistskaro municipality

N#	River	River source	Height of source from sea level (m)	River length km	Basin area (thousand km²)	Length at the territory of the municipality (km)
1	Alazani	Mt. Borbalo	3 000	351	11.8	85
2	Iori	Mt. Borbalo	2 600	320	4.6	35

The population, as well as animals, use ground and fresh water artesian wells for drinking water supplies. The fresh water artesian wells have been drilled for supplying the population with drinking water. Currently 50 operational artesian wells are located at the territory of the municipality.

As it is given in the description of the climate of Dedoplistskaro municipality (Section 1.2.3), this region is one of the driest and arid zones in Georgia. The climatic conditions of the vegetation period are characterized by particularly low precipitation (221 mm). At this time, soil moisture index is below the allowed level[16], which significantly reduces the productivity and inflicts great material loss to the land users.

To replenish the moisture deficit, 4 mechanical irrigation systems with mighty pumping stations and reservoirs were constructed and operated in the municipality from the second half of 1970s. The reservoirs were filled with water resources of Alazani and Iori rivers. 16 213 ha of agricultural land or more than 25% of their total area were irrigated in the district with these measures. 140 thousand ha of pastures were irrigated as well (supplying drinking water to farms). Currently, the most part of these systems is inactive. Difficult economic transition period in Georgia in the recent past significantly damaged the irrigation systems in Dedoplistskaro district. Electricity transmission lines and expensive electromechanical devices were completely broken. Further exploitation of the complex irrigation systems has become impossible and to date, the majority of them are still inactive.

The majority of the irrigation canals operating on the territory of the district are connected to R.Iori which had 3 water pump stations constructed by 1990s. Water pumped from Alazani River nurtured 2 irrigation systems used for lands located on the Shirak Plain. The data of the reservoirs and irrigation systems operating at the territory of Dedoplistskaro during this period are summarized in Table 2.2.9.

[16] Turmanidze T. Climate, disaster and food security. "Universal", Tbilisi, 2010 (p. 199-208)

Table 2.10. Irrigation systems operating in Dedoplistskaro region to 1990

#	Name	Irrigation water source	Irrigated area (ha)	Remarks
1	Taribana irrigation system	R. Iori	3 222	Water supplied from the pumping stations - Gamarjveba, Japaridze located on R. Rioni
2.1	Zilicha I irrigation system	R. Alazani	5 221	Receives water from the pumping station installed at the floating ponton launched in Alazani River to second lifting pumping station, from where water is supplied to Sabatlo-Samtatskaro main canal.
2.2	Zilicha II irrigation system	R. Alazani	4 420	Receives water from the third lifting pumping station. The given system was written off by the Order of the Property Management Ministry issued on 10 December 2002 and does not operate.
3	Telatskali irrigation system	R. Iori	1 610	Received water from Machkhaani, Arboshiki pumping stations located at R. Iori. The given system was outdated and non-operational and was written off by the Order of the Property Management Ministry issued on 10 December 2002.
4	Kvemo Alazani irrigation system	R. Alazani	1 740	
	Total		16 213	

Table 2.11. Water reservoirs functioning in Dedoplistskaro region to 1990

#	Reservoir	Filling type	Filling source (river)	Volume, million, m^3	
				Total	Useful
1	Dali	Riverine	Iori	180.00	140.00
2	Kushiskhevi	Tap	Iori	5.00	4.00
3	Kranchiskhevi	Tap	Iori	1.92	1.25
4	Telatskali	Tap	Iori	1.60	1.30
5	Mtsarestkali	Tap	Iori	1.50	1.30
6	Vake	Tap	Iori	1.29	1.05
7	Zilicha	Tap	Alazani	4.50	4.00

These data demonstrate that mainly small-sized reservoirs were built at the territory of the district. The largest - Dali (Dali Mountain) reservoir was constructed in the 1980s and it had to supply the arid lands in the lower zone of Iori Plain water (approximately 1.600 ha) with irrigation. The irrigation system, which had to irrigate Iori Plain was not built. Currently, the use of this resource for irrigation is actually impossible, as its operational turret needs some rehabilitation.

Despite the existence of the irrigation systems discussed above, the Dedoplistskaro district historically suffered from a chronic shortage of irrigation water. In order to fill this deficiency, Alazani irrigation system was designed in the beginning of 1960s and the construction began in 1965. The main source facilities were constructed in the upper part of R. Alazani, in the Pankisi Gorge. From here, the canal comes in on Alazani Valley and runs along Tsiv-Gombori slopes until Papriskhevi, which is near the town of Gurjaani. From here, according to the second stage construction design, the canal had to connect to the 15 km-long channel cut in the mountain ridge and go out on the Iori Plain near the village Arashenda. After that with the inverted siphon it had to cross the gorge of River Lakbe and flow acros the Karatveli Slope on the left bank of R. Iori, ran through the 8 km-long channel under the hill and ended in the reservoir constructed in the hollow of drying Lake Ole. The size of this reservoir had to be 200 million m^3. According to the design project, the length of the canal from the main channel source to the Ole reservoir was 107 km. The main channel had to be continued from the Ole reservoir on 83 km area to Taribana-Eldari Lowland. In all, the Zemo Alazani irrigation system had to irrigate 67 000 ha area on Iori Plain, namely drought vulnerable valleys of Ole-Naomari, Taribana and Iori. Presently, the Alazani irrigation system functions to Gurjaani district. This information shows how important Alazani water resources can be for irrigation water supply of Dedoplistskaro district.

The operation of the majority of the irrigation systems existing at the territory of Dedoplistskaro district depends on the functioning of the water pumping stations, the operation of which requires a lot of electricity. They were plundered in the beginning of 1990s. In addition, the energy tariff increases and permanent energy crisis led to the inactivity of these systems[17], due to which the large part of tap water reservoirs discussed in the Table 2.2.10 is today unfilled. Consequently, 6 tap reservoirs with a total useful volume of 12.9 million m^3 have lost their function. The old irrigation systems of the municipality were plundered, they are destroyed and only a very small portion is used for watering.

General Overview of Agricultural Sector

Cereal production and livestock farming were the strategic sectors for Dedoplistskaro district in the 1980s.

Cereal production. Dedoplistskaro district was considered as one of the main cereal production traditional region. From 54 480 ha of arable land owned by the municipality, 38 000 ha was cultivated and sown. From total (61 000 ha) farm borderline arable land area, 7 000 ha was grazing arable land, where grazing barley was sown (this area was not included in turnover). Except for autumn wheat, sunflower was sown on the above-mentioned 54 000 ha. 100 000 tons of wheat and barley, 10-15 thousand tons of sunflower seeds were produced annually.

[17] N. L. Ukleba, Use of Georgia's Water Resources in People's Agriculture. TSU Publishing House, Tbilisi, 1977, pp. 334-337

During this period, massive (960 ha) 60-meter-wide windbreaks were landed that ensured protection of soil from erosion by wind and maintaining productivity; Crop rotation was a tested method, 9 field plots were used for seed turnover; Wheat and barley were sown only twice in a row, then the crops were rotated (Sudanese/Sorghum Sudanense (Pip.) Stapf., beetroot, sainfoin, alfalfa, corn).

The State seed and plant material quality inspection monitored quality of the materials, although seed was not produced locally. The inspectors monitored and selected seeds in the plots and imported the best quality seeds. The seed material was mainly supplied from Magharo, Tserovani, Russia/Krasnodar and from Astrakhan. These were the main suppliers. Afterwards, the seed materials were tested in vil. Zemo Kedi, where 90 ha of land was allocated for this purpose on the species test plot. The seed laboratory had determined all norms. The agrochemical laboratory worked full time - it determined the quality of the soil, botanized or qualitatively divided soil (a total of 10 categories).

The autumn crops were sown on 20-23 thousand ha - wheat (Uphkho-1) and barley (Mirage). Phosphoric, nitric and potassium fertilizers were used for improving the quality and productivity of soil. The average wheat hectare yield amounted to 2.5-3.0 tons, for barley - 1.0-1.5 tons. Sunflower was sown on 15 000 ha, the average hectaree yield was 800 kg. The forage crops were sown on 16 000 ha: beetroots, corn, alfalfa, sainfoin, and others.

The situation changed radically from 1990s. The collective farms collapsed. From 1992, the privatization process began, and household land plots were transfer in private ownership to all families free of charge - 0.25 ha - in towns, 0.75 ha - in rural areas. Since 1996, the lands and real estate have been given in lease, redemtion is possible from 2005.

Together with positive results, the privatization process and the plot segmentation also brought negative results. 1 500 ha of arable land and pasture just were turned into roads, lands were transferred to persons, who previously had nothing to do with the land and did not have the appropriate knowledge and experience in this area. Tillage-sowing dates were systematically violated because of the lack of equipment, seed materials, fuel shortages and high prices. Financial problems prevented some farmers to timely use fertilizers, often lands remained uncultivated. Because of the energy crisis windbreaks were destroyed, that caused a reduction in productivity and wind erosion. The soil and seed quality laboratories ceased functioning. The crop rotation regime was transgressed, as well as the practice of selecting the appropriate fertilizer based on needs. The irrigation systems were destroyed and plundered.

Livestock farming. The second strategic sphere for Dedoplistskaro municipality has been and remains to date the cattle farming, production of dairy and meat products (Suluguni, butter, sour cream were produced). In the 1980s, the artificial insemnification station was functioning, where the cattle breeds were improved (breeds: Caucasian Brown, Velistsiteli, Shavchreli). Collective farms had up to 130 sheep farms with 125 000 sheep. 375 000 kg. of wool was produced annually. Up to 100 cattle farms and 6 livestock farms managed 18 000 cows annually, the pig farms produced 35 000 pigs per year; 65 000 tons of milk and 17 000 tons of meat were produced and passed to the state annually. Poultry farms grew and produced 1 050 000 chicken wing and 30 000 000 eggs annually.

During this period, 122 000 ha of pasture land were listed on the balance of Dedoplistskaro. Shiraki and Eldari winter pastures were considered to be a major resource. Cultivation-technical jobs and shrubs cleanup was regularly carried out. The combined forage, wool, and leather was produced.

After the breakup of the collective farms, a part of the pastures were sold along with the farms, the rest was transferred to the Ministry of Economy. Almost every town and village has so called the pasture of common use in a permanent use, which is used for the village herd. Nobody has the responsibility for the protection and rehabilitation, or on sustainable management of the pastures on the balance of the Ministry of Economy and in the common, this is why they are not renovated (fertilizers, surface processing, sow), pasturing with plot rotation, observing the grazing balance, which led to overgrazing. Reduction in grass cover and contamination with weeds, consequently, pasture degradation as a result of climate change and intensification of land degradation were added to this. Even today, preventive and restorative measures are not implemented either on private or community used pastures. Disinfection barriers, drinking places, transfer routes are to be put in order.

Viticulture. Viticulture was the strategic area after the perennial crops. Vineyards were planted on 8 500 ha, mainly in Taribana and Zilicha, Alazani Valley, Shiraki, Vake-Taletskari and Arkhiloskalo. 20 ha area was irrigated, the average hectare yield was 10-15 tons, Taribana, Sabatlo, Pirosmani vineyards were distinguished by high saccharinity. Grapes were sold to Pirosmani, Kvemo Keda and Dedoplistskaro wineries.

Impact of climate change on Agriculture

Observations at the Dedoplistskaro meteorological station demonstrated that in comparison with the years of 1961-1985, in 1986-2010, the start (the move to 5 ^{0}C) of the autumn wheat vegetation period in this district has been postponed by 3 days and has increased by 3 days, which is accompanied by the very serious increase in the total temperature sum (by 213 ^{0}C).

Such a huge increase in the sum of active temperatures is caused by the increase of extremely hot days (SU30) with 17 days in the second period. Precipitation in the vegetation period virtually has not changed. At this background, severe and extreme agricultural droughts have significantly increased.

The impact of **water shortage** on wheat, sunflower and corn production was assessed for climatic conditions of Dedoplistskaro district. Despite the fact that for winter wheat AcquaCrop (FAO) model demonstrated 39% loss of water in the second observation period (1986-2010), based on the observation results of the same model, which also forecasts production and determines the correlation of various parameters and the crop-production, it was concluded that the result of the winter wheat crop reduction by 7% in that current period was not determined by water loss so much, but by incorrect land exploitation and inconsistent management.

It should be also mentioned that the model does not assess the impact on the yield production of such important climate factors, as extreme events: floods, hail, strong winds, etc. They should be certainly taken into account when making the final conclusion. Particularly, it is well known that the negative impact of climate change on the cereal production in Dedoplistskaro district mainly takes place during spring, in the period of high winds, the maximum values of which in the period of 1986-2010 increased on the average from 34 m to 40 m and this happens when the windbreaks are almost destroyed and they were not rehabilitated yet. Salinization of soil also has a significant impact on the reduction of cereal production.

In the selected climate change scenario (A1B) [18], which was used in this assessment, potential wheat, sunflower and corn production in Kakheti for the period of 2070-2100, will presumably increase (to 70% in case of autumn wheat production) despite the reduction in precipitation, which will be determined by the increase of CO_2 concentration in the atmosphere[19]. The forecasted precipitation decline effect, according to this analysis, is relatively small. According to FAO assessments, increased temperature and CO_2 concentration (which is considered as the main mechanism of climate change) will have much more impact on the yield productivity (at the background of unchanged growth cycle) through the increased effectiveness of water use and collection of biomass.

Despite the fact that wheat relatively better resists dryness, unlike sunflowers, which was one of the leading crops in Dedoplistskaro, the hectare yield of both crops decreased in the second period: wheat by 7% and sunflower by 24%.

In general, during the last 25 years, the slight increase in the average annual precipitation (by 0.8%) and air humidity (by 3%) are observed. This increase is not equally distributed on seasons, we observe 22% decreases during spring. At the same time, the number of heavy precipitation days has increased (more than 20 mm precipitation during the day and more than 50 mm precipitation daily for 3 days). The daily maximum precipitation has increased by 67% during last 25 years.

The increase in heavy precipitation significantly reduces the process of water accumulation in soil, which is determined by the heavy mechanical soil composition and soil heel[20] generated by mono crops and often ploughs. As a result, the amount of the runoff water on soil surface increases. In relation to precipitation, if this process continues, which is forecasted by future prognosis (the maximum daily precipitation increases in the summer and autumn on the background of the reduction in the total annual precipitation), sharp intensification of the salinization of soil cover on quite large part of the municipality is expected, promoted by its unfavourable ameliorative characteristic, namely, strata developed in deeper levels of soil containing sulphate salts (gypsum, mirabilis) and uncontrolled irrigation.

It should be noted that the climate change and temperature increase have significantly reduced the **incidences of hail** in recent years, but they were replaced by heavy rains, therefore, for some of the crops, Dedoplistskaro municipality has become less risky.

[18] http://www.ipcc.ch/ipccreports/tar/wg1/029.htm

[19] http://www.fao.org/nr/water/aquacrop.html

[20] If soil tilling is performed at the same depth (for the last 20 years), the tilling cover buttom is ramed and so called "heel" or a rammed, pressed layer of soil is established. Heel hampers correct development of the root system in the active layer and consequently, the use of moisture and elements dissolved from the deep layers.

On the background of rising **summer temperatures and reduced precipitation**, Dedoplistskaro faces a significant risk of frequent droughts. During 1986-2010, 11 more cases of extreme drought occurred on the territory of Dedoplistskaro in comparison with the previous 25-year period. These changes especially had a negative effect on sunflower, the area of which decreased by 40% and in general, on the intensification of soil degradation.

According to the velocity, the winds in Dedoplistskaro municipality belong to the II group of strong winds, which are mainly prevalent in February-March. During the year, north-west and western winds (57%) are dominant, while in the warm period southern winds are prevailing. The average speed of the dominant winds is 5-8 m and for other winds it varies in the range of 1.5-2.5 meters. The analysis of the winds with maximum speed demonstrated that this type of winds and their speed have especially increased in spring and this speed during the last period reached 40 m. There are cases, when the dominant winds uprooted and destroyed thousands of hectares of sown plots with autumn and depleted spring crops, perennial trees, vineyard harvests, etc.

In 1960s, the windbreaks were planted on 1 770 ha (width: 60m and 10m) in order to protect agricultural areas and pastures from the high winds. After the break down of the Soviet Union, 99% of these windbreaks were logged, that was mainly caused by the energy crisis. As a result, more than 5 000 ha, damaged by wind erosion is abandoned for the time being and is not cultivated. Together with the energy crisis, a negative practice of burning stubble, which damages useful microflora of arable plots, also contributed to the eradication of windbreaks. The result of erosion by wind is degradation of 89 000 ha of soils in Dedoplistskaro and the start of the desertification at some places.

In 2009-2011, windbreaker rehabilitation works were implemented in the district. The German government supported the municipality in these works. The project together with the Ministry of Environment and Natural Resources was implemented by the Gesellschaft für Internationale Zusammenarbeit (GIZ) and the local government. The local non-governmental organization, the registered union "Association for the Protection of Agricultural Environment" also participated in the implementation of the project.

During the last 25-year period, on all seasons, except winter, the increase in the absolute maxima of temperature was reported (with the biggest difference in summer +3 ^{0}C). At the same time, the number of the extremely hot days (SU30) in the summer increased by 16 days and the tropical nights (TR20) by 5 days. According to the forecast, this trend will continue in the future and by 2050, the district will become even warmer and droughty at the background of constantly unchanged precipitation. In particular, the number of tropical nights will increase 3 times.

In conditions of non-existence of forests and windbreaks, such changes in temperatures will potentially result in stimulation of soil degradation and desertification processes at the territory of the municipality (Eldari Plain, Didi Shiraki, Patara Shiraki, Taribana, Patara Taribana, Jeirani, Kasristskali, Natbeuri, Nagomarebi and Chachuna plain hollows and the hilly line connected to them).

Intensification of desertification processes will surely entail broadening areas of semi-desert and desert landscapes, hindrance in the growth-development of agricultural crops, significant decrease in yield, thinning out of plots and plants in unirrigated conditions are expected, and in cases of continuous (atmospheric) drought, aridity index will increase.

The impact of climate change on the cattle farming sector is especially observed on the change in food quality. Root plants for livestock forage are sown on 954 ha, silo crops on 6 821 ha, one year grasses on 1 560 ha, perennial grasses on 5 211 ha. Pastures occupy 22 000 ha. In addition, hay is produced on the stubble of autumn crops. The produced hay contains sorghum in large quantities, which unlike to other cereal crops is characterized by relatively low sustenance. Sorghum dominates on the stubble as it is perennial, drought resistant and actively is developing in July-August (when autumn grain crops are already harvested). It is noteworthy that in a number of cases, especially on unirrigated, extreme drought conditions, it contains alkaloids in high quantities and may cause cattle intoxication, in certain cases, even lethal results. Hay harvest significantly depends on summer precipitation, which in Dedoplistskaro is reduced by 22% against the background of slight increase in total annual precipitation sum. Thus, hay business becomes quite risky and unstable.

The municipal herding trails occupy 1 383 ha, from this number, 258.9 ha are for resting of animals, and the total rout length is 159.4 km. More frequent and severe droughts results in the reduction of the debet of animal drinking water sources and in many cases, in their disappearance. There are also the serious problems related with the bathing of animals. The deterioration of already scarce infrastructure, which in turn promotes explosion and dissemination of diseases, contributes to increasing discontent of the population living on the territories along the routes.

The village borderline common usage pastures existing in the municipalities traditionally are the plots with insignificant area, which are scattered around the village and cannot even minimally satisfy the need for cattle forage. In the winter period, these areas are loaded with large quantities of cattle. They mainly are concentrated near drinking water sources. Consequently, they are not distributed equally on existing pastures.

Uncontrolled grazing and as a result, overgrazing takes place on the territory of the municipality. The crop rotation does not take place on mowing pastures. Their radical or superficial improvement has not taken place for a long time. Because of the overgrazing, we observe thinning out of edible grass, grass cover is weakening, bare spots appear on soil surface, non-edible, and weed plants are strengthened. As a result, pastures are weakening, its soil is easily subject to erosion processes.

Along the increase in the vegetation period, which has been already detected in Dedoplistskaro district, the cattle grazing period will increase, which will save the winter forage (hay) and decrease expenditures on livestock forage and increase productivity.

Recommendations

In order to avoid ongoing and anticipated problems of related with climate change, it is necessary to implement the following activities for the municipality:

- Restoration-construction of windbreaks for protecting agricultural lands from droughts and winds and decreasing erosion by wind;
- Planting of artificial forests for the rehabilitation of soil damaged by wind erosion and protection of surrounding areas from drought;
- Arrangement of windbreaks and forest small woods for suspension of erosive processes on mountain slopes, forest groves, territories surrounding villages;
- Provision of the district with drought-resistant, fast-growing tree plants creating windbreaks (establishment of local plant nurseries);
- Rehabilitation of the existing irrigation systems on the territory of the municipality applying modern technology (fertigation, mulching, drip irrigation, artificial rain irrigation) and their proper operation and maintenance;
- Rehabilitation of the wells existing in remote areas from the irrigation channels and efficient, economical use of ground water, construction of new canals for the irrigation of agricultural crops and hay-pasture areas and for livestock drinking water;
- Development of the regulation plans for wells, groundwater and leachate;
- Implementation of systematic soil-protection agro-melioration measures; cultivation of ground in the autumn-winter period at the maximum extent;
- Introducing the practice of seederation, crop rotation, mulching and intermediate crops (rapeseed, turnip, mustard, vetch, oat peas, annual clover, etc.). Testing of modern ecological technologies of soil cultivation (direct drilling, chiseling, etc.) and their selection according to local conditions;
- For improving soil quality, dissemination of perennial crops, for instance sainfoin is recommended, which grows well on degraded soil, survives through and enriches soil with nitrogen. This is why it is a good predecessor to wheat. In cattle farming it is used for preparing sappy forage with silo and haylage. It is mowed twice a year and hay produced from it is quite highly productive and expensive. Introduction of this culture in practice and its multi-use will decrease expenses of the farmers and will bring more profits to them.
- Testing of various capacity, ecologically advisable soil-processing aggregates (chiselling, combined aggregates, unploughed plots) in concrete natural climate conditions and introduction of the best ones in practice (across the municipality);
- Testing of drought resistant annual and perennial crops, selecting and organizing of their seed production in the municipality. Testing and identification of autumn, drought-resistant cultures and varieties, research-introduction of their varietal agro-equipment for non-irrigated, as well as irrigated plots;
- Development of the pasture management plan for the municipality, which will cover the following issues: Determining the terms for grazing on mowing land by taking into account the establishment of time-limits for grazing and 15-20 days shall be left so that grass cover survives winter well; The interval of 20-30 days shall be observed for the repeated grazing. The use of special hummock chisels and rollers against hummocks shall become mandatory as

well as sowing on unaffected and bare soils. The regulation of pasture loads. To eradicate a harmful practice of burning stubble (which damages useful micro flora of arable plots, also productivity of the upper layer of soil) by tightening legislative and administrative measures. Arrangement of the infrastructure livestock herding routes (resting places, shady, drinking and washing places, etc.), which will significantly decrease pasture degradation and spread of diseases;

- Development of highly profitable livestock farms as a priority field. For the development of sheep production, it is recommended to organize genetic centre and breeding farms, where the selection of Georgian sheep variety will take place using modern technologies;
- Electrical supply of farms is necessary with the use of renewable energy sources (sun) and arrangement of access roads to farms;
- Capacity building of the personnel at the Information-Consultation Centers established in the municipalities, their provision with modern technologies (laboratories, internet, etc.), relevant methodologies, learning materials and literature.

2.2.4. Telavi Municipality

Location and borders. In the east, Telavi municipality is bordered by Kvareli municipality, in the north-east it is bordered by Dagestan Autonomous Republic of the Russian Federation, in the north-west by Akhmeta municipality, in the south-east by Gurjaani municipality and in the south-west by Sagarejo municipality. The area of Telavi municipality is 1 094.5 km^2.

Relief. The central part of Telavi municipality is spread on the Alazani accumulative plain, which from the geological point of view represents tectonic unit. It is bound by Tsiv-Gombori Ridge in the south and by Kakheti's Greater Caucasus in the north-east. The height of the plain within the municipality reaches 400-500 m.

Gombori Ridge invades the south-western part of the municipality, which is built with Mesozoic and Cenozoic layers. The highest peak of the Gombori Range – Mt. Tsivi (1 991 m) is located on the territory of Telavi municipality, which is built by mio-pliocene unconsolidated sediments - conglomerates, clays and sandstones.

Soils. Meadow-forest carbonate-free alluvial soil is developed on the left bank of Alazani and carbonate alluvial soil on its right bank. Brown soils are developed in the foothill zone. Grey forest soil is widespread under the broad-leaved forest in the lower part of Kakheti's Caucasus Range and ridge slopes. Humus-calcareous soils are found on the limestone conglomerates of Gombori Ridge. These soils are especially suitable for viticulture and fruit production, also for cereal production and essential oil production in relevant micro-zones.

Rivers and irrigation systems. R. Alazani is the main hydrological artery of Telavi municipality (length – 38 km). An important hydrological unit is also the Lopota River (length – 33 km), which sometimes is torrential.

136 ha of agricultural lands in Telavi municipality are irrigated by the Kvemo Alazani irrigation system, the rest of the lands are irrigated by Zemo Alazani irrigation system.

In Shida Kakheti, except for Kvemo and Zemo Alazani engineering type irrigation systems, there are many non-engineering or semi-engineering type irrigation canals, which are fed by Alazani River and its tributaries.

The Lopota (Vedreba) irrigation canal is fed by R. Lopota. The source facility is built above the river tributary, at the distance of 2 km. From the source, the channel rout runs at the upper part of Alazani Plain, after 7 km it connects to Alazani River from left side. It irrigates 1 670 ha of Napareuli lands in Telavi municipality. Telavi district, except for the given channel also uses smaller canals, sources and springs, which irrigate the total of 5 860 ha area.

Didkhevi and Saniore irrigation channels are fed by R.Didkhevi, which is the right tributary of Lopota River. The source facility of both canals is built on R. Didkhevi near the village Artani. The distance between them is 2 km. The Didkhevi irrigation channel starts slightly above of Artani, it runs in the direction of south-west. After 6 km, near the village Jughaani, it connects to Naurdali channel from the left side. It irrigates 570 ha land in the village Pshaveli. Saniore irrigation canal is fed from the right bank of Didkhevi River, slightly below of village Ardaani. This channel irrigates 530 ha land area in the village Saniore. Turdo irrigation channel is nurtured from the water intake facility constructed on the left bank of R. Turdo near the village Vardisubani. On the left side of R. Jermidi, it moves to the right side of R. Turdo with water pipes. It irrigates 27 ha of lands in villages of Karajala and Ruispiri.

General Overview of Agricultural Sector

Currently, there are 63 farmers' organizations in Telavi municipality, where 39% of employees are female. The average monthly income per capita is 650 Lari. The total number of municipality population is 70 340 people. The total area of the municipality is 1 094.5 km², the agricultural land area is 28 539 ha. The pastures occupy 4 260 ha. The number of small farms, which have an area of less than 1 ha is 17 181 households.

Viticulture. Determined by natural climatic conditions of Telavi municipality, viticulture-wine production is the most common traditional field. From the grape varieties, Rkatsiteli, Saperavi and Mtsvane are mainly represented. According to 1986 data, from 39 000 ha of agricultural lands viticulture occupied 10 300 ha, which produced 70 000 tons of grapes, an average of 6.8 tons of yield per hectare. Changes in the last two decades have greatly altered the data. Currently viticulture is represented by 4 thousand ha, where 26 thousand tons of grapes are produced (6.5 tons of yield per hectare). As can be seen from these data, the hectare productivity has not changed much over the years. It should be noted that the high productivity of grape and the wine quality are in inverse dependence with each other. Therefore, when the emphasis is put on high quality wine production, the productivity moves to the back corner. Due to the recent restoration of relations with Russia, active shifts for the further development of the sector are observed. Namely, a tendency of planting new vineyards is obvious due to the increased demand for wine.

The vineyards cultivated in the municipality are represented according to the following varieties: Rkatsiteli - 2 730 ha; Saperavi – 1 200 ha and hybrid varieties - 250 ha.

The vineyards are distinguished by large areas, for instance, Telavi Wine Cellar in the village Kondoli-1 – 260 ha, GWS in the village Akura – 300 ha, Grigol Vashadze and Brothers in the Village Tsinandali – 360 ha, Paata Burchuladze in the village Tsinandali – 324 ha, Kakheti Wine House in the village Saniore – 360 ha. Besini Ltd. in the village Kondoli – 192 ha, Ltd. Schuchmann Wines Georgia in the village Naphareuli – 150 ha, etc.

The average annual per hectare yield according to the varieties are as follows: Rkatsiteli - 6-8 tons/ha; Saperavi - 8-12 tons/ha and hybrids - 10-14 tons/ha. Processing of the average of 50% of the yield takes place in the municipality wineries; the rest is consumed by manufacturers. Currently planting of new Rkatsiteli and Mtsvane vineyards are underway, but Saperavi is still on the advanced position with export figures and its prospective development. The wine cellars of well-known wine companies are mainly concentrated in Telavi district, starting from a peasant and finished with the medium-size and largest wine production companies. These are:

- Georgian Wines and Spirits Company Ltd (GWS-Georgian Wine & Spirit), one of the first and premium-quality Georgian wine producing companies. Represents a branch of the "Pernod Ricard Europe" group in Georgia.
- Ltd. "Telavi Wine Cellar" – also, one of the first and premium-quality Georgian wine producing companies;
- JSC "Teliani Valley" - one of the most recognizable brand in Georgia and beyond;
- Ltd. Wine Company "Shumi";
- Ltd. “Tsinandali Old Cellar” (Vazi 1);
- Ltd. “Kakhuri”;
- Georgian Wine Corporation Ltd. (CGW);
- Ltd. "Besini" - quite promising project. The company was founded and is already producing wine from its own vineyards. The cellar is already under construction;
- Ltd. "Vinotera", a small, but premium-quality, typical Kakhetian wine cellar;
- Ltd. Tsinandali Winery”;
- Ltd. "Teliani Winery 1950", the cellars with history and traditions. The best wines of all times were produced here. Today, it does not have own production;
- Ltd. "Telavi Wine", the cellar of the former research institute. It does not have own production;
- "Akuri Winery", the cellar of the average size and quality;
- Ltd. “Naphareuli 1890” (Napareuli winery);
- Ltd "Kakheti Wine House" (Saniore Winery), located in the Naphareuli micro-district, a well-equipped cellar with small load;
- Ltd. "Napareuli Old Cellar", a manufacturer of high-quality wines, a small local cellar;
- Ltd. “Schuchmann Wines Georgia” and etc.

Wine production. Georgian and foreign businessmen established a grape nursery in Telavi municipality - Arivie-Georgia, which produces Georgian and foreign grape saplings in line with the European standards. A part of the saplings produced here is exported and the rest is sold locally. This is the only modern plant nursery not only in Georgia, but in the whole South Caucasus, this is why its capacity is not enough for satisfying present needs. Two or three additional large plant nurseries and peasant farms are also operating in Kakheti. In general, it could be said that the full technological production cycle is abrogated in them and the high-quality wine production is thus virtually broken. This is the most urgent and serious problem for Kakheti viticulture. Without its solution the development of viticulture in Kakheti is hard to imagine.

Pomology. In the early period, fruit production was well-developed in Telavi district and rural farms were represented with spermatophytes (apples, pears) and drupe (peach, plum, etc.) crops. In the 1980s, they occupied the area of 604 ha and an average per hectare productivity amounted to 3.6 tons. The harvest was basically handed over to canneries for processing. Today, these factories no longer exist. Fruit production is represented with the individual plantations of the population. New areas are mostly covered with nut plantations, peaches, apples and vineyards, while the arable land area is occupied by wheat, barley, sunflower, corn, potatoes, watermelons and melons.

Animal husbandry. For 1986, from 21 village of the district, livestock, as well as sheep and pig production was represented at the large scale almost everywhere. In the farms, where the livestock was represented with low-productive forage cattle, livestock production was not a profitable field, which was determined by the outbred cattle and the lack of the forage base.

Despite the fact that hay, straw, haylage, fodder, etc. were produced, it still was not enough for ration replenishment. It should be also noted that a number of farms imported Switz heifers from Belarus and various districts of Russia, the production of which reached the best outcomes and was profitable after filling the food ration (this happened when the heifers produced 2 500-3 000 L of milk annually). At present, there are no large livestock farms in the district. Several medium-size farms are in almost every village, which have pure-bred, as well as mixed cattle. In addition, every family has one or more cows. The products manufactured in these farms satisfy the district's needs.

Table 2.12. Indices of volumes for various livestock farming fields in Telavi municipality

Animal category	1980s	2012-2013
Cattle (head)	13 000	15 400
Pig (head)	17 600	7 600
Sheep (head)	37 000	44 700

Cereal Production. According to 1986 data, the following cereal crops were grown in Telavi district - wheat -1 806 ha (harvest on 1 hectare - 2.66 tons), corn - 410 ha (3 ton/ha) and barley -775 ha (1.87 ton/ha).

Corn has the most interesting trend in Telavi district (Table 2.2.12). In the previous period it produced quite low harvest as was mainly grown on the same area and also, the sowing the seeds had not been properly updated. This was a general trend not only in the Kakheti Region, but across the country and was determined by seed material poor quality and the low-technological development. At present, maize is grown on quite large area of the municipality at the expense of reducing the vineyard areas, the imported seed materials are renewed and in some cases, the yield levels are high. Currently corn production is one of the leading fields in Telavi.

Regarding wheat production, the wheat growing areas have decreased, as well as the hectare yield (from 1.8 tons to 2.6 tons).

Horticulture. During the Soviet era, the following vegetable crops were produced in the districts: onions (11.0 t/ha), tomatoes (17.8 t/ha), cucumbers (11 t/ha), garlic (5 t/ha). To date, these crops are grown in every village, which meets the requirements of the local population.

Melons. In 1986, the following melons were prevalent in Telavi district: watermelon, melon and pumpkin. The average yield was 16 tons per 1 ha. Today, these crops are grown individually.

Table 2.13. Changes in the agricultural crop productivity and areas in Telavi municipality

Year	**1986**		**2013**	
Agricultural crops	Area (ha)	Yield (t/ha)	Area (ha)	Yield (t/ha)
Vineyard (grape)	10 300	6.8	4 000	6.5
Fruit	604	3.6	1 503	4.5
Wheat	1 806	2.6	1 370	1.8
Corn	410	3.0	7 044	7.0
Vegetable crops	128	11.0	583	12.0
Melons	95	16.0	55	15.0

In the Soviet period mechanization was represented in the form of fleet of tractors applied to collective farms, which today no longer exists. Technology today is in individual ownership, but Mechanization Centers of the Ministry of Agriculture have been established in the recent years, which contribute to the development of this field.

During the last century, rose production has been one of the most successful branches of economy in Telavi municipality. Rose plantations and consequently, production of rose essential oil from rose petals has been mainly used in perfumery. Produced rose oil was even competitive vis-à-vis to similar French production. Telavi was leading not only with the production scale of essential oils throughout the country, but also with its quality. The plant variety, soil and the existing climate determines production quality and the location of Telavi district is a prerequisite for the production of premium quality essential rose oil. According to the 1986 data, the rose plantations occupied 200 ha area. The total rose oil production equaled to 250 kg. Thousands of people were employed in picking the rose petals. In 1968, the Fourth World Congress of essential oils was held in Telavi Factory. To date, the rose plantations remain only on 7-8 ha area. The rose oil production is stopped as the processing plant was destroyed.

Impact of Climate Change on Agriculture

Temperature. According to an analysis of the climate elements variability, between the periods of 1961-1985 and 1986-2010, the average annual temperature in Telavi municipality increased by +0.4 ^{0}C, and in comparison to 1932-1960 period by 0.7 ^{0}C. Warming takes place at all seasons and is the highest in summer (+0.8 ^{0}C). The observed warming is stable and trend is confirmed in summer and autumn, as well as the average annual value.

The absolute maximum temperature has increased on every season except for winter. An increment at the summer-autumn seasons reaches +2.2 ^{0}C. The absolute minima in winter and summer have significantly (+3, +4 ^{0}C) increased as well. The average daily temperature amplitude has increased within 0.3-0.5 ^{0}C at every season and this increases the risk of plant stress.

Precipitation. Annual total precipitation between these two periods was decreased by 3% (21 mm) in Telavi. As for the daily precipitation maxima, the decrease in absolute values is observed in all seasons except autumn, while 12% increase is observed in autumn.

The annual and seasonal relative **humidity** values remain virtually unchanged between the two periods and vary within 70%. Thus, between the two discussed periods, the temperature increase is highest in summer on the territory of Telavi municipality (+0.8 ^{0}C). Summer precipitation significantly decreased in summer (-17%), but significantly increased in autumn (+12%).

From agroclimate characteristics, the duration of the **vegetation period** for the threshold temperature of 10^{0}C between the two discussed periods increased by 3 days and consequently, the sum of active temperatures also increased by 123 ^{0}C. Total precipitation during the vegetation period was reduced on average by 5%. For the threshold temperature of 12 ^{0}C, the length of the vegetation period increased for 2 days and the sum of active temperatures rose by 115 ^{0}C, while the total precipitation was also reduced here (9%). The length of the frost-free period on average decreased by 9 days, that significantly reduces the risk of night frosts.

From extreme events, it should be noted that the number of very hot days (SU30) increased by 10 days per year (mainly in summer) in the second period. The amount of maximum precipitation during 5 consecutive days increased by 25% in summer and by 24% in autumn. Such an increase in the amount of maximum precipitation for 5 consecutive days causes soil degradation and land erosion on the banks of the rivers. The increased number of very hot days and drought during the vegetation period against the backdrop of reduced precipitation (by 9%) rather increases the risk of reduction of the moisture-loving (water intensive) corn crop productivity.

The Viticulture-Wine Making Research Institute traditionally existed in Telavi, where systematic observation of the soil, climate, plant and other biological changes took place and scientific recommendations were worked out. In addition, soil and plant protection laboratories also were operating. Today, these laboratories are no longer operational.

The recent climate change has led to the activation of a variety of pest diseases, which poses a threat to the vineyards, as well as the grain production, rose production, etc. For instance, 30-50 years ago, there were only few cases of grape tick and scale bug observed in viticulture and wine making. The recent temperature increase resulted in their activation to the level that it is necessary to actively fight against them, not only because of the danger posed to crops and its quality, but to the life of the plant.

The devastating natural disaster of 19 July 2012 (the disasters of a similar scale has not been observed for centuries) seriously damaged agriculture and most of all, viticulture. Generally, once inactive hail has again become stronger and prevalent in Telavi in the last 4 years.

Recommendations

The problems on the territory of Telavi municipality that are caused by the current and expected climate change are similar to the problems in Gurjaani and Kvareli municipalities – hail and land erosion caused by heavy rains should be underlined. In addition, the need for the irrigation systems should be also emphasized in the conditions of increased pace of the cultivating corn areas. In order to avoid these risks, the municipality should implement the following activities:

- Importing modern hay suppression technologies and introducing other insurance measures. State intervention is especially important.
- Rehabilitation of the existing irrigation systems on the territory of Telavi municipality using modern technologies (fertigation, mulching, drip irrigation, artificial rain irrigation) and providing their proper operation and maintenance;
- In connection to increasing the corn producing areas, testing of various capacity, ecologically advisable soil-processing aggregates (chiselling, combined aggregates, unploughed plots) in concrete natural climate conditions and introduction of the best ones in practice (across the municipality);
- Supporting the private sector (by offering modern technologies) in the restoration of the rose and other essential plantations (and in general volatile oil production) in relevant micro-climatic zones, which in turn will reduce soil erosion and increase a carbon absorption reservoir;
- For the fruit production development, it is recommended to establish the relevant nurseries equipped with modern technologies, which will enable the farmers and the peasants to grow virus-free seedlings;
- Mechanisms/means shall be found to support the private sector in sharing the knowledge about the modern technologies to the farmers;
- Capacity building of the personnel at the Information-Consultation Centers established in the municipalities, their provision with modern technologies (laboratories, internet, etc.), relevant methodologies, learning materials and literature.
- Facilitate the process of establishing cooperatives.

2.2.5. Lagodekhi municipality

Location and borders. Lagodekhi municipality is located in the far east of Georgia. It is bordered by Dagestan Autonomous Republic of the Russian Federation to the north; by Azerbaijan in the east, Sighaghi and Dedoplistskaro municipalities in the south and the south-east, Gurjaani municipality in the south-west and Kvareli municipality in the west. It is located on the Alazani Plain and the southern slopes of Kakhetian Greater Caucasus.

Relief. The area of the municipality covers 890 km. It is diverse with its natural-geographic features. A significant part of the territory belongs the State Forest Fund (17 823 ha) and the Lagodekhi State Natural Reserve (24 258 ha), which with its flora and fauna is one of the unique places in the world. Lagodekhi municipality is mostly the agricultural region. 68 settlements - 1 city and 67 villages are located on its territory.

Soils. Mountain-meadow turf soil is developed in the high-mountainous part of Lagodekhi municipality (500-3 000 m. ASL) Forest gray soils (weakly unsaturated, acidic and podzol). A large part of this area is covered by forests and grassland-pasture. The upper part is covered with light-colored brown forest soils. Meadow alluvial carbon-free soil (alluvial acidic and alluvial saturated) is developed on Alazani plain (200-500 m ASL).

Alluvial-pro-alluvial soil is found on alluvial fan and trains. Soils are especially good for vegetables crops and melons, as well as for volatile oils crop production that was well-developed in the past.

Rivers and irrigation systems. Lagodekhi municipality is rich in internal waters. R. Alazani creates a main hydrographic network, which flows at the border of Sighnagi and Gurjaani municipalities. Kabali, Matsimistskali, Lagodekhistskali, Areshi and Apeniskhevi rivers are to be highlighted from other rivers.

R. Kabali is born on the southern slope of Kakheti Caucasus. Its length is 48 km, the catchment area is 391 km². It is one of the tributaries of R. Alazani. Matsimi River also flows through the municipality, which connects to Alazani from the territory of Azerbaijan (its length is 19 km). R. Lagodekhistskali is an important tributary of the river, which is 31 km in length.

The highland part of the left side of Alazani River in Lagodekhi municipality is relatively reach (Lagodekhi town – 1 070 mm) in precipitation, and equals to 646 mm in Alazani Plain and the foothills zone. Warm air masses and the drought period invade from the south-west. Irrigation is necessary at this time. Abundant tributaries of the left side of River Alazani are mainly used for the irrigation.

The source facility of Kabala's irrigation channel is built on the river Kabala, on the right side of Lagodekhi-Kvareli Highway, little bit above the village Kabala. A small capacity hydro power plant is built here. The irrigation canal runs to the south to the village Vardisubani. Its length is more than 14 km and irrigates approximately 1 730 ha land area of Kabala and Orjonikidze villages.

The Baisubani irrigation channel is fed by the left side tributary of Chartliskhevi River and Baisubni River, as well as by the source facility of the right side of the tributary. The channel runs at the length of 10 km to the south-west between the rivers of Kabali and Baisubani and irrigates 660 ha of lands in the villages of Baisubani and Teli. The irrigation canal named after Budioni is nourished from Chatliskhevi River. From the source facility it flows to the south and irrigates 1 260 ha of agricultural lands in the villages of Budioni and Tamariani. Shroma-Kavshiri irrigation canal is fed by R. Shromiskhevi River. From the right bank it flows to the south on the right side of the river and irrigates 1 140 ha of lands in Shroma and surrounding villages. Lagodekhi irrigation channel is nurtured by R. Ladogekhistskali. The source facility of the channel is built at 2 km distance from Lagodekhi town. Here, a small-scale Lagodekhi hydro power plant is also located, which supplies electricity to the Lagodekhi regional center and surrounding farms. Lagodekhi irrigation canal receives water from the left water pumping station of the source facility, runs to the south-west on 9 km and reaches until the border with Azerbaijan. It irrigates 920 ha of lands belonging to the farms located in the district center. Except this irrigation channel, streams, ravines and springs are also used for the irrigation of agricultural lands in Lagodekhi district. These sources irrigate 2 370 ha area.

General Overview of Agricultural Sector

16 collective farms and 1 Soviet farm were functioning in Lagodekhi district during the Soviet period. In addition, the experimental nursery was also functioning, where together with other crops, subtropical plants-citrus fruits were also bred. Tobacco fermentation, essential oil, cheese-butter and canning factories were also successfully operating.

During Soviet times, the following leading fields in agricultural sector were developed:

Tobacco production, viticulture, fish production, production of volatile oils (geranium, basil/ basilica, rose), cereal production (wheat, corn), production of melons, cattle farming, fish production (lake fish, trout), horticulture, pomiculture and apiculture.

After the collapse of the Soviet Union, crops, such as tobacco, essential oils, as well as silk were altogether dropped out of agricultural production. The collapse of collective farms and decentralization contributed to the disappearance of the leading sectors, after which the land privatization began. A lack of access to challenging/highly developed technologies at the level of small farmers and peasants influenced their discontinuation, the small farmers started to cultivate the crops, which were more accessible to them. At this point, a great attention is paid to the kiwi production. Kiwi now occupies a total area of 15 ha and its hectare productivity is 75 tons.

In the past, cereal production (corn, wheat, barley) was the leading field in Lagodekhi municipality, followed by melons and vegetable production. Currently, both fields have moved to the leading position, they are one of the main sources of income for the population. The areas designated for the production of melons (watermelon) areas have grown twice and more as have increased their hectare productivity (from 40 t/ha - to 55 t/ha present). As for the vegetables, the area used for vegetable production is almost the same, but the yield has doubled. It is followed by cereal and in particular, corn production, which showed the best results in Lagodekhi municipality, where the yield from 4 t/ha reached the current level of 6 tons per hectaree. In 2012, corn was produced on 7 000 ha. In 2013, the area was increased to 10 900 ha. During the Soviet period, the area designated for it was twice less (5,000 ha). At the same time, the government organized a corn drying facility, which contributed to the development of this sector in climatically favorable areas.

Another important trend is the greenhouse vegetable production. Lagodekhi district is distinguished in Eastern Georgia with its mild climate. The population uses this advantage and produces the non-seasonal vegetables, such as cucumbers, tomatoes and eggplants in polyethylene covered greenhouse structures without heating. At the same time, the number of the nut crops orchards, such as nuts were increased. Taking into account that Georgia is one of the world's leading hazelnut producing countries and the demand on the market increases every year, it is quite promising direction.

As already mentioned, in the recent years, the vegetable crop sown areas and the production capacities tripled in comparison with the 1970s, that can be explained by the high demand existing on the market and introduction of modern production technologies. At the expense of growth of these cultures, the replacement of the production of products, such as roses, tobacco, mulberry plantations, etc. took place. Data related to the agricultural production volumes and productivity in Lagodekhi municipality are given in Tables 2.2.13-2.2.16.

Table 2.14. Agricultural production yield in Lagodekhi municipality (t/ha)

N	Product Name	1980s	2011-2013
1	Grape	7.5	5.0
2	Wheat	3.0	3.0
3	Corn	4.5	6.0
4	Melons (watermelon)	40.0	55.0
5	Tomato	7.0	15.0
6	Cucumber	7.0	15.0

Table 2.15. Total Agricultural Production in Lagodekhi municipality (t)

N	Product Name	1980s	2011-2013
1	Grape	12 000	7 600
2	Wheat	4 000	1 308
3	Corn	23 000	65 340
4	Melons (watermelon)	21 000	71 500
5	Tomato	6 330	11 925
6	Cucumber	9 500	21 300
7	Tobacco	6 750	-
8	Geranium	4 000	-
9	Basilica	6 100	-
10	Rose	625	-
11	Silk	320	-

Crops such as tobacco, geranium, basil/basilica and rose were produced mainly by the collective farms and Soviet farms. After their collapse, the production of these crops stopped completely. Also, after the abolition of the collective farms wheat production has reduced. As for the corn, its production has increased at the expense of introducing new varieties.

Table 2.16. Livestock Farming Volume Indicators in Lagodekhi municipality

N	Animal Species	1980s	2011-2013
1	Cattle (head)	21 291	18 185
2	Pig (head)	8 150	2 985
3	Sheep (head)	40 700	31 950
4	Poultry (wing)	135 120	105 940
5	Bees (Live)	7 950	3 445

The development of beekeeping in Lagodekhi municipality as the branch, is mainly based on the activity of amateur beekeepers. Sharp weather fluctuations markedly reduced honey brooding. Climate change such as the uneven distribution of rainfall between seasons contributed to the spread of bee diseases and led to a steady decline in bee performance. In the discussed second period (1986-2010) precipitation in Lagodekhi increased by 10%. As a result, the local semi-humid climate gradually moved to the humid climate that could affect the honey-producing plants as their nectars are washed off with a heavy and long rains and the bee performance is declining.

Table 2.176. Changes in Land Use Areas (ha) in Lagodekhi the Municipality

N	Product Name	1980s	2011-2013
1	Grape	2 500	1 520
2	Wheat	1 300	436
3	Corn	5 100	10 900
4	Melons (watermelon)	525	1 300
5	Tomato	900	800
6	Cucumber	9 500	1 357
7	Meadow-Pasture	11 127	11 169

In 1980s, there were 2 500 ha of fruit-bearing vineyards in the Lagodekhi Region. 2 103 ha land was allocated for the Reform Fund and transferred to the population to private ownership, while the rest was leased.

Future priorities are related to the infrastructure development in the current prospective areas. Taking into account the corn production scale, it is possible to speak about the development of profitable animal husbandry complexes. At the background of production of early vegetables and melons, the development of cold storage infrastructure is necessary.

Impact of Climate Change on Agriculture

Because of the current climate change, the climate in Lagodekhi moved from semi-humid to humid climate. Precipitation during the vegetation period has increased by 10% and the number of days without frost has grown by 7 days. It could be said that this is the only municipality in the region where droughts are seriously reduced.

As the temperature increases, here too, there is a difference in comparison with other municipalities. The biggest rise is observed in night temperatures and the absolute minimum temperature, which in the second period has grown by 6 ^{0}C. Such an increase in the minimum and night temperatures will even further reduce the storage periods for perishable melons and vegetables. As the production of melons and vegetable crops is one of the leading areas in the municipality and they belong to the category of perishable products, it can be said that the risk related to the storage of product is the greatest threat faced by Lagodekhi municipality on the background of recent climate change. However, there also are other problems, but they are not so substantial.

As it has already been stated above, regardless of the increase in precipitation, melons and vegetables still need irrigation during the summer period (see. Fig. 2.2. and 2.3). Here, a water shortage in the first period was about 27% for watermelon and 23% for cucumbers, which slightly (1%) but still increased in the second period. As for the plants, in both cases, the plant's water demand is reduced (in the absolute value). Corn demand for water in the second period is reduced in terms of the absolute values (water amount), as well as the percentage value in relation the total demand. In the first, as well as the second period, corn on the territory of Lagodekhi has the least need for irrigation compared to other municipalities (Appendix 3). Quite large areas are not irrigated currently due to the failure of the irrigation systems.

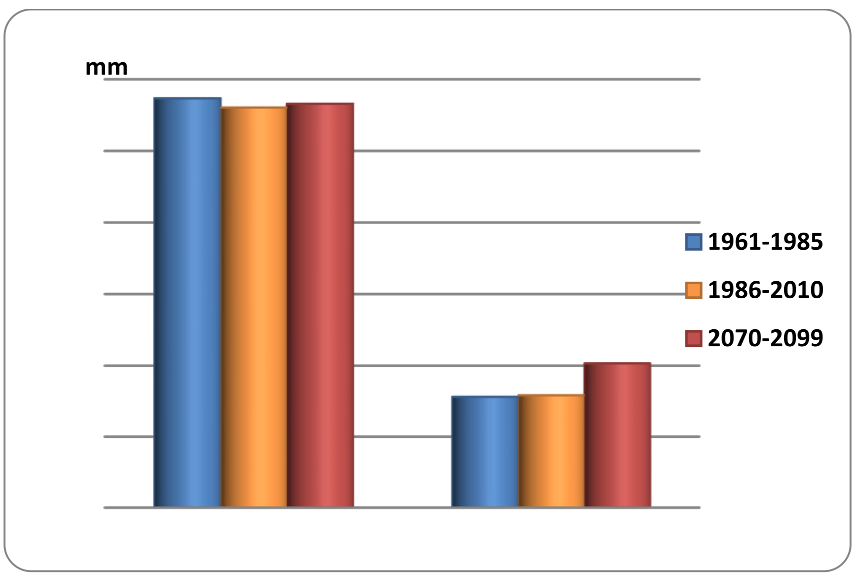

Figure 2.2. Watermelon demand for irrigation in various study periods

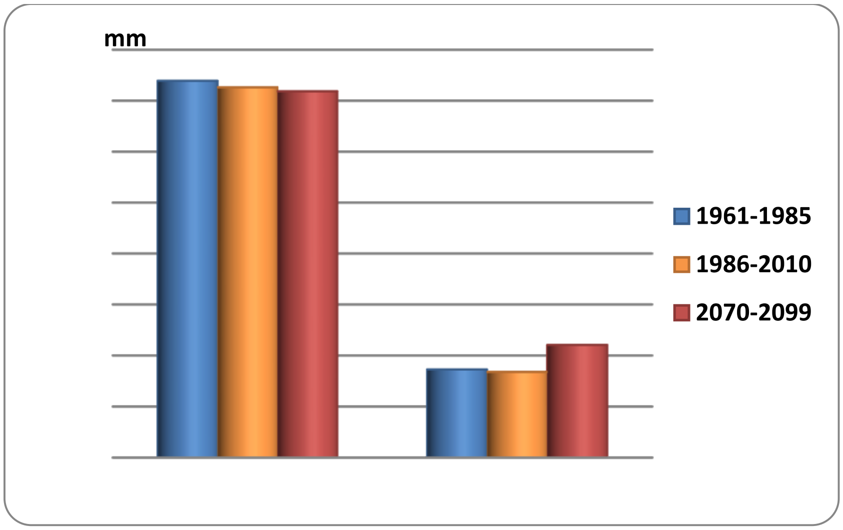

Figure 2.3. Cucumber demand for irrigation in various study periods

Another problem in Lagodekhi, and in other municipalities as well, which is linked to climate change, is plant diseases and they need to be further examined. The degraded area is 380 ha. Windbreaks in Lagodekhi district were planted in one row. 84 out of 108 linear meters require rehabilitation.

Recommendations

In order to avoid problems due to expected climate change, the following measures should be implemented in Lagodekhi municipality:

- The development of quick sale and cold storage (refrigerators) of agricultural products (melons, vegetables). Pomoting the development according to international processing standards.
- Arrangement of relevant nurseries equipped with modern technologies, which will enable the farmers and the peasants to grow virus-free seedlings;
- Rehabilitation of the irrigation and drainage systems existing on the territory of Lagodekhi municipality with the use of modern technologies (modern water saving, high-efficiency technologies for refreshing atmosphere, such as fertigation, mulching, drip irrigation, artificial rain irrigation) and their proper operation and maintenance;
- Supporting the private sector (by offering modern technologies) in the restoration of the rose and other essential plantations (and in general essential oil production) in relevant micro-climate zones, which in turn will reduce soil erosion and increase a carbon absorption resources;
- For the fruit production development, it is recommended to establish the relevant nurseries equipped with modern technologies, which will enable the farmers and the peasants to grow virus-free seedlings;
- Capacity building of the personnel at the Information-Consultation Centers established in the municipalities, their provision with modern technologies (laboratories, internet, etc.), relevant methodologies, learning materials and literature.

- Facilitate the process of establishing cooperatives.

2.2.6. Sagarejo Municipality

Location and Borders. Sagarejo municipality is located in the eastern part of Georgia. The municipality is bordered by Gurjaani to the east, by Gardabani to the west, Tianeti, Akhmeta and Telavi municipalities in the north. The southern border of the municipality adjoins the Republic of Azerbaijan. The town of Sagarejo is the municipality center, which is 45 km away from Tbilisi from the east. The town is located at an altitude of 750-800 meters ASL.

Relief. The municipality territory covers 553.69 km^2. The terrain is characterized by hilly plateau, which is crossed by R. Iori. The northern part of the municipality is located in the foothills of Tsiv-Gombori Ridge and is mostly covered with forest and scrub vegetation. The plain of its southern and south-eastern parts is forestless, while the western part is mostly covered with agricultural lands and pasture. The climate is temperate continental with precipitation ranging from 500 to 700 millimeters.

Soils. Brown forest soils are developed in the foothills and lower slopes of Gombori Ridge. Turfy-carbonate strong skeletal soils are developed on the foothills and the plain of the left bank of R. Iori. Podzol gray soils are developed on the upper slopes of Gombori Ridge. Turf-peaty mountain meadow soil is developed in the highest mountain areas of the ridge.

Small and medium-thick black earth, also chestnut soils are largely developed on Iori Plain. Alluvial soils are developed along Iori River. Various types of weakly developing soil is occupying a large area.

Rivers and irrigation channels. R. Iori is the main artery of Sagarejo municipality, which originates from the southern slopes of the Caucasus Range at the height of 2 600 meters and connects to Mingechauri Reservoir on the territory of Azerbaijan. The river length is 320 km. Its main tributaries within Sagarejo municipality are the following small rivers: Khinchebiskhevi (5.1 km), Vashliani (5.9 km), Gorana (7.5 km), Gombori (13 km), Lapiankhevi (10 km), Dzaghliantkhevi (10.5 km), Patardzeuliskhevi (11.5 km) and Tvaltkhevi (12 km). After connecting with each other, Tokhliauriskhevi, Manaviskhevi and Chailuri rivers connect to R. Iori from the left side as one channel. Alandara Ravine flows at the southern border of Sagarejo municipality, which connects to R. Iori from the left side on the territory of Sighnagi municipality. Its length within the borders of Sagarejo municipality is 19 km.

R. Iori is fed by snow, rain and ground water. Its water regime in natural conditions is characterized by spring floods, summer-autumn freshets and winter sustainable shortage of water.

In 1964, a reservoir was built (height: 84.8 meters and length: 780 meters) with earth dam (total volume - 325.0 million m^3, useful volume - 300 million m^3) near Sioni Village. Sioni Reservoir, which fully regulated the discharge of R. Iori, is of complex use. It provides the irrigation of 68.4 thousand ha agricultural lands in Kakheti and Kvemo Kartli and also to the operation of 4 hydro power plants.

The tributaries of R. Iori on the territory of Sagarejo municipality, as other small rivers in East Georgia, are characterized by sudden fresh floods in the period of intensive rains and with the establishment of maximum flow with the rare recurrent interval during the concurrence of snow melting and high waters, which significantly damages crops and agricultural lands belonging to the local population.

Most part of the tributaries on the territory of Sagarejo municipality is dry during the long period of the year. Water in their river-bed emerges only during the period of snow melting or heavy rains. Such tributaries are: Patardzeuliskhevi, Tvaltkhevi, Tokhliauriskhevi, Nanaviskhevi, Chailuri, Alandara and small unnamed tributaries of R. Iori.

General Overview of Agricultural Sector

Georgia's agriculture comprises of 13 zones and 6 sub-zones. Sagarejo municipality belongs to the 2^{nd} zone (cereal-cattle farming zone of Gare Kakheti), which means that cereal production, animal husbandry and viticulture are the main agricultural areas in the municipality mainly determined by the natural and climate conditions. The data of the last 3 decades on the changes in land use are described in Table 2.2.17.

Table 2.18 Changes in the use of agricultural lands in Sagarejo municipality

Year	**1980**	**2013**
Agricultural lands	Areas (ha)	Areas (ha)
Pastures	32 144	29 575
Perennial plants	5 998	5 205
Grassland	1 325	1 398
Pasture	55 405	58 195
Grape (Total)	4 721	3 530
Rkatsiteli	4 268	2 442
Saperavi	273	873
Kakhuri Mtsvane	180	215
Total	94 872	94 373

As the Table shows, agricultural land has decreased by 499 ha, that is caused by its transfer to the category of the non-agricultural land.

In particular, bushes, gravel and places of residence occupied significant areas on the territory of Iomughanlo. The arable land is decreased by 2 569 ha, they are transferred to the category of pastures, while the perennial plants are reduced by 793 ha. However, grassland has increased by 73 ha and pasture by 924 ha.

Animal husbandry. In 2013, 28 000 heads of cattle were registered on the territory of Sagarejo municipality. During Soviet times, this number did not exceed 22 000 or it has increased by 6 000. The number of livestock per 100 ha of agricultural land also increased from 23 to 30 heads. The growth in the number of livestock was determined by a higher demand for livestock in neighboring

Azerbaijan. As it is well known, Azerbaijan has the lowest per capita beef production in the world, this is why our country does not have a problem of selling livestock in prices attractive to the farmers. According to the National Statistics Office of Georgia (GeoStat), in 2012, Georgia exported 42 679 heads of livestock to Azerbaijan. In 2013, the export amounted to 49 061 heads.

Table below (2.2.18) shows the number of livestock and sheep per 100 ha of agricultural land and pasture.

Table 2.19 Changes in the animal husbandry industry in Sagarejo municipality

1980 Year				2013 Year			
Livestock (head)		Sheep and goat (head)		Livestock (head)		Sheep and goat (head)	
100 ha agricultural land	100 ha pasture	100 ha agricultural land	100 ha pasture	100 ha agricultural land	100 ha pasture	100 ha agricultural land	100 ha pasture
23	40	127	206	30	48	127	206

The number of sheep is almost unchanged and amounts to 120 000. The number of pigs has fallen sharply from 30 000 to 5 000, the poultry amount has also decreased. All of this was caused by the collapse of pig and poultry farms operating on the basis of industrial complexes. The number of the bee hives has also fallen. Due to the high costs of pork and poultry production, meat industry is not profitable. Georgia's agricultural markets are saturated with imported pork and poultry meat and meat products. Among many reasons, a lack of a solid food base also prevents restoration of large pig and poultry farms and factories.

The average annual per cow milking capacity amounts to 1200 kg, the annual live weight per cattle meat production amounts to 100 kg, 200 kg per cow. The annual average ewe milking capacity amounts to 25 kg, the average wool clip to 3 kg, per sheep and goat live weight meat production amounts to 22 kg, ewe - 30 kg. Honey production is an average of 19 kg per bee family, the average egg production capacity amounts to 140 per year. The average meat production per poultry amounts to 2.2 kg. The productivity of agricultural industry in comparison to the Soviet period almost did not change as the agriculture development in Georgia is extensive. Per capita meat production (carcass weight) amounts to 16.4 kg, milk production to 395 liter. 29-31 kg beef and 319 kg milk and milk products are necessary annually for proper human nutrition or is a physiological norm for a human being. 1 hectare good pasture is necessary for one livestock head during the season, the average pasture amounts to 1.5-2.0 ha. During the Soviet period, per capita meat production (carcass weight) in Sagarejo municipality was 12.9 kg and milk - 277.9 kg. For 2012, per capita cereal production in Sagarejo municipality was 60.9 kg, corn production - 238 kg, sunflower - 13.7 kg, vegetables - 50.0 kg, potatoes - 19.1 kg, watermelon - 198.4 kg, beans - 0.87 kg. The development of animal husbandry industry requires the establishment of well-organized procurement system for milk and meat and the high-tech processing conditions in all districts, as well as the establishment of a solid food base. To achieve this objective, the food crop areas shall be increased. In the future an increase in vineyards is expected determined by the organized production of grape in recent years and the price increase.

Cereal production. From annual crops, wheat, seed corn and sunflower are mainly sown in Sagarejo municipality. The remaining annual crops, especially food crops are sown in relatively small quantities. Despite the fact that Kvemo Samgori main irrigation canal serves the district, damaged drainages are the main agricultural problems. It is necessary to repair and clean the irrigation channel. Internal irrigation networks have fully collapsed, that adversely affects productivity and agricultural production. 34% of agriculture lands are privately owned, 61% of lands are state owned, and 5% is the municipality property. The large portion of the state owned lands is pastures, most of which have been leased by the state.

The distribution of the annual crop areas in Sagarejo district demonstrates that the district specializes only on the production of three crops: wheat, seed corn and sunflower. It is noteworthy that potato plant, which plays a very important role in terms of food security, is insignificantly represented in the district. Food crops and melons are also less represented here.

Clearly, relatively small crop areas in Sagarejo are not enough for the local animal husbandry. The district is mainly dependent on the production of such cultures which do not have a competitive advantage in Georgia. As it is well-known, our country imports the largest part of wheat and vegetable oil consumption. The world prices on these products, especially in recent years are characterized by sharp fluctuations. Taking into account that the sunflower culture places great demands to soils, its productivity in Sagarejo is quite low in comparison to the average world index (0.6-0.8 t/ha). Against the backdrop of land fund relative abundance, it will be difficult for Sagarejo agricultural sector to play its potential role in ensuring food security of Georgia. In addition, district specialization peculiarities will not create a stable income source for its population without a sharp intensification of production. During the Soviet period, 80% of the lands were cultivated, today only 30% of the arable lands are tilled. The remaining uncultivated land is used for pastures and grazing by the population. This situation is caused by the increase of land cultivation costs and low productivity. Autumn grain crop areas are reduced from 12 000 to 3 000-2 000 ha. The hectare average productivity has also been reduced from 2.2-2.5 t to 1.5-2.0 t. This is determined by the limitations on fertilizers and the use of irrigation water, unsuitable seed materials, drought prolongation, etc. The amounts of annual and perennial crop grass have also decreased (uncultivated lands were not replaced by anything).

Viticulture. As seen from Table 2.2.17, the total vineyard area in Sagarejo municipality has decreased by 1 191 ha and for today, the total vineyard area amounts to 3 530 ha. The reduction of the vineyard areas concerns grapes of Rkatsiteli variety. In comparison to the Soviet period, the vineyards for Saparevi variety have increased by 600 ha. As for Kakhuri Mtsvane, its area has increased by 35 ha. The vineyard areas in Sagarejo district are by 1.5 times less than similar indices for Telavi district. With these parameters Sagarejo lags behind Gurjaani by 50% and more. Wine-making in Sagarejo district is not as significant as in Telavi, Gurjaani or Kvareli districts.

Pomiculture. The comparative lack of perennial plants in Sagarejo district is also reflected in the structure of existing orchards. The fruit species represented in the district are characterized by the adaptability to arid climate and endurance to the water shortage. At the same time, apples, which have huge revenue potential are more or less prevalent. Nuts, which is the leading export agricultural crop in Georgia, is not practically represented in Sagarejo. Walnuts are quite well-represented in the district, which is considered as one of the substitutes to nuts in terms of income source. Peach, which has potential and for which Sagarejo has suitable climate, is quite well represented here. The leading economic fields in Sagarejo municipality are: production of wheat flour, wine, poultry/egg, tobacco and brick.

According to Geostat information, as of 1 April 2010, 316 enterprises were registered in Sagarejo municipality (10 large-scale, 14 medium-scale and 292 small-scale). Unlike other Kakheti municipalities, wine-making does not play a dominant role here, although from the large-scale enterprises 5 operate in the winery industry.

Two poultry factories operate in Sagarejo town. A tobacco processing plant "Poseidon" is also functioning in Sagarejo. There is one important dairy processing plant and several companies producing refined oils and fats. Seven companies operate in the wood and wood processing, joinery and furniture manufacturing sectors. Three of them are located in Sagarejo, while others are located in the village of Patardzeuli, Ninotsminda, Giorgitsminda and Khashmi. Four companies operate in the production of construction materials, particularly brick and ceramic tiles. The construction cluster is also represented by two construction plastics production and one construction gravel extraction enterprises. Flour is produced by two and bread grains by 8 companies. 3 companies are producing non-alcoholic drinks, among them lemonade, which is consumed locally.

Impact of Climate Change on Agriculture

From natural geological events related to climate and its change, mudflow and landslides represent the biggest hazard on the territory of the municipality. R. Tvaltkhevi, which has a clearly expressed mudflow nature, flows directly to Sagarejo, the municipality center. The second, not weaker flow is Antokis Khevi River. Its broad river-bed is full with large quantities of solid waste material (mainly boulder-coarse gravel and clay material). In general it should be noted that in the villages of Kamshi, Patardzleuli, Ninotsminda, Giorgitsminda, Tokhliauri, Manavi, Kakabeti, Chailuri, Burdiani ground ravines originate in the southern and south-western slopes of Tsiv-Gombori Ridge, where there are extensive outcrops of loose molasse facies rocks. Almost all of them have the mudflow nature.

If we judge by the climate change scenario, in which average annual precipitation is expected to decrease in the municipal area, then it is likely that the intensity of the ongoing erosion remains virtually unchanged or even reduced. The exceptional extreme cases, which may take place in separate future scenarios, are not relevant for these cases.

According to the observations at the meteorological stations, annual atmospheric precipitation on the territory of Sagarejo municipality decreased by 10% in the last 25 years, but the daily maxima increased on every season and especially during autumn (33%). 7% increase in precipitation is expected to 2050, after which the reduction starts and for 2100, precipitation is expected to be 10% less than today. The daily precipitation maxima are also declining, thus reducing the risk of mudflow occurrences (exceptions of course are not excluded), but it will have the impact on agriculture.

The examples of how the extreme temperature changes alter koinos indirectly are already observed in Sagarejo (e.g. droughts). Plants especially underwent significant changes. The largest pastures are overloaded with heavy grazing. As a result of sheep grazing, the vegetation cover of a large part of the steppe ecosystems is trampled and degraded. Droughts forced out many plant species from pastures and resulted in the prevalence of weeds and drought-resistant varieties.

Of course this is not only the result of direct impact of climate change, but one of the stress factors is overgrazing, which is accompanied by the increase in drought in Sagarejo district. All kinds of drought, and especially extreme drought (one-month-long and nine-months-long) have increased, 6 additional cases were reported in comparison with the previous 25-year period of 1986-2010. Droughts dramatically change some of seasonal variety rhythmics of steppes and semi desert vegetation, in conditions of strong dryness and high temperatures (July-August) they are moving to the remaining period.

The largest part of Sagarejo municipality is located in 2nd agroclimatic zone. This zone extends from an altitude of 450 m to 800 m above sea level. The sum of active temperatures in this zone is 3 000°-4 000° C and more. Multi-year average precipitation is 600-700 mm, 450-550 mm in the warm period. Last frosts were observed in the period of 28/03-09/04.

First frosts were observed in 05/11-22/11. The frost-free period lasts for 238-209 days. The climatic conditions in the given zone are acceptable for grain crops, early and late season grape varieties and some of the fruit trees and essential oil crops. Measures for providing water to the crops are necessary for receiving the guaranteed harvest.

Sagarejo weather station is located exactly in this II agroclimatic zone. The observations carried out here demonstrate that in the years of 1986-2010 the vegetation period increased by 7 days (10 ^{0}C threshold), it starts 2 days earlier and ends 5 days late, the sum of active temperatures increased from 3 460 ^{0}C to 3 646 ^{0}C (186 ^{0}C) in comparison with the previous 25-year period and precipitation in the vegetation period in the same interval decreased by 12%.

Annual atmospheric precipitation decreased from 809 mm to 727 mm (by 10%). The number of hot days (SU25) increased by 5-6 days annually. As mentioned above, droughts of all types and duration increased, which is the largest risk for agriculture in Sagarejo district.

The relatively small part of Sagarejo municipality, namely its northern and north-west parts are located in III agroclimatic zone. The given zone covers the area from 450 m to 900 m above sea level.

The climate conditions in the given zone are suitable for cereal crops (autumn wheat, barley, rye, oaths), early grape varieties, vegetables, fruit trees, food crops, grassland-pastures. The zone is sufficiently humid.

Within the framework of this project, the change of demands for irrigation water for watermelon in 1961-2010 was assessed. The results are presented in Figure 2.4.

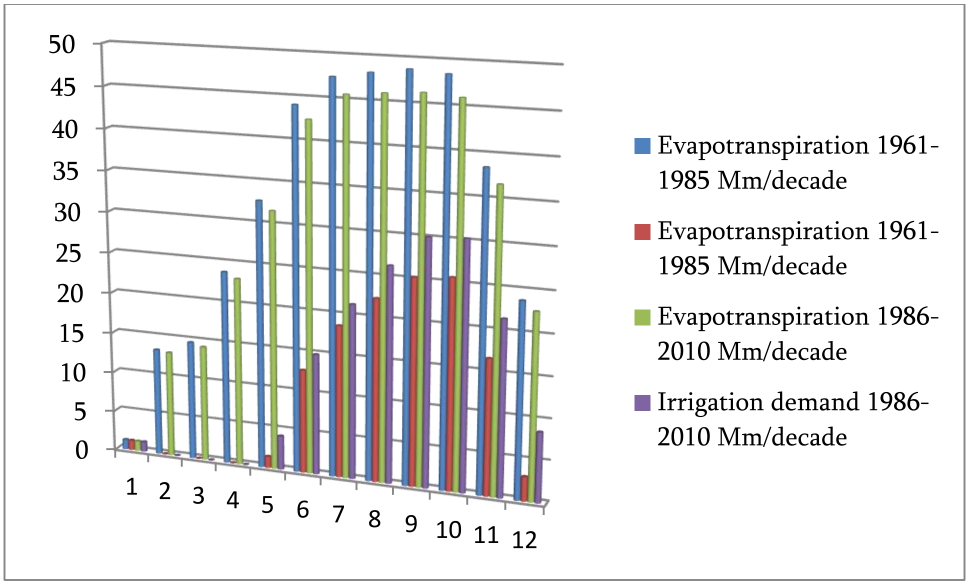

Figure 2.4. Changes between the overall water demand in watermelons and the irrigation demand in Sagarejo

As we see it from the Figure, the overall plant demand on water during the whole irrigation period decreased from 385 mm to 239 mm (by 38%), but the demand on irrigation increases from 127 mm to 159 mm[21] (by 25%), which is determined by the reduction in effective precipitation in the vegetation period from 296 mm to 239 mm (by 19%).

In the future till 2100, the plant demand for water will increase to 418 mm and the irrigation demand grows to 199 mm (25% of today's demand). Thus, in terms of water supply, the conditions for watermelon production in Sagarejo are supposed to deteriorate against the background of climate change.

The second crop, which was assessed on water shortage and productivity, is corn. It became clear that for this crop, if in the first period (1961-1985) the plant was losing water amounted to 45% of the whole water consumption, the decrease in the second period (1986-2010) constituted 52%, but the overall demand for water was reduced by 3.7%. Corn was assessed using the Aquacrop (FAO) model, which also demonstrated that in the second period, even without irrigation, the yield was about 1 t/ha[22]. The irrigation would increase hectare yield with almost 4 t.

When assessing the impact of climate change, we must take into account the following factors: the agricultural sector in the region is characterized by the extensive nature. Consequently, the climate change analysis without considering a variety of anthropogenic factors will not give us the possibillity to make correct conclusions. The main climate change-related threat is the increase in the frequency of extreme atmospheric events. Along with the decrease of the average precipitation indices during the warm period, the risk of droughts in the central and south-eastern parts of the district increases.

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[21] http://www.fao.org/nr/water/infores_databases_cropwat.html

[22] It should be noted here that in fact it may be more or less. Because the corn was not taken into consideration during the evaluation of soil type and characteristics. In addition, in the first period other species were sown and watered, so it's impossible to compare these two periods productivity.

The problem remains and provision of agricultural lands with irrigation water may even become more complicated.

Adaptation measures (both short-term and long-term) should be integrated into development strategies and the local municipality development strategy. In addition, the main structural development directions of the agricultural sector should be defined (which crops are more competitive in the medium and long-term prospects of climate change). In addition, there are a number of measures the implementation of which in any case are necessary for the development of the agricultural sector in Sagarejo district: improving the infrastructure, farmers' trainings and breeding operations, improving quality of mechanization.

Recommendations

In order to avoid problems anticipated in relation with climate change, it is necessary to implement the following activities in the municipality:

- Rehabilitation of the irrigation systems existing on the territory of Sagarejo municipality by using modern technologies and ensuring their operation at the relevant level. Construction of new systems in places where they were not previously necessary (for instance, the Udabno district);
- Introduction of humidity-saving agricultural equipment and technologies, particularly in areas prone to desertification;
- Development of the pasture management plan for the municipality. Determining the pasture capacity norms. Eradication of harmful practice of burning stubble (which damages useful micro flora of arable plots, also productivity of the upper layer of soil) by tightening legislative and administrative measures. Arrangement of the infrastructure on cattle herding routes (resting places, shady, drinking and washing places, etc.), which will significantly decrease pasture degradation and spread of diseases;
- Development of highly profitable cattle farms as a priority field. For the development of sheep production, it is recommended to organize genetical center and breeding farms, where the selection of Georgian sheep variety will take place using modern technologies;
- Systematic implementation of soil protective agroameliorative measures: cultivation of the soil as much as possible in the autumn-winter period; testing of modern technologies for soil cultivation (deep tillage, chiselling, etc.) and their selection for regional conditions;
- For improving soil quality, dissemination of perennial crops, for instance sainfoin is recommended, which grows well on degraded soil, survives drought and enriches soil with nitrogen. This is why it is a good predecessor to wheat. In cattle farming it is used for preparing sappy forage with silo and haylage. It is mowed twice a year and hay produced from it is quite highly productive and expensive. Introduction of this crop in practice and its multi-use will decrease expenses of the farmers and will bring more profits to them;
- Testing of various capacity, ecologically advisable soil-processing aggregates (chiselling, combined aggregates, unploughed plots) in concrete natural climate conditions and introduction of the best ones in practice (across the municipality);

- Testing of drought resistant annual and perennial crops, selection and organization of their seed production in the municipality. Testing and identification of autumn, drought-resistant crops and varieties, research-introduction of their varietal agro-equipment for non-irrigated, as well as irrigated plots;
- Capacity building of the personnel at the Information-Consultation Centers established in the municipalities, their provision with modern technologies (laboratories, internet, etc.), relevant methodologies, learning materials and literature.

2.2.7. Sighnagi Municipality

Location and Borders. The total area of Sighnagi municipality is 1 251 km2, from which 93 375 ha are agricultural lands and 5 500 ha - forest area. The territory of the municipality includes the slopes of Gombori Ridge and Alazani Plain. Sighnagi is the center of the municipality is located at the altitude of about 800 meters above sea levels. An important part of the municipal territory covers Iori Plain, which is located in the southern part of Gombori Ridge. The municipality is bordered by Gurjaani and Sagarejo municipalities in the north-west and the west, by Dedoplistskaro municipality in the south-east and Lagodekhi municipality and the Republic of Azerbaijan from the north and the north-east.

Relief. The municipality covers quite a large territory stretched from the banks of R. Iori to the Alazani River. It covers 4 climate zones. Its southern part belongs to the Iori Plain covered with arid steppes at the heights of 300-700 m ASL. A relatively small area covers the slopes of Tsiv-Gombori Ridge at the height of 800-1 000 m, where the town of Sighnagi s located, while the eastern part is spread on the Alazani Plain at the height of 200-500 m.

The highest mountain of Gombori Ridge within the municipality is Choporti (1087 m). The northern part of the municipality is the accumulative plain of Alazani with the absolute height from 219 to 350 meters. Taking into account that the majority of the municipality's territory belongs to the plains and the foothills, Tsnori weather station, which is characterized with the full series of observations and is quite representative, was selected for its description. It is located at an altitude of 293 meters ASL.

Soils. Small and medium-thickness black soils, as well as gray, saline and alkaline soil complexes are developed on Iiori Plain.

Brown forest soils are dominant in the foothills of the slopes of Gombori Ridge, which are rich in humus and plant food elements. Brownish, alluvial-carbonate and meadow carbonate soils are developed at the transitional strip of forest steppe on Alasani Plain. Mainly brown soils are developed in the high zone (700-1 600 m), where the humus layer is 2.5-3.5%. Brown meadow soils are covered with annual and perennial crops. Gray-brown soils are developed in the south of Iori Plain and their humus composition is up to 3-4%. Blackish soils are mainly met at the Alazani Plain and its humus composition is up to 6%. These soils are rich in the plant food elements.

Water resources and irrigation systems. The territory of Sighnagi municipality is poor in hydrographic networks. Rivers mainly are of periodic nature. The rivers of R. Alasani and Iori have to be distinguished. Alazani flows in the eastern part of the municipality near the border with Lagodekhi municipality and Azerbaijan. R. Iori intersects the Iiori Plain in the southern part. The length of Iori River within the municipality is 28 km. Dry ravines are located on the south-west slopes of Gombori Ridge, but they cannot reach R. Iori.

Sighnagi municipality has temperate limited and surface water resources. Although the municipality does not have reliable information on assessed water resources. Water resources in the administrative unit are represented by surface and underground waters with the ratio 1/9. Small amounts of wetlands are also represented, which are mainly located in the river groove. Their area is approximately 1 000 ha and its number has not decreased during the recent years. Surface waters in Sighnagi municipality are mainly used for the irrigation. The water supply of the population is based on subterranean deposits.

The Alazani lower irrigation system serves the irrigation of Sighnagi municipality. This system was at certain time irrigating 22 944 ha area. The irrigation systems are in very bad shape presently. Moreover, approximately 40% of the agricultural lands in Sighnagi municipality require drainage, although the drainage systems are also outdated.

General Overview of Agricultural Sector

The main economic activity in Sighnagi municipality is agriculture. According to the Sighnagi District Agriculture Development Service, the total area of agricultural land as for 2011 consists of 95 182 ha (Table 2.2.19).

Table 2.20. Changes agricultural land areas and crop productivity in Sighnagi district

Year	1980s		2011	
Agricultural crop	Areas (ha)	Yield (t/ha)	Areas (ha)	Yield (t/ha)
Vineyard	4 500	10.0	2 941	8.5
Fruit trees	160	3.5	104	3.9
Arable (wheat, barley, oats, corn, sunflower)	45 000	3.5	38 016	2.5
Among them wheat	22 000	3.5	19 104	1.5
Among them barley	5 000	3.0	2 800	1.5
Among them oats	2 500	2.0	162	1.3
Among them corn	2 500	8.0	1 338	4.0
Among them sunflower	7 000	1.2	4 809	0.6
Pasture and grassland	54 213		54 121	
Total	103 873		95 182	

Cereal Production. It is noteworthy that in comparison with 1988, the sown areas, as well as the average yield decreased (mainly, cereal and sunflower), that is determined by the fact that after the collapse of the Soviet Union, the irrigation/drainage, as well as breeding testing and centralized mechanization infrastructure broke down. The centralized fertilizers supply, as well as delivery of other auxiliary materials stopped, which negatively impacted the agricultural sector. Taking agroamelioration measures plastering is impossible for salinized/alkaline soils. In the Soviet period, the wheat hectare yield amounted to 4.5-5.5 t. One of the reasons for decreasing productivity of wheat and cereal crops is a lack of access to high-quality certified seed by peasants and farmers (that does not contain weeds and diseases). The cases of importing weeds with seeds have dramatically increased, which very seriously reduces soil productivity. The low-productivity of the above-mentioned crops is determined by the disarrangement of the irrigation and drainage systems, neglecting the crop rotation principle and the negative impact of cutting down windbreaks and field-protective.

The above mentioned cereal crops and forage grasses, which were sown and produced in 1980s, where not distinguished by overly high indices, but as for the present situation (2011), they are very much decreased in all parameters. After the breakdown of collective and Soviet farms, it became difficult for an individual peasant to address challenges in agricultural sector, many peasants and farmers abandoned agriculture and started to work on something else. The vineyard areas almost halved mainly due to the disintegration of the irrigation systems.

Animal husbandry. Changes in the animal husbandry industries in Sighnagi municipality are clearly shown in the data of Table 2.2.20

Table 2.21. Indices of various animal husbandry industries in Sighnagi municipality

Animal category	1980s	2012-2013
Livestock (head)	42 500	13 200
Pig (head)	6 500	3 650
Sheep (head)	265 000	35 000
Poultry (wing)	352 000	40 000
Meat Production (tons)	5 400	740
Milk production (tons)	8 000	870
Eggs (Piece)	12 800 000	855 000
Wool production (t)	325	45

In comparison with the above-mentioned previous period, only in Tsnori livestock complex 24 000 heads of livestock were listed, whereas today this livestock complex does not at all exist. In the 1980s, forage crops were sown on 4 000-4 500 ha (alfalfa, sainfoin, Sudanese/Sorghum Sudanense (Pip.) Stapf.). These forage crops were mainly produced for feeding cattle with green mass, also for producing haylage and hard forage. A part of the area was used for developing seed-farming. Presently, the forage crops are sown only on 150 ha (2011). The weakening of cattle farming industry is also somewhat determined by the lack of forage. Despite the fact that a livestock artificial insemination center operates in the village of Tibaani, the amount of the commercial farms is still very low is Sighnagi municipality. At the same time, the overall productivity has also decreased, which is clearly seen from the data presented in 2.2.20 Table.

The new direction, which just started to develop in Sighnagi, is fish-farming. The area of the artificial ponds constructed on the territory of the municipality amounts to 1101 ha.

Expected Impact of Climate Change on Agricultural Sector

The data of Tsnori weather station were used for assessing climate parameters change in Sighnagi district. These changes in main parameters are described in the chapter 1.2.7. The increase in temperature, especially of severe temperatures (SU25, SU30, TR20) and droughts were observed on the territory. Precipitation decreased slightly (1%). Winter in the low zone of Sighnagi municipality during the last 25 years became warmer, the risk of winter frosts decreased, although the risk of spring frosts still remains. Summer became noticeably hot and relatively dry. Precipitation in the vegetation period decreased by 5% and by 15% during the summer season. During two examined periods (1961-1985 and 1986-2010), in the lower zone of Sighnagi municipality (where the Tsnori weather station is located), the temperature rise is the highest in autumn and winter (+0.7 ^{0}C) and the temperature decrease is marked in spring (-0.2 ^{0}C). Precipitation decreased noticeably in summer (-15%), although was increased in autumn and winter (+11, +14% respectively).

The decrease in the number of drought periods of all time scale was identified between the two discussed periods except for the one-month-long severe droughts. Their occurrence doubled. At the same time the number of extreme droughts of the same duration increased slightly. In addition, certain increase in the number of heavy rainfall days (≥50 mm) demonstrates that in Signaghi municipality, which belongs to the central part of the very high mudflow risk zone, the risk of mudflows increased.

About 80% of the arable land in the administrative unit needs irrigation, but the lack of irrigation systems complicates the irrigation process. The rainwater collection for economic activities does not take place. Approximately 40% of agricultural lands require drainage and drainage systems exist in the territorial unit, but they are not operational and need cleaning. This is why ensuring agricultural lands with relevant drainage systems is so far impossible.

As a result of mudflows, the arable land area decreased. Lack of cultivation and over-irrigation in the past resulted in salinization of soils on Alazani Plain, namely in “Milari”, which demonstrates that the timely cultivation of soils is necessary for their desalination.

For Sighnagi municipality, based on data of Tsnori meteorological station, the change in the irrigation demand between the two periods of 1961-1985 and 1986-2010 were assessed for wheat and sunflower. The assessments were made using the AcquaCrop (FAO) model, which unlike the CropWat (FAO) model, takes into account the change in CO_2 concentration in the atmosphere during the water evaporation process from the plant and therefore, according to this model, the water shortage at the end of the century and the irrigation demand will be far lower than at present.

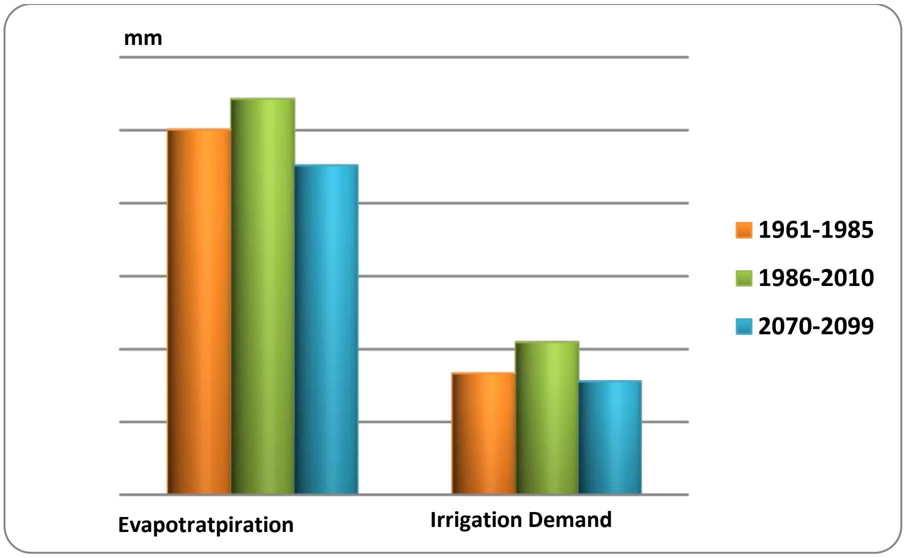


Figure 2.5.Water shortage for autumn wheat in the municipality (Tsnori weather station)

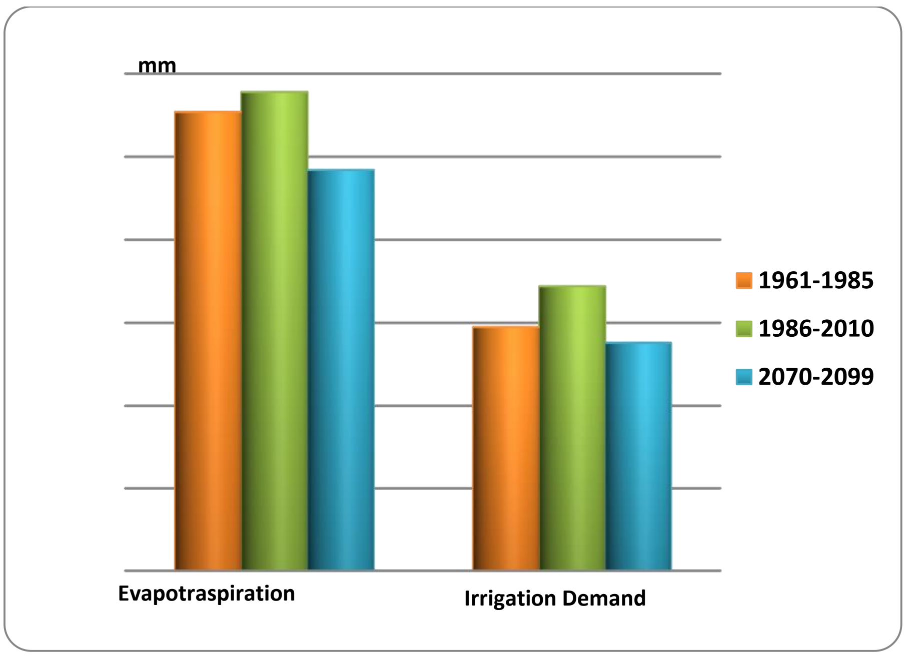


Figure 2.6.Water shortage for sunflower in the municipality (Tsnori weather station)

In addition to drought, strong spring winds are another problem in Sighnagi district. Windbreaks in Sighnagi, similar to Dedoplistskaro, were almost fully bogged, that significantly increases the risks posed by the climate. The multicriteria analysis demonstrated that Sighnagi, after Lagodekhi, will be the most vulnerable municipality to climate change.

Recommendations

Continuous droughts and strong winds are the most serious problems in Sighnagi municipality on the background of climate change. Thus, this district almost repeats Dedoplitskaro, albeit is less hot. This is why the recommendations for the prevention of problems determined by expected climate changes for this municipality are similar to the recommendations given for Dedoplitskaro district:

- Restoration-planting of windbreaks for protecting agricultural lands from droughts and winds and decreasing erosion by wind.
- Planting of artificial forests for the rehabilitation of soil damaged by wind erosion and protection of surrounding areas from drought;
- Rehabilitation of the existing irrigation systems on the territory of Sighnagi municipality with the use of modern technologies (fertigation, mulching, drip irrigation, artificial rain irrigation) and their proper operation and maintenance;
- Rehabilitation of the wells existing in remote areas from the irrigation canals and efficient, economical use of ground water, construction of new channels for the irrigation of agricultural crops and hay-pasture areas and for livestock drinking water;
- Development of the regulation plans for wells, groundwater and leachate;
- Implementation of systematic soil-protection agro-melioration measures; cultivation of soil in the autumn-winter period at the maximum extent; introducting the practice of seederation, crop rotation, mulching and intermediate crops (rapeseed, turnip, mustard, vetch, oat peas, annual clover, etc.). Testing of modern ecological technologies of soil cultivation (direct drilling, chiseling, etc.) and their selection according to local conditions;
- For improving soil quality, dissemination of perennial crops, for instance sainfoin is recommended, which grows well on degraded soil, survives drought and enriches soil with nitrogen. This is why it is a good predecessor to wheat;
- Testing of various capacity, ecologically advisable soil-processing aggregates (chiselling, combined aggregates, unploughed plots) in concrete natural climate conditions and introduction of the best ones in practice (across the municipality);
- Testing of drought resistant annual and perennial crops, selection and organization of their seed production in the municipality. Testing and identification of autumn, drought-resistant crops and varieties, research-introduction of their varietal agro-equipment for non-irrigated, as well as irrigated plots;
- Development of the pasture management plan for the municipality, which will cover the following issues: Determining the terms for grazing on mowing land by taking into account the establishment for time-limits for grazing and 15-20 days shall be left so that grass cover survives winter well; the interval of 20-30 days shall be observed for the repeated grazing. The use of special hummock chisels and rollers against hummocks shall become mandatory; sowing on unaffected and bare soils. The regulation of pasture loads. To eradicate a harmful practice of burning stubble (which damages useful micro flora of arable plots, also productivity of the upper layer of soil) by tightening legislative and administrative measures. Arrangement of the infrastructure on cattle herding routes (resting places, shady, drinking and washing places, etc.), which will significantly decrease pasture degradation and spread of diseases;
- Development of animal husbandry as a profitable priority field on the basis of providing the industry with high-quality forage;

- Capacity building of the personnel at the Information-Consultation Centers established in the municipalities, their provision with modern technologies (laboratories, internet, etc.), relevant methodologies, learning materials and literature.

2.2.8. Kvareli Municipality

Location and Borders. The territory of Kvareli municipality is 1 000.8 km^2. In the east, the municipality borders Lagodekhi, in the south – Gurjaani, Telavi municipality in the west and the Great Caucasus Ridge in the north.

Relief. The territory of Kvareli municipality can be divided into two main parts: plain and high mountainous territories. The high maintain places in the municipality are located in the north, at the slopes of Kakheti Caucasus and its southern branches. As for Alasani Plain, it is located in the southern part of Kvareli municipality.

The southern part of Kvareli municipality is spread on the accumulative Alazani Plain. Its height within the municipality amounts to 240-400 m ASL. Alazani Plain is characterized by flat surface and alluvial fan. It is built with young alluvial sediments – cobbles, sands and clays.

Soils. Alluvial meadow forest carbone-free loamy soils are prevalent in Kvareli municipality, but because of the terrain and micro-geographical conditions, other types of soils are also found in small plots here and there. At the mountain foothill alluvial fans, in Akhalsopeli, Kvareli town, Eniseli and other areas, strong skeletal alluvial of small thickness and proluvial soils are dominant. In the gorges of Chelti and Intsobi rivers, alluvial carbone-free loamy soils are found. In the basin of R. Duruji several types of soil are met, including, brown forest soils, gray-brown, less-developed washed off soils, mountain-forest-medow soils, under developed brown proalluvial and diluvial soils. On the left bank of Alazani Plain carbone-free alluvial soils are predominant, but in some places Jurassic limestones emerge on the surface, and on the places of their exhaustion crust alluvial-meadow clay carbonate soils are developed. In the south of vil. Gavazi, wet-meadow heavy clay soils are located. In the highland zone (600-3 000 m ASL), the majority of the territory is covered with forests and grassland-pastures. Fruit trees and vegetables also thrive here. In the lower zone (400-600 m ASL), all types of grape varieties, including special varieties grow (Saperavi, etc.).

Water resources and irrigation systems. A dense river network is characterized for Kvareli municipality. R. Alazani is its main river artery. It flows for 35 km in the south part at the border of Telavi and Gurjaani municipalities. R. Duruji attracts a special attention, which emerges as a result of confluence of Shavi (black) and Tetri (white) Duruji. Duruji's river bed is rocky and rich in rapids.

Below Kvareli, R. Duruji flows in the form of several streams in the direction of Alazani and discharges in its left side. The river is fed by rainy and snow waters. The average annual flow is 1.06 m^3/s. It is the strong mudflow river, which repeatedly damaged town of Kvareli. Measures to prevent mudflows were repeatedly implemented on R. Duruji, but without a success. Periodically, typical mudtorrents are developed in the upper flow of R. Duruji and their capacity can reach 200 m^3/s. At the right bank of Duruji River, at an altitude of 430 meter ASL, the Kvareli Reservoir was constructed, which is well equipped. The length of the reservoir is used for irrigation and resort. Rivers Bursa (length 27 km), Chelti (28 km), Intsoba (22 km), Lopota (33 km), Areshi (36 km), Avaniskhevi (28 km) and others flow in from the southern slopes of the Caucasus Range. There are smaller rivers flowing through in the territory of the municipality (streams) that emerge of the territory of the same municipality. Such small streams are predominantly found in the eastern part of the territory. The Municipality Rivers belong to the mixed nourishing river types. The small rivers are fed from small underground springs.

Duruji irrigation canal is located in Kvareli district. The main source facility is set up on R. Duruji near Satskhenisi village. From the river source, the channel is directed towards the south, it irrigates the 620 ha area located between the rivers of Bursa and Duruji at the distance of almost 12 km. The short irrigation channel in Kvareli district is built from vil. Bursa which connects to Fatmasuri wine-growing lands. This channel irrigates Fatmasuri vineyards.

General overview of the agriculture sector

Agriculture is predominantly viticulture well developed in Kvareli municipality. This main sector of agriculture makes up 80% of the whole income from agricultural production. Both in the Soviet times and now, the main sector of Kvareli economy is agriculture that employs up to 70-80% of the local labor resources. There used to be 7 Soviet farms, 7 collective farms, where viticulture, cereal, animal husbandry and sericulture were the main industries.

26% of the territory in Kvareli municipality is occupied by perennial crops. Today, 9 154 ha in Kvareli municipality is under perennial crops, of which vineyards make 5 675 ha, Rkatsiteli - 3 240 ha, Saperavi - 2 264 ha, hybrids grow on 171 ha. Compared to Soviet period, peach, nut and persimmon plantations have increased significantly.

Table 2.22 Productivity of Perennial Crops and Overall Productivity in Kvareli municipality

	1980s	**2013**	**1980s**	**2013**
Crop	Productivity (t/ha)		Overall Productivity (t)	
Viticulture	4.9	6.0	28 420	34 700
Fruit trees	4.0	5.0	11 200	17 315

Viticulture. From the technical grape types, Rkatsiteli, Kakhuri, Saperavi and Mtsvane were grown in Kvareli district during the Soviet period. The local population also grows the same grape varieties. It is worth mentioning that Kvareli municipality is considered as a micro-zone for growing Kindzmarauli, where Saperavi grape variety is grown and Kindzmarauli wine-material is made that has become world famous.

A specific viticulture Kindzmarauli zone is located in Kvareli administrative district, at the southern slopes of the Caucasus Range branching (Latitude: 41º30"N, Longitude 45º50"E). Industrial vine farms are mainly located at the height of 250-550 m ASL on the right bank of R. Alazani (Gaghmamkhari).

Alazani Plain is located at the plain foothill, which rises towards north, transits to foothill stripe and sets against Caucasus foothill.

In Soviet times, viticulture was oriented on the amount of grapes and less attention was paid to micro-zone features and production of high quality brand wine. At the same time, other grape types were almost forgotten, namely Khikhvi, Mtsvane, Mtsvivana and others. Intensive planting of new grape varieties took place in Kakheti in the second part of 1990s. This process was especially fast in Telavi, Kvareli and Gurjaani municipalities as world famous vine micro-zones: Kindzmarauli, Akhasheni, Mukuzani, Tsinandali, Vazisubani and Napareuli are located here. The cultivation process is quite unorganized and spontaneous. The issue of politicization of the Russian market is not considered thoroughly enough and risks related to the export ban, which could again happen at any time are not properly assessed. In the new vineyards, the wine varieties are represented according to the following ratio: Saperavi – 96%, French red grape sorts: Cabernet Franc, Cabernet Sauvignon, Merlo and Malbec (1.8-2%). Old Georgian white grape sorts: Kisi, Khikhvi and Kakhetian Green (Kakhuri Mtsvane) – 2-2.2%.

The old vineyards are very sparse and their hectare productivity is low (2-2.5 t/ha). Rehabilitation of these vineyards is necessary for increasing their quality and competitiveness. A lack of virus- and disease-free plants which are well adapted to local conditions is a special problem in the process of the rehabilitation of old vineyards and planting new areas.

Cereal crops. In the Soviet period, annual cereal crops were sown mainly in collective and Soviet farms. Wheat, barley and maize were the main annual crops grown here. Seeds were mainly supplied from Ulianovks and Tserovani testing farms. Locally grown seeds were also used.

Table 2.23. Productivity of annual crops and overall productivity in Kvareli municipality

	1980s	**2013**	**1980s**	**2013**
Crop	Productivity (t/ha)		Overall Productivity (t)	
Cereals	2.6	3.6	5 400	17 553
Watermelons	22.0	25.0	17 600	33 550
Vegetables	6.0	8.0	3 000	7 600

After the Soviet period, annual cereal crops were mainly grown by large farmers. As for the population, they grew annual crops in small amounts, which were determined by the high price of hybrid seeds. With the support from a special governmental program, this year, the majority of the population sowed maize.

Animal husbandry. In the soviet period, Kvareli district collective and soviet farms paid great attention to the development of animal husbandry industry, cattle productivity, selection, breeding methods and basics of cattle nutrition.

Table 2.24. Volume Indicators of Various Sectors of Animal Husbandry in Kvareli Municipality

Animal Category	1980s (annual)	2013
Livestock (head)	15 264	12 270
Pig (head)	8 470	4 035
Sheep and goats (head)	25 700	26 624
Poultry (wing)	66 000	86 000

The Table above demonstrates that the number of pigs significantly decreased and the number of poultry, sheep and goats increased.

In the Soviet period, a poultry factory functioned in Eniseli village (5 000 wings). There was one cattle-farming complex operated in Balghojiani village (800 heads) which used to produce 5 000 t of meat and 6 000 t of milk annually. Two pig breeding complexes operated in Kvareli and Grami, which had purebred pigs, particularly, large white short eared breed. In addition, all collective and soviet farm complexes had cattle, poultry and sheep farms. These farms mainly had local breeds - primarily in cattle and sheep production sectors. The population in all villages of the district was engaged in cattle breeding.

Table 2.25. Indicators of Volume for Various Animal Husbandry Products in Kvarili Municipality

Product Type	1980s (annual)	2013
Meat (t)	7 320	1 260
Milk (l)	12 000	1 080
Eggs (piece)	4 700 000	3 100 000
Wool (t)	130	80

In the given period, the total average milk production per cow was 1 600 l in Kvareli district. Collective and soviet farms together with the population produced 7 000–8 000 tons of meat annually.

High quality cattle nutrition is a basis for animal husbandry development. In Soviet times, collective and soviet farms produced locally stubble, hay, silage, haylage, but deficiencies are affecting forage quality, which in turn was linked to the productivity increase.

Recently, a cattle farm was renovated in Eniseli village. The internal farm service was equipped with modern technologies. Purebred cattle with high milk productivity was bought by the farm.

As for Kvareli cattle farm it has no analogues in Georgia with all its modern equipment, sanitary and hygiene conditions. 100 heads of high milk productivity black-marked cattle breed were imported from Germany, which were selected based on the breed assessment, the lineage and the individual evaluation. In case of good nutrition, the cows milk three times a day.

Currently, there is sufficient nutrition base for the animal husbandry development in Kvareli municipality, where they can produce high quality forage.

Impact of climate change on Agriculture

Kvareli municipality climate zones and main changes in climate changes are described in 1.2.8 section.

The main problem for Kvareli municipality agricultural sector in the conditions of climate change is hail, which in the vicinity of the weather station decreased in the second period, but there is a certain risk, especially in terms of vineyards. Mudflows and landslides, which wash out agricultural lands, are also important, but are not large-scale in this area. According to the last year's data, with the total amount of agricultural crops in Kvareli municipality, degradation is mainly caused (50-100%) with erosion by water and abundant precipitation.

In order to prevent degradation of agricultural lands, the municipality with its own forces and budgets implements all possible measures for strengthening the river banks. Last year, rainfall to some extent damaged infrastructure, namely a certain part of 3 ha sediment and walking path was damaged by 100%.

According to Kvareli weather station data, the vegetation period (10 ^{0}C threshold) has significantly, by 5 days, increased here at the expense of autumn, which will facilitate full fruit maturity. As for 20 ^{0}C temperature transition and the period of accumulating sugar in grapes, it increased by 9 days mostly at the expense of autumn, although the beginning moved by 2 days towards spring. The sum of active temperatures in this period increased by 256 ^{0}C. This contributes to increasing the sugar content in grapes and this is why grapes in the recent years have been harvested earlier. Precipitation in the vegetation period almost did not change, which increases dryness on the background of temperature increase.

Within the framework of the project, a water loss assessment was conducted for two main crops (melon and tomato) in Kvareli district. The assessment results demonstrated that in the climate conditions characterising the municipality, in comparison with melon, tomatoes consume 21.5% more water. In the second period, overall water demands (in absolute values), as well as irrigation demands decreased in both crops.

Table 2.2.25. Irrigation demands in Kvareli municipality

	Plant evapotranspiration/Overall water demand (mm)			Water loss/Overall water demand (mm)		
Plant	1961-1985	1986-2010	2070-2099	1961-1985	1986-2010	2070-2099
Tomato	546.3	523.4	524.9	180.5	174.3	207.3
Melon	430.7	410.7	401.5	133.0	129.5	150.7

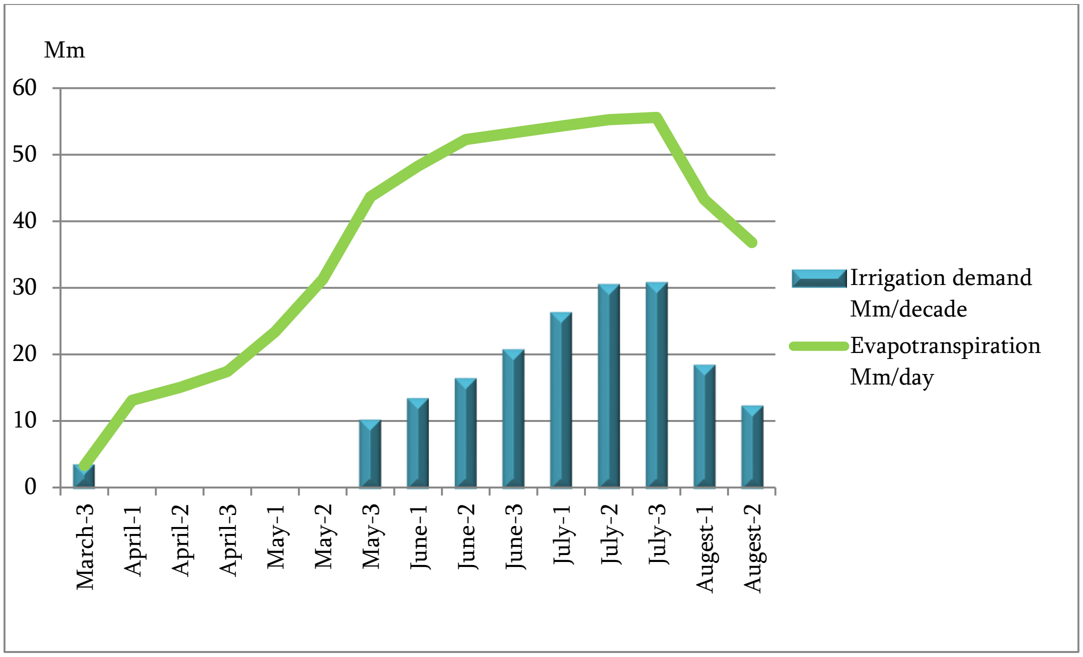


Figure 2.7. Tomato water loss in Kvareli municipality in 1961-1986

The figure demonstrates that the greatest loss takes place in two last decades of July.

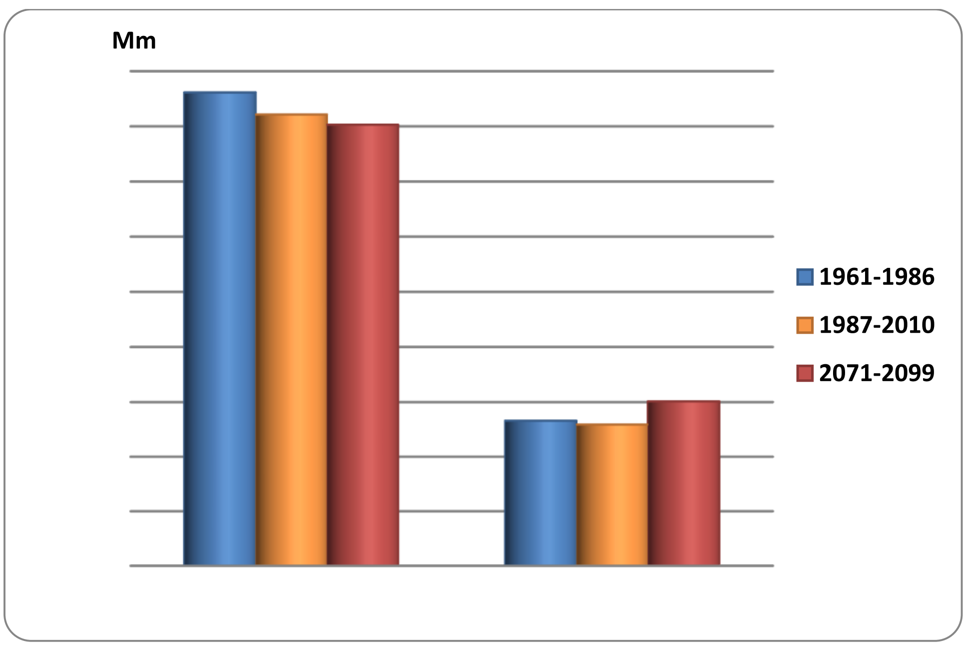


Figure 2.8. Melon water loss in Kvareli municipality in 1961-2099 years

Thus, the irrigation demand in the period of 1961-2010 has slightly decreased (at least for these two crops). For 2010, the irrigation demand for both crops increases by approximately 13% in comparison with the period of 1961-1985.

The number of windbreaks in Kvareli municipality was not a lot, but they were especially protecting annual crops. Presently, 16 ha of windbreaks are in good shape and functioning. Mainly demanded trees were cut and windbreak zones in the villages of Gremi, Akhalsopeli, Gavazi, Eniseli and Kutschatani are outdated.

Recommendations

In order to prevent problems determined by expected climate change, the following measures shall be implemented in Kvareli municipality:

- Importing modern hail suppression methods and introducing other insurance measures. State intervention is especially important.
- Rehabilitation of the irrigation and drainage systems existing at the territory of Gurjaani municipality by introducing modern technologies (new water saving, high-efficiency technologies for refreshing atmosphere, such as fertigation, mulching, drip irrigation, artificial rain irrigation, etc.) and ensuring their proper operation;
- Contraction of a modern plant nursery for the development of viticulture, which will allow farmers and peasants to grow virus-free plants;
- Mechanisms/means shall be found to support the private sector in sharing the knowledge about the modern technologies to the farmers;
- Reinforcing water banks to prevent washing down of land by rivers;
- Establishment of early warning systems for forecasting extreme hydrometeorological events in the municipality, on vulnerable areas. The introduction of a mechanism for reducing the damage caused by hydrometeorological risks, including hail;
- Increasing the potential of the information - consulting services that were established in the municipalities by the Ministry of Agriculture (information, methodologies, availability of laboratories, learning materials, videos, demonstration projects, etc.) to effectively serve the cattle-breeding and plant growing fields;
- Facilitate the process of establishing cooperatives.

2.3. Assessing climate change vulnerability in municipalities of the Kakheti Region using the multi-criteria analysis methodology

Within the framework of the current project, a multi-criteria analysis methodology[23] was used to generally assess vulnerability of agricultural sector to the climate change in all eight municipalities of the Kakheti Region. In total 27 parameters were assessed. The list of parameters and their explanations are given in Annex 4. Vulnerability was assessed in three areas: the impact of climate change on agriculture, the sensitivity of the agricultural sector to climate change and the population's ability to adapt to climate change. Climate change parameters for two 25-year periods were analysed: 1961-1985 and 1986-2010 as it is presented in the chapter on climate scenarios. Data of 8 weather stations were used to monitor the results (Annex 1, Table 1.1), which more or less describe the

[23] http://www.rec-caucasus.org/projects.php?land=en

relevant climate zone. As it is stated in the chapter on climate (1.2.7), the climate in Sighnagi was described according to the data of Tsnori weather station.

For assessing the impact of climate change, the increase of number of days in the abovementioned two periods when the daily maximum temperature is greater than 30^{0}C (SU30), the increase in agricultural droughts calculated with SPI index i.e. precipitation for one-month period is substantially less than the average rate for one month (known as agricultural drought) and the change in the aridity index were analysed.

According to the methodology, all 25 indicators have to be assessed by experts in the relevant fields and their weights shall be estimated in the evaluation process. Assigning weights to these indicators was carried out at the first workshop organized within the framework of the project (11-12 July 2013). The assessment results are included in the calculations. Municipality representatives unanimously recognized that hail caused the most serious threat to the local agriculture especially in the municipalities in which viticulture is a leading field, where hail damages not only harvest of a particular year, but also vineyards which after the damage do not yield harvest for the next 2-3 years.

Hail is quite a local phenomenon and its registration by the closest weather station is often doubtful. At the same time, the hail long-range forecast cannot be done in Georgia for this moment. Hence, hail has been replaced by the aridity index describing the area. Figures 2.7 and 2.8 show the current and future vulnerability of the municipalities (in conditions of current climate change).

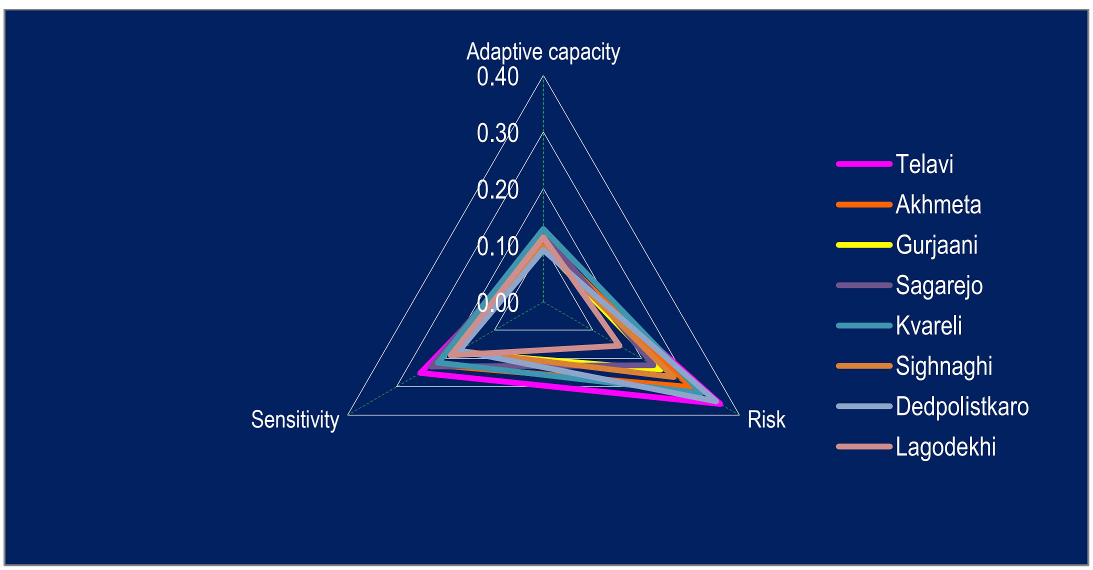


Figure 2.9. The current vulnerability of Kakheti agricultural sector to climate change by taking adaptation capacity of the municipalities into account

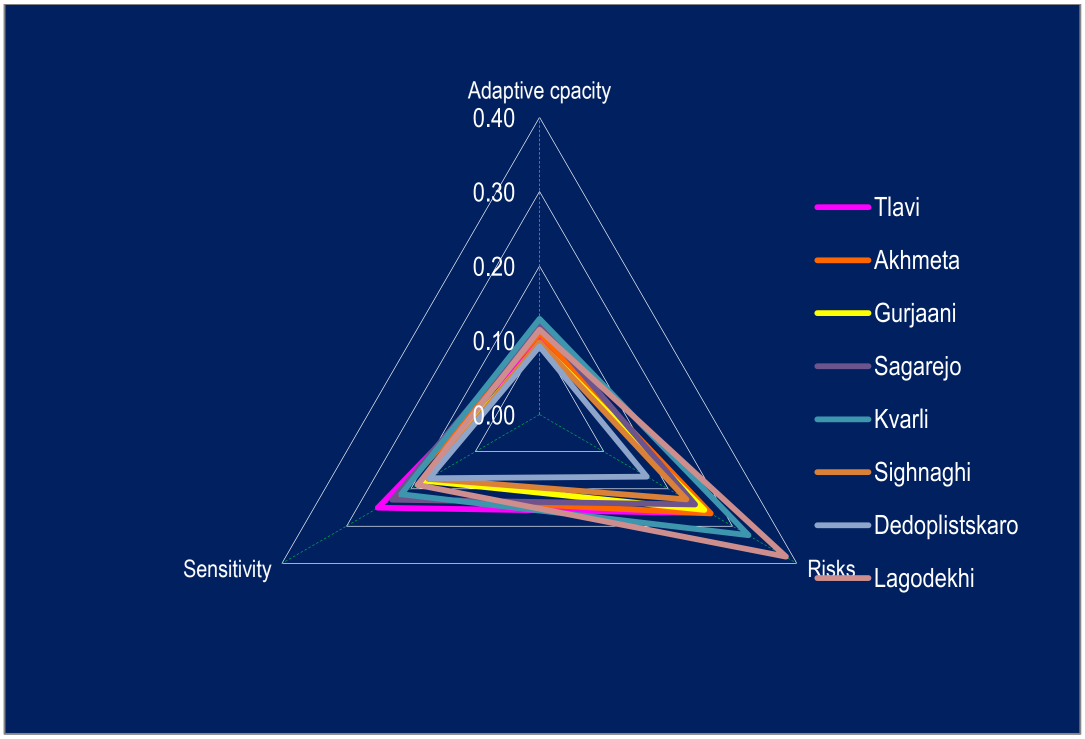


Figure 2.10. The current vulnerability of Kakheti agricultural sector (in the future 2071-2011) to climate change by taking adaptation capacity of the municipalities into account

The same picture in tabular form is presented in Table 2.3.1.

Table 2.26. Municipality opportunities and risks assessed using the multi-criteria analysis methodology

Municipality	Adaptation ability	Sector sensitivity	Risks Between the periods of 1961-1985 and 1986-2010	Sum	Adaptation ability	Sector sensitivity	Risks for 2071-2100	Sum
Akhmeta	0.11	0.22	0.30	0.63	0.11	0.22	0.27	0.60
Dedoplistskaro	0.09	0.17	0.35	0.62	0.09	0.17	0.17	0.43
Gurjaani	0.10	0.18	0.24	0.51	0.10	0.18	0.26	0.53
Telavi	0.10	0.25	0.36	0.71	0.10	0.25	0.26	0.61
Lagodekhi	0.11	0.19	0.16	0.46	0.11	0.19	0.38	0.69
Sagarejo	0.12	0.23	0.22	0.57	0.12	0.23	0.24	0.59
Sighnagi	0.10	0.17	0.27	0.54	0.10	0.17	0.23	0.50
Kvareli	0.13	0.21	0.32	0.67	0.13	0.21	0.32	0.67

Assessments revealed that climate change (described by the above-mentioned three parameters) was most of all detected for Telavi, Dedoplistskaro and Kvareli municipalities and the least in Lagodekhi, Sagarejo and Gurjaani municipalities. Telavi, Sagarejo and Akhmeta municipalities are the most sensitive to changes in the parameters of soils and biodiversity. The least and equally sensitive are Sighnagi and Dedoplistskaro.

As for the adaptation potential, Kvareli was assessed as having the weakest adaptation potential, Lagodekhi and Akhmeta have the similar potential. Dedoplistskaro was evaluation as having the highest adaptation capacity (i.e., it has the largest population and infrastructure is the most developed), followed by almost identical scores by Telavi and Sighnagi. A joint estimation of all three parameters revealed that the agricultural sector is the most vulnerable to climate change in Telavi (0.71), followed by Kvareli (0.67) and Akhmeta (0.63). Lagodekhi agricultural sector turned out to be the least vulnerable in the current conditions.

The same method was used to evaluate expected future changes in terms of the vulnerability of rural municipalities of the Kakheti Region (2071-2100). The results are presented in Figure 2.8 and Table 2.3.1. The Table demonstrates that Kvareli (0.67) and Telavi (0.61) are still in the top list of the most vulnerable municipalities, and Akhmeta will be replaced by Lagodekhi (0.69). The main reason for the increase in Lagodekhi vulnerability is the increase in climate (aridity index). Dedoplistskaro and Sighnagi are the least vulnerable municipalities. Generally, the climate-induced risks assessed according to three parameters will significantly decrease on the whole territory of the Kakheti Region, with the exception of Lagodekhi, where the risk increases. It should be also mentioned that strong spring winds and hail are not included in climate risks, which by this time are associated with quite high risk in some municipalities. This parameter (strong winds) was not reviewed because at this stage its future forecast is impossible.

2.4. The main barriers/risks faced by agricultural sector in the Kakheti Region

Impact on soils of assessed climate change at the territory of Kakheti. 38% of arable land of the country is located in this region. Arable and pasture lands occupy especially large areas. Kakheti is on the first place in Georgia according to this category of land, which makes Kakheti the leading cereal production and animal husbandry region. Therefore, soils are the region's most important resource. In addition, agriculture is the leading field in this region and 82% of the population is employed in agriculture. The region is characterized by agricultural mono-economy and a very low level of urbanization, which significantly increases its vulnerability to current and expected climate change.

Despite of such importance of land resources, the region still does not have a complete land cadaster, which together with the land registration should include quantitative and qualitative land registration, economic assessment of land and the land users' state registration. Monitoring of the rational use of land resources does not take place. In Kakheti, as well as in other regions of the country, climate change takes place against the background of serious anthropogenic loading on soils, which further exacerbates the negative impact of these changes. The impact of climate change on agricultural lands is especially noticeable in Dedoplitskaro, Sighnagi, Sagaredjo and Akhmeta municipalities and are mainly determined by the strong spring winds (Dedoplitskaro, Sighnagi), droughts (Sagarejo) and river floods (Akhmeta, Kvareli). Soil salinization (Dedoplitskaro, Sighnagi), which seems to be indirectly related to climate, but is closely linked with droughts, takes place. Annex 5 lists agricultural lands and areas with degraded soils by municipalities.

At present, according to rough estimates, 27 000 ha of agricultural land, which is 5% of the total agricultural land, is malfunctioning, washed off and eroded. These are mainly pasture and arable areas.

Land degradation is a serious problem especially for two municipalities (Dedoplitskaro and Sighnagi). Basically, we are dealing with erosion by wind and soil salinization. The latter is often caused by excessive irrigation because these areas are quite dry and droughts are frequent here. Changes leading to the main parameters of land degradation are given in Table 2.4.1.

Table 2.27. Changes in main climate parameters causing land degradation between the two periods (1961-1985) and (1986-2010)

Municipality	Winds (m/s)	Amount of drought increment in the second period	Hot Days SU (30) (days)	Precipitation during the vegetation period (%)
Akhmeta	NA (40)	+9	+16	-4
Dedoplitskaro	+ 6 (40)	+11	+17	-2
Sagaredjo	0 (29)	+14	+3	-5
Sighnagi	NA (32)	+9	+10	+2

By taking these processes into account, the major events without which we cannot talk about agricultural profitability in these municipalities, are the windbreak restoration-planting, provision of these municipalities with modern irrigation systems (which are linked to the soil moisture and automatically adjust the volume of water) and systematic implementation of necessary irrigation measures for alkali soils.

In general, it is necessary to monitor the state of soils by **establishing the Soil Bank**, which in addition to the soil types will include their productivity, monitoring results for this productivity and monitoring of the climate change impact. The Soil Bank should certainly include information on **agroclimatic zones,** which had not been carried out for a long time. It is necessary to restore this tradition for Kakheti, but only modern methods and technologies should be used for the zoning. The land resource database with the agroclimate zoning must exist for each municipality and the whole Kakheti Region. At the first stage, the focus should be made on the zoning of grape and cereal (wheat, corn) crops because they are at the moment the main crops in the majority of the municipalities. It is very important to know how these zones may change in the future. For example, from the semi-humid zone Lagodekhi moved to the humid zone, but according to the climate forecast, aridity of this territory will increase dramatically at the end of the century. Production of the same species in the same area may become impossible or so much irrigation may be necessary, that it may become physically impossible to irrigate these lands. It is also important to accurately estimate which grape or grain varieties are the most cost-effective to cultivate in these zones. For protecting soil, it is very important to import effective agro-amelioration modern technologies that prevent soil degradation and promote productivity growth and offer them to farmers.

For assessing and determining the agroclimatic zones it is necessary to restore and establish **a network of agrometeorological stations** close to the area where crops are grown. This will increase the accuracy of the climate parameters in relation to the agroclimatic zones. Currently, most of the meteorological stations are located at the altitude that cannot provide a realistic picture, especially in dry and droughty places with increased aridity.

Impact of climate change on biodiversity revealed on the territory of Kakheti (protected areas). The role of biodiversity in reducing agricultural risks is very important. Where biodiversity and in general, ecosystems are sustainable, are supported and anthropogenic impacts are minimized, the risks for agriculture caused by the climate and its change are relatively reduced. Exactly this principle is included in the above mentioned multicriteria analysis, the indicators of which include in quite ample amounts elements reflecting biodiversity (e.g., agricultural land areas, meadows and pasture lands, forest lands, the amount of local varieties produced in agriculture, degraded soil area) and based on just these elements the assessment of the sensitivity of the system takes place. In the process of preparing this document, an assessment of the role of the reserves and protected areas in Dedoplitskaro and Lagodekhi municipalities in the reduction of the vulnerability of agricultural sector did not take place (except in the reflection of these areas in the multi-criteria analysis). But it is clear that the strong biodiversity protects surrounding agricultural lands and pastures from degradation, in the periods of severe droughts and strong winds. The best example for this are the windbreaks planted in Kakheti and other regions of Georgia in the Soviet period.

In addition, changes observed in biodiversity of the protected areas and reserves are actually almost free from anthropogenic pressure and therefore, monitoring carried out in such areas provides relatively accurate information about the impact of climate change on biodiversity, including agriculture, some crops and pastures (without anthropogenic loading).

The process of preparing Georgia's Second National Communication on Climate Change it has been revealed that the porcupine and the earth rabbit populations, which are familiar to hot, arid regions of Pakistan and Iran, emerged at the territory of Vashlovani protected area (Dedoplitskaro municipality) in the last decade. At the same time, the pheasant population was reduced in some parts of the district. It is assumed that pheasant faces breeding difficulties in the conditions of high temperatures and long droughts. A similar phenomenon was observed during the preparation of Adjara's Climate Change Strategy (2012). In particular, an increase in the spread areas of old plant diseases and the emergence of new plant diseases were observed in the protected areas on the territory of Adjara in the recent period, the brook trout spawning period was decreased because of water temperature rises in the river, which is described in detail in the Climate Change Strategy of Adjara (Section 3.5).

According to information provided by the management of Adjara Botanical Garden, ivy in the Botanical Garden began to land to soil, which is only characteristic for tropical forests. Sustainability of biodiversity and increasing the areas of protected areas will reduce the risks in agricultural sector, and constant monitoring of these areas is necessary in order to more accurately and reliably assess the real impact of climate change on agricultural biodiversity (especially in the case of pastures) and agriculture.

Windbreaks and their role in reducing risks in agricultural sector. Planting windbreaks for several municipalities in the Kakheti Region was of vital importance. In fact, the leading crop and land productivity (except in exceptional years) in these municipality fully depend on the presence/absence of the windbreaks. Only windbreaks protect the fertile humus layer from complete destruction. Dedoplitskaro and Sighnagi in the first place belong to such municipalities. From 3 000 ha windbreaks in these two municipalities at least 75% (there is no accurate inventory) was cut off. As for the single row windbreaks, which were more intended for drought and heat protection, they existed in almost all municipalities of Kakheti, mainly at the road sides and river banks. Their massive logging did not take place, but a large amount is cut or outdated and needs to be updated.

The climate change vulnerability assessment in 2006-2009 revealed that the biggest blow to the agricultural sector in Dedoplitskaro municipality was a result of the windbreak destruction. As a result, in Georgia's Second National Communication the recommendation has been given that rehabilitation of windbreaks was strategically crucial for maintaining and developing pastures and arable lands and cereal and livestock sectors, also for stopping the migration of the population. Several project proposals for the rehabilitation and planting artificial windbreak forests (energetic forests) were prepared. The German government has expressed an interest in this proposal and works started, but the final outcome is almost impossible to achieve for several reasons:

- **The issue of ownership**. It is not clear who owns different types (up to 60 m wide and 10 m wide) of windbreaks. In most cases, the legislative framework concerning the windbreaks is contradictory (according to some legislative acts they belong to local municipalities, but according to other documents they are owned by neighbouring farmers). This is a serious obstacle to the recovery and protection of the windbreaks. Currently, works are underway in the country and the Ministry of Environment and Natural Resources Protection of Georgia is actively involved in the process;
- **Management and maintenance issue.** This issue is also too vaguely addressed by the legislation. A division of pre-existing functions among the Forestry Department, Motor Road Department and the Ministry of Agriculture is no longer valid. It is unclear who is responsible for the windbreak protection (police, Department for Environmental Supervision, Forestry Agency, municipal inspection services);
- These legal uncertainties are accompanied with the problems of **grazing and fires**. Fires are caused by two reasons: (a) Cleaning the area after wheat harvesting from stubbles and weed with the burning method and (b) burning pastures by shepherds in order to boost rapid grow of fresh grass. Both fire types are uncontrolled and destroy the old, as well as new windbreaks. As for grazing, there are similar problems in this respect: because of a lack of control and protection, shepherds do not care if their cattle destroy young windbreak trees. To protect the seedlings from the latter, GIZ experts used modern technologies, which partially improved the situation.

Currently, the Parliamentary Committee on Agriculture and the Ministry of Environment and Natural Resources Protection of Georgia are working on these issues. It is essential to involve local farmers and municipalities in this process. It is not excluded and even is likely that different models would work better in different regions and municipalities than a unified model. As explained above, windbreaks and artificially planted forests are essential for some municipalities (which is one of the best ways to rehabilitate soil), while they were not so important in other municipalities. The problems, discussed above, are exactly the reason why the rehabilitation of the windbreaks is very risky without the appropriate legal framework and protection mechanism.

The impact of climate change on water demand by various agricultural crops. During the vulnerability assessment of agricultural sector towards the climate change the water shortage among a variety of agricultural crops along with many other parameters and the impact of water shortage on crop productivity has been discussed. Table 2.4.2 lists agricultural crops analysed in each municipality.

Table 2.28 Agricultural crops assessed for the water shortage in various municipalities

Name of the plant	Municipality
Sainfoin	Sagarejo, Dedoplitskaro
Alfalfa	Sagarejo, Dedoplitskaro
Sunflower	Sighnagi
Spring wheat	Akhmeta
Autumn Wheat	Sighnagi
Watermelon	Sagarejo, Lagodekhi
Melons	Kvareli
Cucumbers	Lagodekhi
Tomatoes	Kvareli

Water losses were assessed with two different FAO methods (CropWat[24] and AcquaCrop[25]).
The following crops were assessed with CropWat model:

- Kvareli – Tomatoes, melons
- Lagodekhi – Watermelon, cucumbers
- Sagarejo - Watermelon

Wheat, corn and sunflower in different municipalities were assessed with AcquaCrop model.
Water loss indices of following periods were compared: (1) The baseline period of 1961-1985; (2) baseline period of 1986-2010 and the forecast period of 2070-2099; Plant ratios for tomatoes and melon and other characteristics were taken from the indices of CropWat database. For watermelons information published on FAO web-site[26] and also information provided by Lagodekhi and Sagarejo-based local experts was used. All necessary parameters for cucumber was searched in various sources[27], also information provided by local experts was used. In consultation with experts in

[24]http://www.fao.org/nr/water/infores_databases_cropwat.html

[25]http://www.fao.org/nr/water/aquacrop.html

[26]http://www.fao.org/nr/water/cropinfo_watermelon.html

[27]Allen, Pereira, Raes, and Smith, 1998. Crop Evapotranspiration, FAO Irrigation and Drainage Paper, United Nations Food and Agriculture Organisation, Rome, Italy დაDoorenbos and Pruitt, 1977. FAO Irrigation and Drainage Paper 24 (), Table 22, United Nations Food and Agriculture Organisation, Rome, Italy, Depletion factor- Aws Hafez Mujahed, 2011. Estimation of Crop Water Requirement for Cucumber (Cucumis sativus) Grown in Green Houses, MSc thesis, Hebron University, Palestinian Territories. მოსავლიანობის ფაქტორი - Al-Omran and Louki, 2011. Yield response of cucumber to deficit irrigation in greenhouses, Water Resources Management VI, Ecology and the Environment volume 145.

agriculture, the planting dates were selected for the plants and the harvest date was calculated by the software.

Table 2.29. Simulated values of water shortage (mm) in the vegetation period[28]

		Water Shortage (mm)		
Municipality	**Plant**	**1961-1985**	**1986-2010**	**2070-2099**
Kvareli	Tomatoes	181	174	207
	Melons	133	130	151
Lagodekhi	Watermelon	78	79	102
	Cucumbers	75	77	104
Sagarejo	Watermelon	127	158	177

Table 2.4.3 demonstrates that from the agricultural crops listed in the Table, watermelon is affected by the water shortage in Sagarejo district. The same crop in Lagodekhi has almost 50% less need for irrigation. Figure 2.9 shows the change in evapotransportation and irrigation water demand for watermelon in Sagarejo municipality.

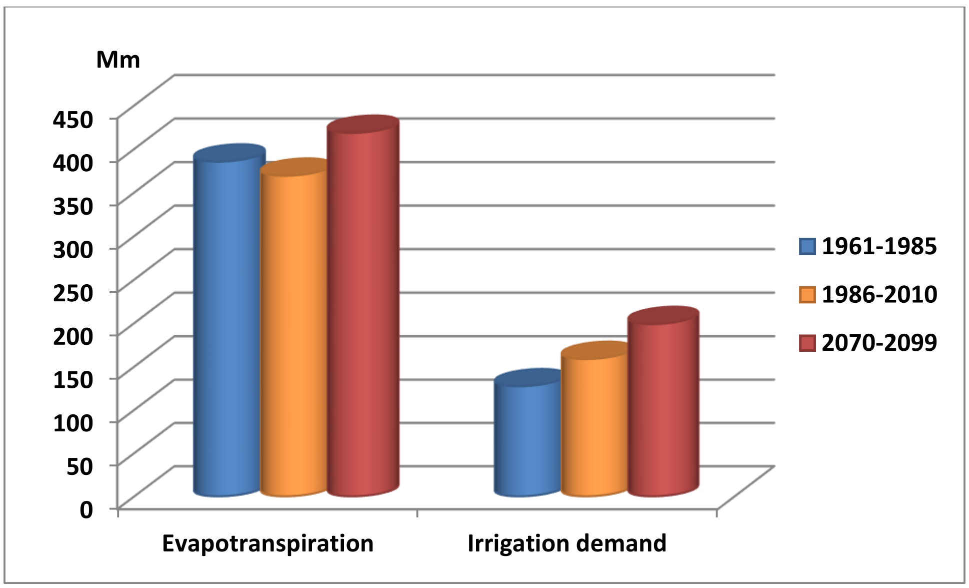


Figure 2.11. Change in evapotransportation and irrigation water demand for watermelon in Sagarejo municipality

Figure 2.9 shows that despite the decrease in the evapotransportation coefficient in the second examination period, the demand for irrigation in watermelons increases due to the reduction in precipitation and the increase in droughts.

If we analyre the water shortage or the irrigation demand in absolute values, Table 2.4.3 shows that most water among these three municipalities is necessary for tomatoes in Kvareli.

[28]This requirements is calculated for $1m^2$ area

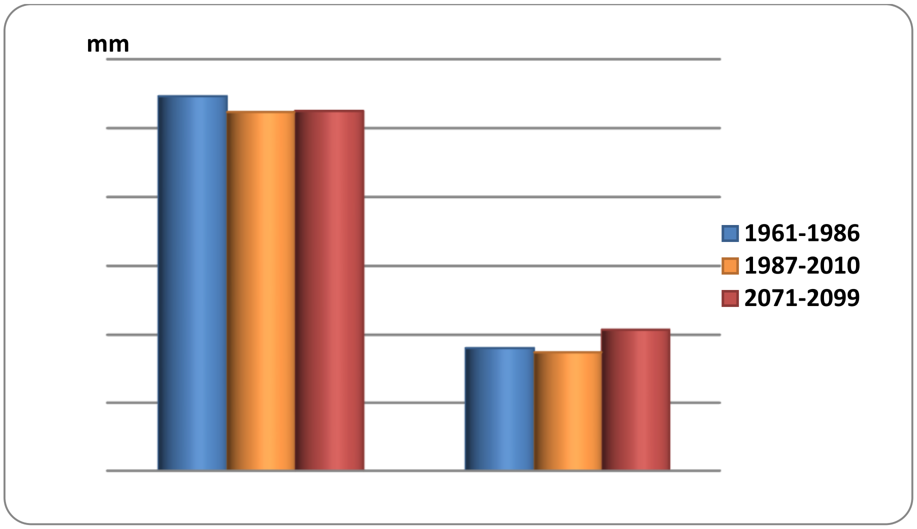


Figure 2.12. Change in evapotransportation and irrigation demands for tomato in the Kakheti Region

Figure 2.10 demonstrates that the tomato water demand in absolute quantities in the second period is slightly reduced, but increases by 33 mm/m^2 at the end of the century and 2100, tomatoes, instead of the loss in water demand by 34% will have 39% water loss.

As stated above, the demand for irrigation in cereal crops and the link of this process to productivity was assessed by AcquaCrop (FAO) model (See results in Annex 3). Figures 2.13 a), b) and c) show water shortage in maize[29] in different municipalities for different observation periods.

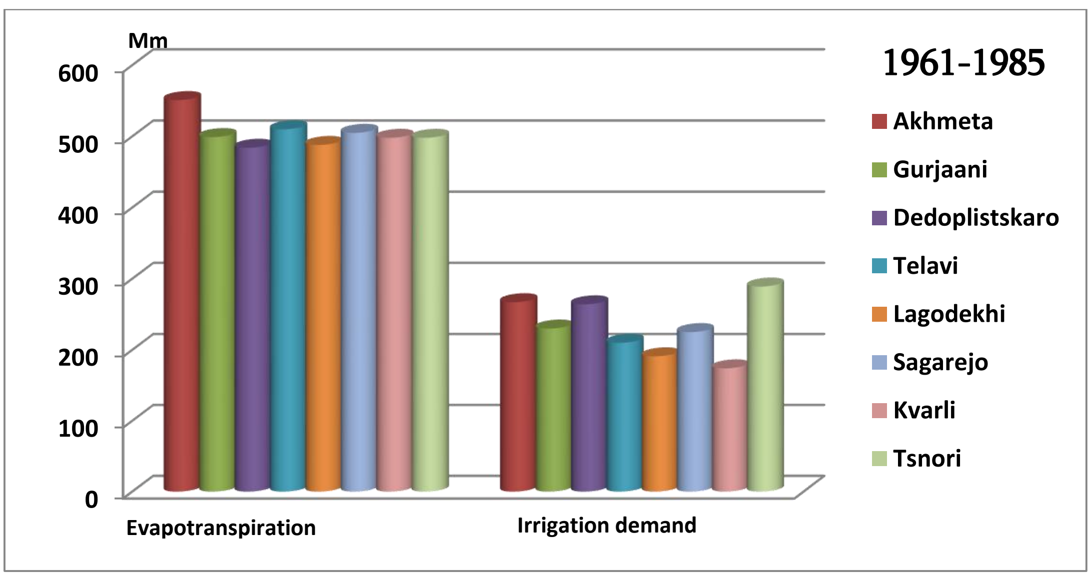
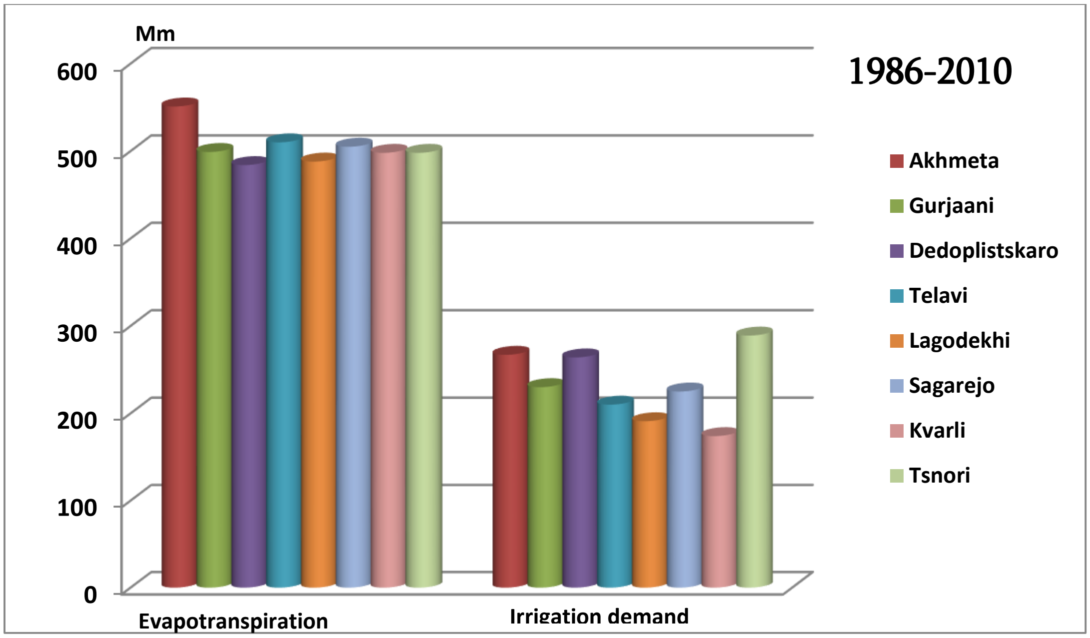
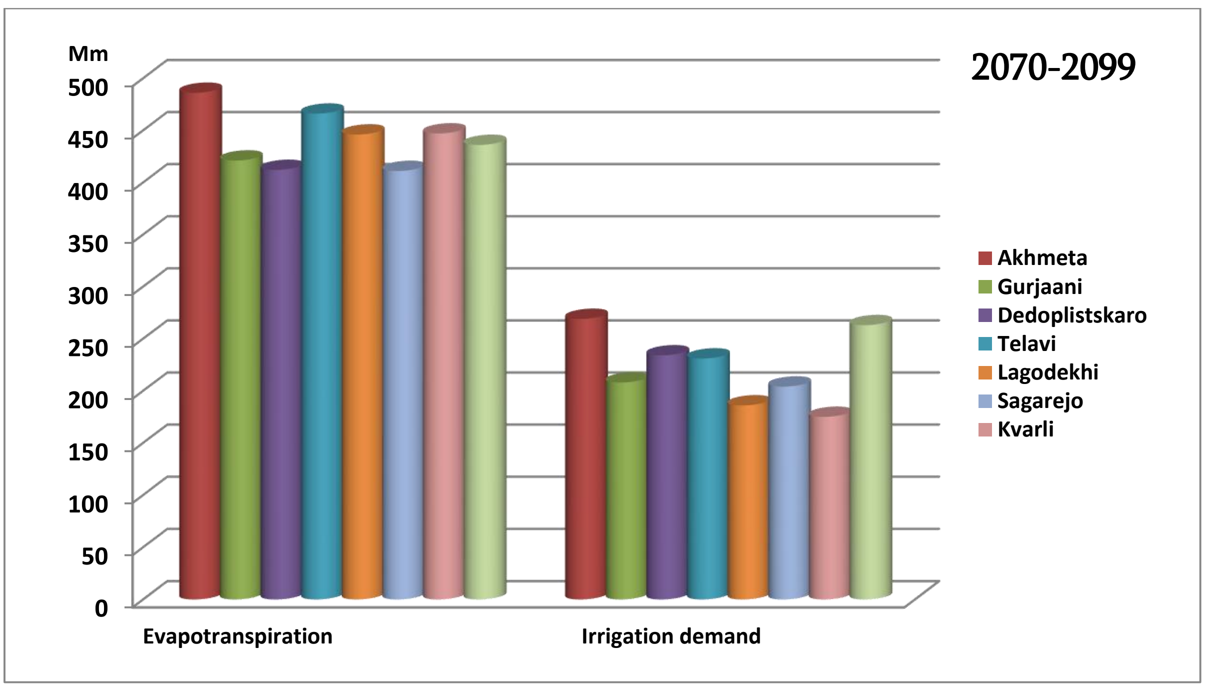


Figure 2.13 a). Irrigation requireent of maize in the Kakheti Region (I period)

[29] A standart corn variety included in the model was used, which is not at this stage adapted to existing varieties in Georgia. The aim of this study was to compare the municipalities in cases of the same corn variety.



b). Irrigation requirement of maize in the Kakheti Region (II period)



c). Irrigation requirement of maize in the Kakheti Region (III period)

Figures 2.13 a), b) and c) show that no significant changes are observed between the first and second periods, but in the future it is likely that maize in Telavi and Dedoplitskaro regions will have shortage of almost the same amount of water.

As for the current two periods, Kvareli and then Lagodekhi will have the least water shortage. Consequently, productivity in the non-irrigation conditions must be highest in Lagodekhi and Kvareli.

Rehabilitation of irrigation and drainage systems. The sharp rise in the temperature on the whole territory of Georgia in the years of 1986-2010 in comparison with the 1961-1985 period was detected in the eastern part of East Georgia, where the temperature increment was 0.4-0.6^{0}C. In the same period, the reduction of precipitation from 0% to 5% is observed on the territory of Kakheti and in some areas (Tsiv-Gombori and Kakheti slopes), the reduction in the precipitation sums reached 10%. Lagodekhi weather station is an exception among Kakheti stations showing 8% increase in precipitation, as a result of which Lagodekhi climate moves from the semi-humid climate zone to humid climate zone. However, the magnitude of these changes does not exceed the scope of natural variation and so far does not change the configuration of agroclimatic zones (except Lagodekhi). As Table 1.5 of Annex 1 demonstrates, extreme and severe droughts and the number of very hot days increased in all municipalities and precipitation during the vegetation period is reduced or altered in the majority of them (except Lagodekhi).

The previous chapter describes the water shortage for different crops according to the seasons and the connection of this loss to the yield. Therefore, the proper operation of irrigation systems it is very important for the region and especially for those municipalities (Sagarejo, Dedoplitskaro, Telavi and Akhmeta), where the greatest increase in droughts is observed.
Groundwater is mainly used for drinking in the Kakheti Region, which is also very important for rural farms, because it partially determines soil moisture.

The last survey of ground water state in the region was conducted in 2003. According to the observations made by local residents, the shallowing process takes place in many areas, especially on the territory of Dedoplitskaro municipality, which is quite poor in ground water. Periodic monitoring of the ground water resources of the Kakheti Region and the appropriate risk assessments are necessary.

During the rehabilitation of old irrigation systems or the construction of new systems mistakes made in the irrigation regimes, which enhanced alkalinisation of soils in Dedoplitskaro and Sighnagi, should be taken into account to the maximum possible extent and together with the irrigation technologies relevant agroamelioration works shall be also offered (plastering or other modern technologies), which will protect the loss of soil fertility. At the same time, the growth trends for the irrigation water demand for each municipality and water supply sufficiency during excessive droughts and reduced precipitation shall be assessed.

With respect to the irrigation systems, it is a priori assumed that our water aboundant rivers satisfy the irrigation requirement. But this approach is incorrect, because these rivers are not abounding in water during droughts, when irrigation of agricultural lands and pastures is required. Possible risks shall be precisely assessed and recommendations shall be issued by taking modern technological advancements into account. It is possible that construction of new reservoirs will be required in some municipalities.

It is necessary to propose several secondary anti-waterlogging measures along with the irrigation systems (Sighnagi, Gurjaani). Especially in Sighnagi, where before the installation of the drainage system, quite large land areas were wetland soils (4 000 ha).

Quality of seed material. Those municipalities (Dedoplitskaro, Sighnagi), where cereal production is the leading industry, see the problem in a lack/absence of certified, high quality seed materials, because non-certified seeds are often concomitant with weeds and diseases, which encounter favourable propagation conditions at the background of current warming and droughts. Accordingly, establishment of a seed certification system and at the same time, production of local, high quality, weed- and disease-free and drought-resistant seed materials according to the market demand is one of the important recommendations for cereal producing regions in the process of adaptation to climate change.

Production of certified grape seedlings. The total area of vineyards in Kakheti is 28 500 ha. Gurjaani is distinguished by the size of vineyard areas - 7 000 ha, followed by Kvareli - 5 700 ha and Telavi – 4 000 ha. Dedoplistskaro (1 500 ha) and Akhmeta (2 072 ha) have the smallest areas. 50-60% of the region's vineyards are planted during the Soviet period, the remaining part was planted from 1994-95 to the present. Scarcity is high in old vine plantations and therefore the hectare productivity and grape quality are lower.[30]

In general, viticulture is quite vulnerable to climatic parameters and soils. Moisture is a necessary condition for grape growing and productivity. For example, the lack of moisture in the Kvareli municipality is especially observed in July and August, which significantly affects the plant and reduces the hectare productivity. The aridity index in this municipality fell from 0.79 to 0.77, but it is not a semi-arid area. Presently, grape saplings are mainly produced by the general population. Large farms buy grape saplings from them. Only one large modern plant nursery "Arivie Georgia" located in the village of Kondoli is functioning on the territory of Kakheti. Sharing knowledge by the private sector to local communities shall take place in such a way as not to disrupt and reduce the competitiveness of the private sector. Vines in Kakheti are especially damaged by underground pests (especially Polyphylla olivieri Castelnau).

Animal husbandly. In those municipalities where animal husbandry is the leading branch (**Akhmeta, Sagarejo, Dedoplitskaro and Telavi**), the largest challenges are ensuring high quality forage for livestock and overcoming diseases. Both of these problems are directly related to climate and could be strengthened or weakened as a result of the change in climate parameters. This especially concerns livestock diseases, the danger of which increases in the case of operating small farms. The establishment of farming cooperatives that will work together to reduce this risk may be one of the most effective measures in conditions of ongoing climate change. Rodents and helminthes (which are not only carriers of diseases, but also main reservoirs of disease sources) are very dangerous, because they seasonally (not simultaneously) emerge in natural environment during different seasons. Therefore, animals suffer from their effects during the whole grazing season and severity of this

[30]Kakheti Regional Development Strategy: 2014-2021

influence depends on the variability of temperature and other climate factors (humidity, wind) in natural territorial complexes.

Knowledge of bioecology of a variety of carriers in various landscape-geographic zones allows to scientifically justifying effective preventive and annihilation measures against insects and mites in animal husbandry. It should be noted that in those municipalities where animal husbandry is the leading field and grazing areas are large, increasing trends of droughts and the number of hot days (Annex 1, Table 1.5) are the most defined, that leads to overgrazing and pasture degradation and fertility loss in case of their neglect. Using appropriate technologies for windy and arid regions is also important with regard to pastures of these municipalities.

The following issues were not assessed in present Report: How many heads of cattle is possible to keep at the existing pastures? What is the amount of artificial food necessary to produce for providing cattle with high quality forage? Are the existing areas in Kakheti enough to feed cattle or a forage import would be necessary in cases of certain increase in cattle total number? What is the maximum number of cattle each municipality and the entire region is able to keep in light of the present changes? In addition, below is a list of the problems from the Kakheti Region Development Strategy (2014-2021) fully shared by this document:

- Deficiency of legal regulations on control of meat quality;
- Unfavourable epizootic state in the region and in the country;
- Inefficiency of veterinary system in the region and in the country;
- Low nutritive value and high cost of fodder;
- Lack of high-productivity breeds;
- Inefficiency of food quality control system;
- Poor infrastructure in butcher shops and sale points;
- Low-calorie summer and winter pastures, partial desertification of pastures.

In fact, all these problems are largely climate-related risks or are enhancing the risks posed by climate change.

In terms of forage and diseases, cattle (mostly sheep) **herding routes** and existing infrastructure shall be especially underlined. The herding trail infrastructure is underdeveloped, that further damages pastures in the process of cattle driving and promotes the proliferation of diseases. One of the main reasons for the infrastructure failure is an absence of relevant legislative framework. At present, pastures and herding routes are not separated in the majority of cases and the unit responsible for their operation and security is not defined.

The necessity for resolving this issue is also reflected in the strategy presented below and the reduction of anthropogenic pressure on the vulnerable systems, such as pastures and herding routes are one of the most effective adapting measures to climate change.

Apiculture. Kvareli, Sighnagi and Telavi are the leading beekeeping zones in the region, while apiculture is the least developed in Akhmeta. Consequently, these municipalities are the large honey producers in the region. Lagodekhi municipality has a great potential for beekeeping, its woods and fields allowed for high-quality honey production, but presently the number of bee families has nearly halved.

Bees are very sensitive to climatic changes (hot weather, frosts, heavy rains) and at the same time play an important role in reducing the negative impacts of climate change on plants (including agricultural) in the process of pollination and productivity growth.

These issues need to be studied in detail. An action plan for the development of apiculture in Kakheti in the conditions of climate change shall be developed.

Specific threats caused by climate change, which were detected in Kakheti Region by the analysis of the above mentioned data are presented in Table 2.4.4.

Table 2.30. Problems and Recommendations revealed in the Municipalities

Municipality	Identified Problems	Recommendations
Akhmeta	Strong winds, droughts and excessively hot days; Enhanced degradation of pastures; Damaged irrigation systems; Wash down of agricultural lands by the rivers.	Required: the rehabilitation of windbreaks that protect from droughts; Restoration of irrigation systems using energy-efficient modern irrigation systems, use of renewable energy at water pumping stations; Ensuring sustainable pasture management by taking climate change into account; Introduction of modern forage producing and distribution technologies; Development of animal disease prevention plans by taking climate change risks into account; Establishment of large farms' and farmers' associations/cooperatives; Implementation of bank protection works in the area of agricultural lands.
Gurjaani	Hail; Soil degradation (secondary bogging) in lowland areas; Shortage of high quality seedlings of fruit trees, which will be the best for this agroclimate zones.	Required: Fruit processing production; Rehabilitation of drainage systems in Kachreti district; Provision of certified grape saplings by taking local agroclimate conditions into account; Iintroduction of hail-suppression technology.
Dedoplistskaro	Strong winds, droughts and very hot days; enhanced degradation of pastures and arable land; damaged windbreaks; damaged irrigation systems; shortage of high quality seedlings; forage shortage;	Required: Rehabilitation of windbreaks that protect from soil wind erosion and mitigated drought; Restoration of irrigation systems using energy-efficient modern irrigation systems, use of renewable energy at water pumping stations; Ensuring sustainable pasture management by taking climate change into account; Introduction of modern forage producing and distribution technologies; Development of

		animal disease prevention plans by taking climate change risks into account; Establishment of large farms' and farmers' associations/cooperatives; Implementation of river bank protection works in the area of agricultural lands.
Telavi	Hail; Shortage of high quality vine seedlings recommended according to climate and microclimate zones.	Required: Provision of certified grape saplings by taking local agroclimate conditions into account; Introduction of hail-suppression technology; Promotion to the restoration of expensive rose oil production for export using modern technologies in relevant microclimate zones; Establishment of the Rose Oil Producers Association.
Lagodekhi	Storage and selling of perishable products (melons and vegetables).	Required: The development of cold storage farms and food processing enterprises; Promotion of restoration of expensive rose oil, tobacco and silk production for export by introducing modern technologies in relevant microclimate zones.
Sagarejo	Increased droughts. Irrigation canals are destroyed. Production of sufficient amount of high quality forage is a problem without irrigation.	Required: First of all, rehabilitation of the existing irrigation systems and construction of the new system on the territory of Udabno village; Introducing modern technologies in forage production.
Sighnagi	Increased frequency of strong winds, droughts and very hot days; As a result, enhanced degradation of arable and pasture areas; Cut down windbreaks; Damaged irrigation systems; Shortage of high-quality seeds; Forage shortage.	Required: Rehabilitation of windbreaks that protect from droughts; restoration of irrigation systems using energy-efficient modern irrigation technologies, application of renewable energy at water pumping stations; Ensuring sustainable pasture management by taking climate change into account; Introduction of modern forage producing and distribution technologies; Development of animal disease prevention plans by taking climate change risks into account; Establishment of large farms' and farmers' associations/cooperatives; Implementation of river bank protection works in the area of agricultural lands.
Kvareli	Hail; Shortage of high quality vine seedlings recommended according to climate and microclimate zones.	Required: Provision of certified grape sapling by taking into account local agroclimate conditions; Iintroduction of hail-suppression technology.

The final conclusion is that from extreme climate events drought, increased temperature (increase in the number of extremely hot days), soil erosion by wind and hail were identified as the serious problems in the Kakheti Region.

Droughts. Frequent droughts were identified as one of the manifestations of climate change. The drought results were reflected in the productivity decrease of annual, as well as perennial crops and forage grasses. At the same time, production of some crops became useless and these sectors turned to be unprofitable. An example of sunflower and corn crops could be used. Although new productive hybrids were introduced in corn production, high yield is impossible for instance in Sagarejo due to the periodic droughts.

The best way to reduce the risks associated with drought is the rehabilitation of irrigation systems and introduction of modern irrigation technologies in production. At the same time, it is necessary to test and popularize drought-resistant varieties. This requires strong testing centers.

Temperature increase (increase in the number of extremely hot days). In this regard, climate change may have a negative as well as positive effect, because the temperature increase in some regions may facilitate an introduction of new crops and enable their commercial production. In addition, there is a counter effect, which is especially relevant in the case of producing some drupe and seed/fruits. In such cases, the existence of minimum values of the sum of active temperatures is necessary.

The rise in temperature and the number of the hot days have quantitative implications in terms of plant protection. The effectiveness of plant protection means and the likelihood of spreading pests also depend on temperature. Activities related to temperature change include agro-climatic zoning of districts, which for a long time has not been conducted in the Kakheti Region. There are some objective reasons for this. First of all, the solution of this issue is related to the existence of sufficient number of district-level, as well as the regional agrometeorological stations. In this case it is necessary to activate both public and private sectors. A simple example might be the installation of mobile agrometeorological stations in the districts, that enables to monitor climate change and allows for regional climate zoning.

Erosion by wind. Based on the available data it is possible to conclude that in the 1990s, the windbreaks were cut down in virtually every district, which is directly linked to the development of wind erosion and reduction in the topsoil layer. Windbreak damage causes destruction of crops, as well as the reduction in productivity levels. The state, as well as local municipalities, farmers and donor organizations are interested in restoring the windbreaks. Improving the legislation related to the operation of windbreaks shall accompany this process in order to guaranteed proper operation and management of maintained and restored windbreaks.

Water bogging. Marshing of soil takes place in many districts of Kakheti. Gurjaani and Sighnagi have to be especially mentioned. The main reason is the failure of the drainage canals, depreciation/filtration of the irrigation channels and the widespread gravity flow practices of irrigation. In this situation, rehabilitation of drainage and irrigation channels is an obligation of the state and namely, the Ministry of Agriculture. The Ministry implements these measures through the

United Amelioration Systems Company. In 2014, more than 71 million Lari was allocated for the financing of these activities across the country. As for the improvement of the irrigation technologies, here it is necessary to activate the private sector and support from donor organizations. Modern technologies require a lot of investments and expertise. Kakheti Region, as well as entire Georgia, is experiencing shortage in both areas.

Hail. In the last few years hail has significantly damaged large agricultural lands of Kakheti. Hail in July 2012 resulted not only in complete loss of the annual harvest, but almost fully destroyed cultivated areas and perennial plantations. It will take at least three years to recover harvest rates of damaged plants (including vine and drupe). Many perennial orchards were destroyed and as a result were cut down in Gurjaani and Telavi districts. Hail especially damages perennial plantations, particularly in the districts with developed viticulture and fruit production (Gurjaani, Telavi, Kvareli). From hail suppression measures, it is necessary to focus on the restoration of early existed practices using relevant new technologies, as well as the installation of safety nets in private farms. The latter requires considerable investments from the side of the private sector, which is directly linked to the availability of financial resources for farmers.

At the background of climate change and an increasing number of extreme weather events it is necessary to share experiences of Western countries. These countries consider an insurance of agricultural production as a way out to the reduction of climate risks. The World Bank has established a reinsurer organization of the local insurance organizations, which is based in Switzerland and determines reinsurance portfolios of insurance companies in the developing countries in terms of agricultural sector. The Balkan countries are currently involved in the scheme. An index-based insurance system in agriculture, which operates based on the principle of temperature and rainfall parameters insurance, is widely common in the United States.

2.5. The Strategy of Adaptation of the Kakheti Region Agricultural Sector to ongoing Climate Change processes

(The Strategy covers the period up to 2025)

As a result of the analysis of agriculture development and variation of climate conditions during 1960-2010 in the Kakheti Region it has been revealed that it is necessary to assess climatic risks, determine vulnerability to expected climate change and develop relevant adaptation activities in natural as well as anthropogenic systems.

Considering the leading role of agriculture in the economy of the Kakheti Region, it is necessary to identify priority directions and assess associated risks caused by climate change.

The present adaptation strategy has been developed in the process of the drafting of Georgia's Third National Communication of Georgia about Climate Change. The Strategy primarily focuses on the activities of assessment and mitigation of climate change driven risks for the Kakheti agricultural sector. The Strategy is comprised of three parts. The first part covers the activities necessary for the enhancement of adaptive capacity of the region, while the second part focuses on the activities that will significantly reduce the impact of extreme climate events on ecosystems and on the agricultural sector in general; The third part comprises the activities of the reduction of sensitivity of the agricultural sector to climate changes. The mentioned activities will significantly enhance the sustainability of the sector and stable development potential.

In the course of the Strategy development the recommendations of the Kakheti Region Development Strategy 2014-2021 approved by the Government in 2013, as well as the results of Georgia's Second National Communication on Climate Change, and the materials of the USAID project "Institutionalization of Climate Change Adaptation and Mitigation Activities in the regions of Georgia" implemented by NALAG[31] were considered as much as possible; Furthermore, 2009-2014 Kakheti Regional Development Strategy Recommendations prepared jointly by UNDP and the Romanian Government, the results of all other research activities conducted in Georgia were taken into account.

The Strategy is accompanied by 10 project proposals, the implementation of which should pilot the activities recommended in the Strategy and demonstrate their effectiveness.

[31]National Association of Local Authorities of Georgia

Adaptation Strategic of the Kakheti Region Agriculture to Climate Change was developed at the workshop held in the Lopota Hotel complex on April 15-16, 2014

Key strategic objective	Target group	Activity	Potential leading organization	Expected result	Potential donors
Enhancing adaptive capacity					
1. Supporting the establishment of large farms/farmers' associations/farmers' cooperatives	Local farmers, the Ministry of Agriculture	▪ The benefits of associations and cooperatives in the process of coping with the climate change should be explained to the farmers; ▪ Identify within the municipalities directions in which establishing cooperatives will be more effective at the initial stage; ▪ Provide/offer preferential loans, subsidies and other incentives (e.g., insurance) to newly established associations and cooperatives; ▪ Ask donor organizations to facilitate the strengthening of this process by means of ensuring the necessary knowledge base and technologies.	Information-consultation Offices created by the MoA at municipalities	▪ Maximally active local farmers associations and cooperatives	GoG/MoA[32] /MENR[33] ; EU GiZ UNDP USAID
2. Maximum provision of existing extension, service centers and information	Extension centers[34]; Farmer service centers[35];	• Retrain service personnel of information consultancy centers and continuous trainings in modern	NGO sector	• The potential of MOA information-consultancy	MENR, GEF; EU; USAID;

[32]The Ministry of Agriculture
[33]The Ministry of Environment and Natural Resources
[34] Have been established under the project Vocational Education and Extension implemented by UNDP and the Swiss Development and Cooperation Agency. These centers have mainly been established on the base of vocational colleges (Kachreti, Akhaltsikhe, Ambrolauri, Kutaisi, Marneuli, Mtskheta) and universities (Zugdidi).
[35]Established with the support of the ENPARD project run as part of the European Neighborhood Policy

consultancy services with necessary information bases and knowledge that is necessary for coping with the climate change problem	Regional service centers; Information consultation Services established at municipalities.	achievements and technologies in agriculture; • Retraining and continuous trainings of information consultancy centers staff in the methodologies of climate change risks assessment and adaptation technologies; • Raising awareness of extension centers not subordinated to state, farmers service centers, regional service centers and all similar organizations on the issues of climate change and adaptation. Providing information to them on modern achievements, with the purpose of use and subsequent dissemination of this information.		offices is maximally enhanced; • Increased capacity of extension centers and service centers; • Farmers are able to receive freely necessary information about the impact of climate change and the activities of adaptation to climate change.	UNDP;
3. Establishment a permanent system of monitoring at protected areas to assess the impact of climate change on the degradation of soil and endemic varieties of flora and fauna in the conditions free from anthropogenic impact.	Local farmers and administration of municipalities; Various research institutes; The Ministry of Environment and Natural Resources Protection; The Ministry of Agriculture.	▪ Include of the Monitoring Plan in the Action Plan of the Protected Areas Department (Regional Division); ▪ Perform monitoring over soil degradation; ▪ Carry out monitoring over the change of endemic flora and fauna varieties; ▪ Identify the most vulnerable parameters; • Assess climate change and its impact.	Agency for Protected Areas (APA)	• Widely available information on the actual (free from anthropogenic pressure) impact of climate change on biodiversity and soils in the Kakheti Region	APA; EU (Clima East); GiZ; ADA;

4. Establishment of agro meteorological stations network. This type of stations enable to accurately measure agro meteorological parameters and their changes in places where the plants are grown, that, in turn, will ensure accurate assessment of impact of ongoing changes.	NEA[36]; Information consultation services of municipalities; Extension centers; Farmers.	▪ Select agro climatic zones; ▪ Purchase agro climatic stations and deploy those in agro climatic zones; ▪ Collect, store and process the information.	NEA	Information on changes in vegetation season of climatic parameters is available; ▪ The impact of the change of climate parameters during the vegetation season on various crops is assessed and made available to famers; ▪ Adaptation recommendations are available.	FAO; NEA; Various financial mechanisms available by the Climate Convention
5. Agro climatic zoning of agricultural lands (farmlands and pastures) and establishment of a relevant information bank	MOA; MENR; Information-consultation centers at municipalities; extension and information service centers not under state subordination; The Agrarian University of Georgia Institute of Soil Sciences	▪ Regulating land use legislative framework; ▪ Purchase agro climatic zoning electronic base that is accompanied by the software for the assessment of the of climate change impact on soil productivity; ▪ Establish local capacity for ongoing updating and operation of this base (the most effective host structure has to be determined and local staff should be trained); ▪ Collect information/update old information necessary for completing the mentioned base; ▪ Complete the base and provide services to farmers, scientific-	Lead organization should be selected for this activity	▪ Information on agro climatic zoning of soils established in the country (for the entire country or for the Kakheti Region) and there is the capacity to forecast possible future changes in this zoning ▪ Agricultural lands are assessed in terms of productivity, estimated information about which crop will be most effective in which agro-climatic zone and how its yield may change in	FAO

[36]National Environmental Agency (NEA) of the Ministry of Environment and Natural Resouces Protection

		research institutes and consultancy centers.		the future is available; ▪ The mentioned information is available to every interested individual.	
6. Assistance to local farmers in the selection and introduction of modern technologies to the country	Private sector engaged in agriculture; Farmers' cooperatives	▪ Assist interested private sector (and cooperatives) in preparation and implementation of pilot projects that would facilitate the introduction of new technologies in the country; ▪ Support interested private sector and cooperatives in finding funding for and implementation of pilot projects; ▪ Special attention should be placed to the following technologies: -Irrigation -Drainage -Land improvement (ploughing and sowing) -Windbreaks -Hail -Embankment (vegetative reclamation)	NGO sector	▪ New technologies introduced to and piloted in the country for the production of saplings, seed material, fragrant and therapeutic essential oils, for the storage of excessive products, safe (for long term) packaging of products, utilization of renewable energies.	USAID; EU; UNDP; Donors working on advanced agricultural technologies.
Reduction of risks caused by extreme climate events					
7. Promoting the rehabilitation of all types of wind shelter belts (in the first place in Dedoplistskaro and Sighnagi, Akhmeta municipalities) This is the activity for	The Parliament of Georgia; The Forestry Department; The Agency of Protected Areas; MOA; Local Government	▪ Legislative framework related to windbreaks should be created considering current situation (form of ownership, protection mechanisms, responsible agencies); ▪ Involvement of local farmers and farmers' cooperatives/associations in the	▪ Municipality leadership; ▪ local NGOs ▪ Farmers' cooperatives	▪ Legislative framework for the development, maintenance and protection of wind shelters is improved and ensures safe operation of windbreaks in places where these are	GiZ; EU (Clima East pastures).

the protection against strong winds (35-40m) that is common in spring in these municipalities Such activities will contribute significantly to the development of low emission strategy as well.	Executive Offices; independent farmers and farmers cooperatives in Dedoplistskaro, Sighnagi, Akhmeta municipalities	preparation and implementation of pilot projects is going on; ▪ Restoration of wind shelter belts has started in places where it will be possible to protect them		necessary; ▪ Some portion of wind shelters has been restored; ▪ Wind belts often serve as a corridor for migrating wild species, as well as shelter for them; ▪ Farmers benefit from additional products (fruit, firewood, etc.) derived as a result of wind shelters; ▪ Soil degradation process is slowed down and productivity increased; ▪ Greenhouse gases absorption has increased.	
8. Restor action of existing and setting up new irrigation systems. This activity has to be implemented in the first place in Sagarejo (Udabno) and Dedoplistskaro	Georgia United Land Improvement Systems Company, Ltd.[37] Local farmers; Rural population.	▪ Specify water shortage in the months of July and August, in the first place for the mentioned municipalities, and next, for the entire territory of Kakheti, considering the requirement for water by leading crops of these municipalities. ▪ It is necessary to hold at least periodic monitoring of underground waters outflow and	Georgia United Land Improvement Systems Company, Ltd (on central networks); Farmers' cooperatives (on internal networks).	▪ Central canals of irrigation systems restored at most in Dedoplistskaro and Sagarejo municipalities; • Main canal been brought to vil. Udabno territory. ▪ Farmers' cooperatives ensure	Climate Change Framework Convention Adaptation Fund; GCF[38]; FAO.

[37]The mentioned company (State-owned LTD) has four system sub-divisions throughout the region. Specifically: Zemo Alazani, Kvemo Alazani, Lagodekhi-Kvareli and Kvemo Samgori system sub-divisions that ensure the supply of irrigation water to all municipalities of Kakheti.

[38]Green Climate Fund that will fund adaptation projects, among others

where drought is the biggest problem, followed by Sighnagi, Akhmeta and Gurjaani. This activity is aimed at the reduction of such climatic risk as drought. During the second period (1985-2010) severe and extreme droughts have increased the most in Sagarejo and Dedoplistskaro		its trend, which, in the first place is necessary to assess potable water risks and is also important for agriculture (stock-breeding); ▪ Encourage maintenance of internal (non-central) irrigation systems by farmers' cooperatives; ▪ Prepare the scheme of priorities for the restoration of systems and adding new systems; ▪ Select the most effective irrigation systems for the municipalities of Georgia, Kakheti, and specifically for the most drought-stricken municipalities, and maximally offer the use of renewable energies for operating water pumps; ▪ Prepare demonstration projects on internal systems rehabilitation and maintenance schemes; ▪ Support attracting of investments and implementation of such demonstration with projects, maximum involvement of farmers' cooperatives in this process.		maintenance of internal irrigation systems; ▪ Irrigation systems are maximally provided with the necessary amount of water during drought months; ▪ Water charge payment scheme is improved; ▪ Soil degradation has been reduced and productivity increased	
9. Restoration of hail protection activities is especially	NEA; „Delta“[39]; Insurance companies;	• Survey of modern hail protection Technologies available on the market; • Prepare recommendation for	▪ Insurance companies	Risks caused by hail have been reduced	USAID; GoG; Private sector; Insurance

[39]Scientific-Technical association of the Ministry of Defense of Georgia that has been moved to the Ministry of Economy and Sustainable Development

important for those municipalities in the Kakheti Region where viticulture is a leading sector, because heavy hail results in ruining not one but several years (2-3) of crops. It is Gurjaani, Telavi and Kvareli municipalities that need hail protection technologies In the first place	Private sector farmers involved in viticulture; Large wineries;	best technologies to be applied in the Kakheti conditions; • Promote farmers associations/cooperatives in the implementation of a joint strategy for supression hail			banks; The Government of Bulgaria.
10. Arranging embankment works for reducing flash-flooding and mudflow risks. Almost all municipalities need some volume of these works, but Akhmeta district agricultural lands are mostly threatened. This activity is directed towards the reduction of risks caused by downpour rains.	Local communities; Farmers; Municipality leadership; Information-consultation services.	• Assessment agricultural territories under the risk; • Preparation of recommendations on embankment activities; • Provision of knowledge and assistance (by means of preparation of pilot projects and involving in those) to the most vulnerable population/villages; • Co-funding of rehabilitation works (especially at the initial stage).	▪ Local communities	▪ farmers are united around the mentioned problem; ▪ the process of losing of territories weakened; ▪ farmers permanently monitor the problem and implement embankment works; ▪ Government interferes in case the situation becomes complicated.	GoG; Local municipalities leadership USAID; Japanese government; Climate change Adaptation Fund (CDM);
Reducing the susceptibility of the Agricultural Sector					
11. Facilitating biodiversity.	Local administration;	▪ Create legislative framework for the development and unimpeded	▪ Local administration;	▪ Relevant legislative framework and	GIZ; ADA;

Development of planted (commercial) forests on abandoned and eroded soils first of all in Dedoplistskaro and Sighnagi These activities are necessary in the first place in locations where there are large areas of degraded and abandoned agricultural lands. Similar activities will make significant contribution in low-emission development strategy as well.	local farmers; The association/cooperatives of farmers with degraded and abandoned land plots.	use of commercial forests; ▪ Select abandoned areas with eroded soils for setting up forest husbandries; ▪ Till the soil and apply fertilizers for the development of planted forests; ▪ Select tree varieties with high calorific capacity and intensive carbon dioxide absorption capacity. The varieties should also have high capacity of soil recovery and high drought resistance; ▪ Develop planted forests/groves; ▪ Support establishing association of farmers willing to develop planted forests.	▪ MoA; ▪ The Ministry of Environment and Natural Resources Protection Climate Change Convention, Desertification Convention); ▪ Forestry department; ▪ Land Use Department; ▪ Protected areas Department; ▪ NGOs	incentive mechanisms established for the development and use of commercial forests in Georgia; ▪ Commercial forests are developed on degraded areas; ▪ Additional biomass is created that can be used by the private sector for the production of renewable energy; ▪ Eroded soils are partially rehabilitated; ▪ Illegal cutting down of firewood material on protected areas, in wind shelter belts and forests is reduced; ▪ Carbon dioxide emissions from degraded soils is reduced and the CO2 sinks are increased.	EU.
12. Promoting the production of quality, disease and weed free, local seed (cereals and in the first place, wheat) material and facilitating the formation of certification system	MoA; MENR; Information-consultancy centers; Local farmers/farmers cooperatives.	• Detailed analysis of the problem of quality and lack of seed material, including the assessment of risks caused by climate warming and droughts; • Survey of modern technologies for the production of high quality (not only high	• Private sector	• High quality seeds are produced in an organized manner and in sufficient quantities in the Kakheti Region; • Certification of local, as well as imported seeds is	UNFCCC Adaptation Funds (CDM, GCF); Technology Transfer funds operating under the UNFCCC

Seed production considering agro ecological zones for Dedoplistskaro and Sighnagi municipalities in the first place		yielding, but also having relevant taste, disease and weed free and resistant to droughty conditions) seed and selection of the technology for the production of seed relevant to the agro climatic zones of Dedoplistskaro and Sighnagi districts; • Setting up of seed production and testing specialized farm; • Involvement of existing seed producers in the process of production of high quality seed; • Establishment seed certifying system and certification of imported as well as locally produced seed material.		performed (at the first stage this should be voluntary); • Soils are protected from weeds; • Wheat (and other cereals) are protected from diseases; • Productivity of locally produced seeds is increased as it has been adapted and tested for agro-climatic zones.	FAO.
13. Supporting the production of quality, vine disease resistant, local vine seedlings and promoting the establishment of certification system. Seedlings should be produced considering agro-ecological zones, to meet the requirement of Gurjaani, Telavi and Kvareli municipalities in the first place.	MoA; MENR; Informational consultation centers; Local farmers/farmers' cooperative; Wineries.	• In-depth analysis of problems related to vine seedlings and lack of those, including the examination of risks caused by climate warming, droughts and hail; • Study of modern technologies for the production of high quality (not only high yielding, but also with relevant features of taste, disease free) vine seedling and identify vine seedling production technology suitable for agro climatic and microclimatic zones in Gurjaani, Telavi and Kvareli			Climate Change Framework Convention Adaptation Funds (CDM, GCF); Technology Transfer funds active under the UNFCCC; FAO.

		districts; • Arrangement of vine seedling production farm; • Mobilize action of existing vine seedling producers (if applicable) and their involvement them in the process of high quality seedlings; • Establishment of, vine seedling certification system and certification of produced seedlings.			
14. Determining conditions conducive to plant diseases, offering to farmers optimal methods for fighting with those diseases (so as not to harm the crop)	MoA; MENR; Information-consultation services; Extension centers; Institute for Plants protection; Farmers associations/cooperatives.	• Determination of correlation betweenplant diseases and ongoing climate change and if applicable, working out relevant recommendations for disease prevention • Since such diseases spread easily, it is very important to carry out joint activities against them. It is necessary to involve farmers In this process, that has to be done by informational consultation services formed at municipalities	• Local self-government bodies and Ministry of Agriculture informational consultation services at municipalities	• Causes of plant diseases have been studied; • Preventive activities performed; • Plant protection activities have been carried out	The private sector; Large farmers; The GoG.
15. The impact of climate change, soil degradation and other changes on leading crops has to be assessed at municipalities and only considering the obtained results final selection of crops and	MoA; MENR; Information consultation services; Extension centers; Institute for plants	• Leading crops have to be selected for each municipality; • For selected crops water shortage and its correlation with yield should be assessed using FAO models (AcquaCrop and CropWat); • The potential for filling this	Information consultation Services; Extension centers.	• Water shortfall is assessed for leading crops at each municipality; • Recommendations for the reduction of risks caused by this shortfall	FAO; GEF; USAID; UNFCCC adaptation funds

determination of irrigation needs should be performed	protection; Farmers' associations/cooperatives;	shortfall via irrigation should be assessed (the availability of irrigation systems and water resource – using the WEAP model) and relevant recommendations should be provided; • Some crops may be replaced by crops that are more drought resistant.		developed; • Farmers have carried out relevant activities.	
16. Main problems of water-melon, melon and gourd growing are associated with the storage of excessive perishable production. this is a serious problem for Lagodekhi (market garden produce and vegetables) and partially for Gurjaani (peaches)	Local farmers	• Supplying the sector with warehouse and refrigeration facilities for the storage of market garden produce and vegetables especially in the vicinity of the markets; • Supporting the development of canning industry by means of offering modern technologies to the private sector and engagement in pilot projects.	Local farmers		USAID; EU.
17. Designing the portfolio of activities for the reduction of risks to stock breeding development in the context of global warming; stopping the degradation of pasturelands, production of high quality fodder, Undertaking activities for the prevention of livestock disease outbreaks.	MoA MENR; Farmers engaged in stockbreeding.	• Planting animal food crops on certain massifs of pasturelands, and their watering; • Breeding of highly productive livestock and its provision with quality fooder; • Setting up artificial insemination points; • Strengthening of live-stock food basis by means of the utilization of free and abandoned agricultural territories;	Private sector; Stockbreeder farmers' cooperatives.	• High caloric/ quality food is provided to the livestock; • relative protection against communicable diseases; • preventive activities to reduce the risks of diseases are carried out on a regular basis; • Final products are stored safely until	ENVSEC

As a priority these activities have to primarily be carried out in Sagarejo (stockbreeding), Akhmeta and Dedoplistskaro (sheep-breeding)		• Setting up livestock slaughter-houses, that will bring down the risks of disease outbreaks; • Forming a private veterinary system; • Establishment of modern dairy, meat production enterprises, that will ensure the storage of products even at high temperatures; • Studing the correlation of animal diseases with climatic and geological phenomena (drought, powerful wind, landslides and land-flows); • Regulating legislative framework necessary for sustainable management of pasturelands and herding routes where the issues of rights and obligations and the conditions for the development of herding routes infrastructure will be explicitly stipulated, which will significantly reduce animal diseases and will protect pasture from degradation; •		realization; •	
18. Study the impact of climate change on apiculture and develop recommendations		• Bees are highly vulnerable to climate parameters and it is important to study this phenomenon well, analyre the possibility of using bees for		The impact of climate change on bee and the role of bees in the reduction of risks caused by	

for the use of bees in adaptation activities (pollination/yield increase)		fertilization of plants and increase in yield and to work out relevant recommendations. It has to be assessed why the number of bees has halved in Lagodekhi and increased in Gurjaani, Kvareli and Sighnagi; • Promoting certification and export of honey, therapeutic material and other bee products, that will in turn facilitate proper development of the branch and will increase the role of apiculture in adaptation to climate change.		climate (winds and showers) in agriculture have been studied well.	
19. Kakheti Agriculture Long-term Strategy (following 2025) has to be combined with agro-tourism development, considering resources of each municipality and global warming risks.	GoG, leadership of the Kakheti region Farmers' associations/cooperatives	Strengthening the continuous monitoring system over the ongoing climate changes. In addition to hydro meteorological parameters, that measure the change in climatic elements and the river water regime in quantitative terms continuous monitoring should be performed on soil, flora and fauna.			

2.6. Demonstration Project Proposals to Reduce Negative Impacts of Climate Change

2.6.1. Alazani River and Ilto River Bank Reinforcement on the Territory of AkhmetaMunicipality

(Reducing the Risk of Erosion of Agricultural Lands)

2.6.1.1. ProblemDescription

The main activity of the population living in Akhmeta Municipality is agriculture and their income heavily depends on harvest from agriculture and agricultural lands. Wheat, corn, fruits and vegetables are mainly produced here.

Municipality total agricultural farmland area in R.Alazani Basin is 2359 hectares (3 villages in Jokolo Community: Jokolo, Birkiani and Dzibakhevi; 2 villages in Duisi community: Duisi and Tsinubani. Sakobiano Community - 7 villages: Sakobiano, Bakilovani, Dedisferuli, Kutsakhta, Koreti, Kvareltskali and Khevistschala. Matani Community - 1 village Matani) and225 ha in R.Ilto Basin (Shakhvetila Community - 8 villages: Vedzebi, Naduknari, Sabue, Chachkhriala, Chartala, Jaburi and Bukhrebi).

In recent years, the population of the communities living in Ilto and Alazani watershed areas faces problems caused by climate change.

According to general observations made by the local population, during the last decades the disproportionate distribution of precipitation during the year has been revealed (i.e., excessive rainfall or on the contrary, dry periods, droughts), which as locals say has a negative impact on the quantity and quality of products produced by them.

According to them, they also face other problems such as soil erosion, landslides and other risks triggered by such processes.

According to the data from Akhmeta Meteorological Station, average annual precipitation sum and seasonal sums, as well as maximum daily precipitation were reduced in the second period (1986-2010), but maximum 5-day consecutive precipitation(Rx5day) increased by 22%in summer.

Droughts of certain types and duration were reduced, but extreme one-month and nine-month droughts were increased, which is consistent with the observation made by the local population.

Rivers Alazani and Ilto swollen during excessive precipitation threaten and significantly damage the local population, as the main agricultural farmlands of the population are precisely located on the banks of these rivers.

Floods are reoccurring every year with different intensity and they wash away arable lands belonging to the population.

In recent years, Alazani River washed away about 8 ha black plum orchard in Jokolo Community, the 2 ha land that survived the washing away is caught inside the river bed.

Additional 45 ha area in the same municipality also faces a danger of washing away. In Sakobiano Community, 35 ha area, which was used by the population for growing corn and wheat, was washed away and more than 35 ha area is threatened. In Duisi, 40 ha of arable land is threatened by the same problem. 200 ha arable land in Matani faces the flooding threat. Flash floods threaten the population of Shakhvetila Village in Ilto Gorge. Each year, inudated R. Ilto destroys the only motor road linking to the village. In addition, R.Ilto periodically floods 20 ha arable lands along its banks and poses a threat to the houses of the local population.

During droughts, on the contrary, there is the problem of lack of water necessary for irrigation. At such times, the malfunctioning and outdated irrigation-drainage system does not compensate for the water loss.

2.6.1.2. Project Goal

The goal of the project is to mitigate risks increased as a result of natural disasters caused by climate changes in Ilto and Alazani basins and to protect local communities and their arable land. In particular, the following areas should be protected from the washing away: 45 ha area in Jokolo Community, more than 120 ha area in Sakobiano Community and 40 ha area in Duisi. Also, the project envisages protection of 200 ha arable land in Matani facing the threat of washing away. The only motor road connecting to Shakhvetila Village in Ilto Gorge, houses of 15 families in Shakhvetila and their arable lands are threatened by flash floods as well.

To achieve these goals, the project plans to conduct river bank reinforcement works on Ilto and Alazani rivers. Namely, it is necessary to build 8 gabions on the right bank of R.Alazani (each gabion will be 60 meters long, 300 m^3 in volume), where arable lands belonging to Jokolo, Duisi, Sakobiano and Matani communities are located. On the Ilto River bank, where arable lands belonging to Shakhvetila Community are located, it is necessary to build 4 gabions of the same shape (each gabion will be 60 meters long, 300 m^3 in volume).

Reinforcing rivers with stone dams is a proven method. It is confirmed that it gives good results. In particular, such dam provides reliable protection of hundreds of hectares of land. The project also seeks to increase the level of community mobilization and involvement of the local communities in solving problems caused by climate change.

2.6.1.3. Project Implementation

Methodology

The project envisages the construction of twelve, 60 meter-long (each) stone gabions on the banks of Ilto and Alazani rivers in the areas surrounding arable lands. The design must be a three-tiered: the first stage (gabion mattress) with 0.5×4 m size, the second stage with 2×1 m size and the third stage with 1×1 m size. The height of the gabion construction will be 2.5 m and the length – 60 meters, the cross-sectional area will be 5 m^3 and the total volume – 300 m^3. Gabion wire thickness will be 2.7 mm. The wire drawer size should be 10×8 cm. Diaphragm on each meter shall be made on the gabion boxes. It should be noted that it is planned to plant 1 200 seedling willow trees along the gabions for reinforcing riverbanks and maintaining local biodiversity. It is recommended to implement the works in two stages.

Planned Activities

The following main works shall be planned at the first stage of the project implementation:

1. Processing Alazani and Ilto river beds with excavators. Removing water from the working area - 800 m^3;
2. Ground processing – grading with bulldozer to arrange the gabion bottom – 1 920 m^2;
3. Arrangement of hollow for gabion mattress;
4. Arranging bed for gabion mattress – 1 760 m^3
5. Collecting stones for gabions and loading them on a dump truck – 1 200 m^3;
6. Construction of gabions - arranging stones in a cage – 1 624 m^3;

The following materials are necessary for carrying out these activities:

1. Gabion cage (10×8 cm) made of galvanized 2.7 mm diameter wire - 1 200 m^3;
2. Stainless steel 2.7 mm wire - 1 440 kg;
3. 12-25 cm sizes cobble stones- 1 200 m^3;
4. Fuel - 4 000 liters.

The second stage (gabion installation -150 m^3) - The following major construction worksshall be carried out:

1. Collecting stones for gabions and loading them on a dump truck – 1 200 m^3;
2. Filling the gabion back part with ballast - 2 720 m^3;
3. Planting seedlings.

The following materials are necessary for carrying out these activities:

1. Gabion cage (10×8 cm) made of galvanized 2.7 mm diameter wire - 1 200 m^3;
2. 12-25 cm sizes cobble stones - 1 200 m^3;
3. Seedlings – 1 200 pieces;
4. Fuel – 2 400 liters.

2.6.1.4. Project Partners and Beneficiaries

Partners:

- Ministry of Infrastructure and Regional Development of Georgia, which is responsible for carrying out the bank reinforcement works and is ready to render technical assistance to the project;
- Municipal Development Fund of Georgia, which mainly funds infrastructure projects to be implemented in municipalities;
- Ministry of Agriculture of Georgia, which is interested in protecting agricultural farmlands and improving quality of soils;
- Akhmeta Rural Municipality, which is interested in increasing wellbeing of its population and has an obligation to assist the population in mitigating such serious common risks. The municipality is ready to mobilize the local population;

- Donor agencies that are funding the agricultural sector, land degradation mitigation and problems of mobilizing agricultural communities (USAID, WB, UNDP, etc.);
- Non-governmental organizations working on similar issues (CENN, REC, Mercy Corps, etc.).

Beneficiaries:

- Families, farmers and peasants living in Akhmeta District (800 families, 2700 individuals);
- The leadership of Akhmeta Municipality who will garner positive sentiments of its population.

2.6.1.5. Factors Contributing to the Project Implementation

- Readiness of the local population to participate in the project at the maximum extent;
- Increasing the scale of rehabilitation of river reinforcement infrastructure by the state (funding increase);
- Serious donor activities in this direction;
- Significant support from the non-governmental organizations;
- Approval and support to the initiative by the municipality;
- Project sustainability. After finishing the works scheduled within the project, Akhmeta Rural Municipality will take over the works carried out by the community groups for their maintenance.Also, in addition to the local Gamgeoba, the community group will assume responsibility for the maintenance of the dams and taking care for the planted seedlings;
- The constructed dams and the place where plants where cultivatated will be systematically examined and in case of the dam failure it will be repaired in a timely manner, damaged plants will be replaced with new ones by Akhmeta Municipality Gamgeoba.

2.6.1.6. Challenges to Project Implementation

- Lack of river cobbles in Alazani and Ilto river beds, which are needed for the construction of gabions;
- Interruption of the community mobilization process by objective and subjective reasons;
- Lack of interest by the local population and migration from the area;
- While planning the project activity time-table, it should be taken into account that late autumn is the best time for the implementation of the works in a timely and successful manner. At the same time, rains are frequent at this time and they might impede the works. Choosing favorable time for the construction is a very important barrier;
- Decrease in investments in the agricultural sector.

2.6.1.7. Project implementation stages (milestones) and budget

Total duration of the project – 2 years

Activities	Implementing Link	Implementation Period (in months) and Budget (USD)	Estimated Results
Processing the river bed with the excavator. Ground stacking. Removing water from the working area.	Hired private company	41 000	River bed is processed
Ground processing – grading with bulldozer to arrange the gabion bottom	Hired private company	21 500	River bed is corrected
Arranging structural basins for gabion mattress	Hired private company	23 000	Structural basins for gabion mattress are arranged
Collecting stones for gabions and loading them on the dump truck	Local communities	38 500	Stones (cobble stones) for gabions are collected
Construction of gabions, installing the wire care, arranging stones in the cage	Local communities	45 200	Gabions are built
Filling the gabion back part with ballast	Local communities	26 000	Gabion back part is strengthened
Planting seedlings	Local communities	2 000	Phyto-amelioration measures are carried out
Rehabilitation of the river reinforcement infrastructure as envisaged by the project	Local communities; Akhmeta Municipality Gamgeoba; National Environmental Agency of the Ministry of the Ministry of Environment and Natural Resources Protection of Georgia.	24 months 197 000	Houses of 15 families in Shakhvetila and their arable lands are protected from flooding during rivers swells. 180 ha arable lands in Jokolo, Duisi, Sakobiano and Matani communities are protected from washing away and floods. - Agricultural land will be rationally and efficiently used; Crops (corn, wheat, fruits, vegetables) will be protected and with them, income sources of the local populations will be maintained;

			The level of the socio-economic conditions of the local population will be increased, which will be related to the restoration and use of agricultural landsthat are currently unused; The level of the community mobilization and the participation of the local population in issues related to the management of natural resources will be increased.
Total		**197 000**	

2.6.2. Restoring Territories Damaged by Soil Erosion in Gurjaani Municipality

2.6.2.1. Problem Description

The project area covers approximately 8 ha land area in Alazani River Basin near Vazisubani Village.

The process of climate change on the territory of Gurjaani Municipality is manifested by the overall decrease in annual precipitation in the last decades and its increase in certain seasons. Despite the fact that the amount of annual precipitation decreased by 2% in 1986-2010 in compared to the previous 25-year period (1961-1985), spring precipitation increased by 3% and autumn precipitation by 11%. The annual decline mainly takes place at the expense of summer precipitation (-20%), which significantly increases the demand for irrigation during this period. The daily rainfall maxima, which mainly cause swelling of rivers, also increased in spring (34%) and fall (12%).

All these are happening against the backdrop of increasing the average annual temperature by 0.4 ^{0}C between the mentioned above periods.Winters are quite warmed, the absolute maximum is increased and the absolute minimum is reduced, the annual number of hot days with more than 30^{0}C have increased by 9 days and the number of hot nights by 4 days. All these exacerbate attacks of R. Alazani. In conditions of increased precipitation and elevated temperatures, snow in R.Alazani basin during winter and spring melts more intensively, resulting in flooding of Alazani riversides. This is followed by the wash offs of river banks, surrounding agricultural farmlands and ground. Alazani streamflow increased by 8% during the last 20 years in Shakriani (post).

This process has been particularly active in recent decades. In particular, from the Vazisubani remote territories, where agricultural lands owned by the local population are located, 8 ha farmland was washed away. In addition, a water pump station supplying Gurjaani Town with drinking water is located on this territory. The pump station pumps drinking water through 17 km and supplies Gurjaani Town. This station, in case of freshets, faces a threat of washing away and because the town does not have an water supply alternative source, there is a real danger that its 12 000 inhabitants will be left without drinking water.

As mentioned above, during the last decade, R. Alazani washed away about 8 ha agricultural farmland in Vazisubani Village. The river moved by 150 meters from the previously existing river-bed.

Unfortunately, this process is still going on and if no measures are taken for halting it, the result will be disastrous: More than 20 ha agricultural lands and the Gurjaani Town water supply station are under threat.

2.6.2.2. Project Goal

Gurjaani Municipality, according to the number of its population, is a land-poor district, with only 0.52 ha agricultural land per person. Therefore, tackling erosion and land loss problems are very acute for the municipality.

The goal of the present project proposal is to demonstrate the possibility of stopping erosive processes at Alazani River banks, preventing future threats and restoring the territory. The application of this method will be also possible on the territories of other villages and municipalities across R. Alazani, as it is a serious problem for them too. At present, Alazani River washed away in total 55 ha of agricultural land on the territory of the municipality and this process continues even today. Therefore, the implementation of this pilot project will be an important measure in the soil conservation strategy.
The pilot project envisages the implementation of the following project activities: Recovery of 6 ha land from an overall 8 ha land area that was washed away as a result of mechanical destruction and washing down by flooded Alazani River; Also, the construction of 1 300 meter-long gabion structure to prevent further erosion, which in turn will alleviate a threat posed to the Gurjaani Town drinking water station.

2.6.2.3. Project Implementation

Methodology

The methodology offered by the project proposal mainly involves rehabilitation of agricultural lands washed away from the river by using lands unsuitable for agriculture and their reinforcement with gabions to prevent spread of the process to other areas.

The gabions built on the territory of the municipality in the past demonstrated that they are quite effective in performing the river bank reinforcement functions. Besides, construction of gabions should take place in parallel of phyto-amelioration activities, which will ensure further soil consolidation.

Planned Activities

The estimated project duration is approximately one year, during which the following works shall be undertaken:

- Approximately 150 000 m^3 of inert material (gravel) and land are necessary for the reclamation 2-meter-high 6 ha land. Consultation with geologists revealed that artificially recovered soil could be quite stable and could be used for agricultural (if we add humus layer), as well as for non-agricultural purposes (if this soil is reclaimed with correctly selected technological cycles). If inert material existing locally will not be enough, there are additional resources, in particular the possibility exists of bringing it from the surrounding villages located within 3-4 kilometers from the project territory. If we use 6 ha project area for agricultural purposes, creation of 6 ha land with the height of 1.65-1.75 meters will be necessary, which will be filled with humus to 2 m;

- Arrangement of the 1 300 meter-long and 3 meter-wide river bank reinforcement gabion. Local resources cobble stone will be used for the construction of the gabion;
- Implementation of phyto-amelioration works, that includes planting of trees along the river bank. The plants that are more likely to have river bank reinforcement qualities will be selected;
- Raising public awareness and organization of trainings on measures that are necessary to be implemented systematically in order to prevent bank erosion.

2.6.2.4. Partners and Beneficiaries

The project partners are:

- Irrigation Systems Management Department of the Ministry of Agriculture of Georgia and Gurjaani Section of Alazani Irrigation Systems, which use Alazani water for the irrigation and are interested in this issue;
- Gurjaani Municipality and its Gamgeoba (Citycouncil) er bank erosion on the territory of its municipality, as well as in the restoration of the washed away territories where this is possible, and also, in preventing the possible disruption of the town's drinking water supply;
- Vazisubani Village self-government body interested in stopping soil erosion in general and specifically, in mitigating risks caused by river bank erosion of Alazani rivers;
- The population of Vazisubani Village/Community, who already suffered as a result of Alazani River freshets and whose lands are further threatened;
- Ministry of Regional Development and Infrastructure of Georgia, which is involved in the preparation of the regional development plans. The reduction of the climate change risks must be one of the priorities in these documents.
- Emergency Management Department of the Ministry of the Interior Affairs. One of the EMD functions is to promote mitigation of disaster risks by implementing preventive measures;
- Ministry of Environment and Natural Resources Protection of Georgia. Its activities include implementation of the climate change adaptation strategy, as well as natural disaster risk reduction activities in general.

Project Beneficiaries:

- A part of the Vazisubani population who suffered serious losses due to erosion and those who actually currently faces the threat of erosion. This part of the population is ready to contribute to the present project and physically carry out different works;
- Local Gamgeoba and Gurjaani municipality leadership. They can offer the same methodology to other villages at risk and assist them in carrying out these activities. Also, in case of successful implementation of the project, Gurjaani Town water supply system will be protected.

- Villages located along Alazani River, who face the loss of territories and lands as a result of a periodic floods and frequent freshets of Alazani River.

2.6.2.5. Factors Contributing to the Project Implementation

- Support from Vazisubani local population, whose lands have been washed away by Alazani River or are likely to face such threat. They are ready to establish a community-based organization and after some trainings to independently build gabion structures and carry out phyto-amelioration works. They will be trained within the framework of the project. The project will purchase materials required for the construction of gabions;
- Interest of the Gurjaani Section of Kvemo Alazani Irrigation Systems in implementing this project. The agency is ready to provide co-funding for the project if the project is able to provide (hire) expensive heavy machinery/equipment to clean the river bed;
- Readiness of Gurjaani Municipality to share financial costs of the project in order to prevent the risk of disrupting drinking water supply to the town;
- Gurjaani Municipality is one of the most densely populated administrative units in the Kakheti Region (population density - 86 persons/km^2 and 0.52 hectares of agricultural land per capita), that increases its vulnerability to climate change and other threats. Therefore, it is in the interest of the municipal and the local (rural) governments to reduce the agricultural risks in this municipality;
- Vasizubani Community and leadership will receive 6 ha additional area that could be used for different purposes;
- Inert material that is necessary to fill the territory is found in sufficient amounts on territories adjacent to the project area.

2.6.2.6. Barriers Faced by the Project

- The project cost is very high, as it requires the use of heavy machinery and the training of the population in modern adaptation technologies. Implementation of the project is almost impossible without co-funding;
- The population and the local self-government body are not aware of additional dangers of climate change. It is necessary to closely work with them and inform them about all prevailing threats;
- A lack of knowledge of modern technologies by the local population, the implementation of which are essential for maintaining their agricultural lands and reduction of other risks. For example, they cannot built the gabions and are not aware of phyto-amelioration measures, which are quite effective among the existing river bank reinforcement technologies;
- Despite the existence of the relevant law in the country, no accurate, quantitative and qualitative land registration, which would include the economic assessment of land, is so far undertaken nationawide or at the level of the municipality. The state registration of land users is not over. A large part of the agricultural lands are not still privatized and registered;
- The state focuses its attention on strategically important facilities and less important facilities are entirely left to the care of the local Administration and population, but they do not have necessary theoretical knowledge, practical experience and technical resources to resolve these problems.

2.6.2.7. Project Implementation Stages and Cost

PProject duration is planned to be 1 year

Activities	Implementing Link	Implementation Period (in months) and Budget (USD)	Estimated Results
Preparing a detailed business plan, examining stocks	Project implementing unit, Gurjaani Section of Kvemo Alazani Irrigation Systems	5 10 000	Business plan is prepared for the implementation of the project
Collection and processing of stone-crushed rock and land on the ground for the reclamation of 2-meter-high 6 ha of land. The required volume is approximately 150 000 m^3.	Gurjaani Section of Kvemo Alazani Irrigation Systems, Gurjaani Municipality	12 360 000	At least 150 000 m^3 soil is collected on the river bank recovery site.
Gradual grading and ramming of 150 000 m3 material	Gurjaani Section of Kvemo Alazani Irrigation Systems, Gurjaani Municipality	12 7 000	Material is leveled, rammed and needs to be reinforced with gabions
Deepening and forming the river bed with a bulldozer	Gurjaani Section of Kvemo Alazani Irrigation Systems, village territorial body	12 37 000	The river bed is cleaned and deepened, material necessary for the gabion construction is obtained from the river
Construction of protective gabion structure (length 1300 m, height 3 m)	Village territorial body, the community/association established by the affected and at-risk population, which shall ensure the future sustainability of the process.	12 400 000	1 300 m long and 3 m high reinforcement gabion is arranged that protects 20 ha lands.
Implementation of phyto-amelioration activities (cultivation of land fixing plantations)	The community/association established by the affected and at-risk population, which shall ensure the future sustainability of the process.	12 36 000	Phyto-amelioration works are carried out, the protective phyto-amelioration strip is planed;
Organizing trainings for the population on activities required to implement annually for the maintenance of the gabions and the territory	Project implementing unit	3 36 000	Ensuring sustainability of project results
Total		**876 000**	

2.6.3. Recovery of the territory damaged by secondary waterlogging of soil in Gurjaani Municipality

2.6.3.1. Problem Description

The project area covers about 100 ha agricultural lands in Kardanakhi Village of Gurjaani Municipality, which is located between the right bank of Alazani River and Kvemo Alazani irrigation canal. The areas belong to the village population. Along with other factors, the process of secondary bogging of soil in this area was reinforced by three maijor factors:

- **Consequences of climate change.** Climate change on the territory of Gurjaani Municipality has become quite noticeable in the recent decades, which is demonstrated by the decrease in annual precipitation and the increase of total precipitation in different seasons. Despite the fact that the total annual precipitation in 1986-2010 decreased by 2% in comparison with the previous 25-year period (1961-1985), annual spring precipitation increased by 3% and autumn precipitation by 11%. The annual decrease mainly happened at the expense of summer rainfall (-20%), which significantly increases the demand for irrigation during this period. The daily precipitation maxima, which mainly causes rivers to swell, also increased in spring (by 34%) and fall (by 12%). All these are happening against the backdrop of increasing the average annual temperature between the mentioned periods by 0.4 ^{0}C, when winters are quite warmed, the number of hot days with more than 30 ^{0}C have increased by 9 days and the number of hot nights by 4 days. All these exacerbate attacks of Alazani River. In conditions of increased precipitation in R.Alazani during winter and spring and elevated temperatures, snow is melting more intensively, resulting in flooding of Alazani. This is followed by the wash offs of river banks, surrounding agricultural farmlands and ground. Alazani streamflow at the Shakriani hydrological post increased by 8% during last 20 years.
- **Proximity with ground water level, heavy mechanical composition of soil and low water permeability**. 100 ha pilot area within the project is located in Kardanakhi Village, on the territories of so called "Korulebi", "Chalebi", "Nakodrebi" and "Nasakirali". These soils belong to partly meadow brown, but mostly alkali soil types, have heavy mechanical composition and low water permeability. This leads to the accumulation of excessive amounts of moisture, which is a reason for secondary bogging of soils.
- **The lack of a drainage system**. It is well known in agriculture that soils prone to marshing constantly need excess moisture drainage, after which they can be used in agriculture. Excess moisture was removed in the past through the drainage systems and so called drainage channels that existed in the area during the Soviet period.

Presently, there is no drainage system on the pilot territory (nor it previously existed) and the drainage canals, which survived from the old times, are literally filled with soil. They are unable to conduct water leaked from soil and are practically inactive.

In some places, where their presence is extremely necessary, there are no drainage channels. Because of these reasons, secondary waterlogging of soils continues even presently. Approximately 300 landowners abandoned their land areas because they can not afford their treatment. Therefore, this part of the territory is gradually covered by marsh plants, and if urgent measures are not taken, the process will become more large-scale in the future. Now, this area is unsuitable for agricultural or any other activity. Along with the massive land loss, a real basis for spreading malaria and other diseases is created.

2.6.3.2. Project Goal

Gurjaani Municipality is one of the most densely populated administrative entities in Kakheti Region (density of 86 persons/km^2) with 0.52 ha agricultural land per person, that increases its vulnerability to climate change and other threats. Therefore, land loss caused by soil erosion and a lack of maintainance are very urgent problems faced by the municipality.

The goal of this project proposal is to stop current soil erosive processes and to prevent future threats, as well as to demonstrate the feasibility of restoring currenly unused territories after implementing rehabilitation of the existing drainage systems and additional agroamelioration measures. The restored and newly constructed drainage system should lower groundwater so that to enable plant growth and development. The implementation of this pilot project will be an important measure in the soil conservation strategy of the country. A precedent of similar activities already exist in the district. In particular, as a result of restoring the old drainage canals and constructing the new ones, 250 ha agricultural land was reclaimed and preserved in Bakurtsikhe Village. These lands belong to the the residents of Bakurtsikhe Village. The project was funded by the state from the central budget. Landowners contributed to the project with their physical labor. The latest technology, namely Kamatsu excavators were used during the cleaning of the channels. As for the ownership of internal networks, this issue is still unclear.
In case of implementing the pilot project, about 100 ha agricultural land will be reclaimed and preserved, thereby 300 Krdanakhi Village inhabitants will be able to grow and cultivate annual, as well as perennial crops.

After conducting reclamation works, prior to the exploitation of the soil, it is necessary to carry out a whole range of agro-technical activities. Before cultivation, it is necessary to clean up the terrotory from unnecessary plants and sod. After which, its agricultural improvement starts. The population expressed its readiness to use its financial, as well as technical resources for carrying out additional agrotechnical works and final rehabilitation of lands.

2.6.3.3. Project Implementation

Methodology

The main methodology offered by the project proposal envisages restoration and preservation of damaged agricultural lands from secondary boggying by using the latest technologies.

Planned Activities

- First of all, it will be necessary to gather information about the modern drainage systems, to analyse them and select the best technologies for the pilot territory. It is possible that the rehabilitation of the old systems could the most optimal method for this particular territory. It should also be determined whether there is a need for adding the new systems (canals);

In case of the rehabilitation of the old systems, the implementation of the following activities will be necessary:

- Inclined cleaning of 1 200 meter-long water conductor channel at 2.5-3 m depth and 5 meters width. Large dimension and high capacity technology, in particular Kamatsu excavators are required for implementing these works. The price of these excavators is very high (several million GEL) and their average daily rent is about 800 GEL. The population does not need this machine in permanent use.
- Inclined cleaning of 3 500 m^3 water drainage canals at 1.5-2 m depth and 3 m width;
- In total, approximately 10 000 m^3 wet soil will be excavated and after drying wet ground piled along the banks, they will be graded. After cleaning water conduction and drainage canals, the territory will be cleaned from trees, shrubs and sod;
- Agro-technical processing of cleaned and cleared area. In particular, chemical and biological examination of soil, based on which mechanical processing and application of fertilizers to soil will take place;
- Raising public awareness and training on how to maintain and use the restored areas, systematically take care of the drainage and drying systems and recovered areas.

2.6.3.4. Partners and beneficiaries

Project Partners:

- Irrigation Systems Management Department of the Ministry of Agriculture of Georgia and Gurjaani Section of Kvemo Alazani Irrigation Systems, which use Alazani water for irrigation and are interested in this issue. In particular, Gurjaani Section of Kvemo Alazani Irrigation Systems is interested in solving this issue and ensuring proper functioning of the irrigation system, supplying the population with the irrigation water with the acceptable schedule and in the payment of the fixed fee to the irrigation systems company by the population;
- Gurjaani Municipality and its Gamgeoba interested in stopping erosion of agricultural territories on the territory of its municipality as well as in improving economic conditions of the population;
- Kardanakhi Village self-government body interested in stopping soil erosion in general and specifically, in mitigating risks caused by soil erosion;
- The part of the inhabitants in Kardanakhi Village, whose agricultural lands are located on the pilot project area and who already suffered as a result of ongoing process and whose lands are further threatened;
- Ministry of Environment and Natural Resources Protection of Georgia. Its activities include implementation of the climate change adaptation measures and strategy, as well as soil degradation prevention measures.

Project Beneficiaries:

- 300 families living in Kardanakhi Village, who will be able to use 100 ha of agricultural land after its reclamation.
- These families have expressed their readiness to contribute to this project by carrying out various physical activities. They also commit to ensure proper operation of the drainage systems in the future to avoid reocurrance of the same situation. It should be also

mentioned that ground removed as a result of cleaning the channels is very fertile and should give abundant harvests;

- Kardanakhi Village Gamgeoba interested in stopping the secondary waterlogging of soils and preserving its agricultural lands;
- Gujaani Municipality leadership interested in improving economic and social conditions of the local population;
- Gurjaani Section of Kvemo Alazani Irrigation Systems, which is in charge of rehabilitation of the drainage systems.

2.6.3.5. Factors Contributing to the Implementation of the Project

- Gurjaani Municipality is one of the most densely populated administrative units in Kakheti Region (population density - 86 persons/km^2 and 0.52 ha agricultural land per capita), which increases its vulnerability to climate change and other threats. Therefore, it is in the interest of the municipal and the local (rural) governments to reduce the agricultural risks in this municipality;
- Kardanakhi Village self-government body interested in protecting its agricultural farmlands from secondary bogging of soils and other types of degradation; local Gamgeoba is ready to support the population (with equipment and partly with co-funding) in restoring the irrigation systems on the pilot territory;
- The state increases support to agricultural lands and irrigation/drainage systems. Several international projects (mainly related to irrigation) are also implemented in the country.

2.6.3.6. Barriers to the implementation of the project

- The project cost is very high, as it requires the use of heavy machinery, as well as the training of the population in proper operation of the irrigation system. It is expected that the population will take the responsibility for its operation after the implementation of the project;
- The population and the local self-government body are not aware of the additional dangers of climate change. It is necessary to closely work with them and inform them about all prevailing threats;
- A lack of knowledge of modern technologies within the local population, the implementation of which is essential for maintaining their agricultural lands and reduction of other risks. For example, they cannot independently restore the drainage systems, which were abandoned long time ago and are in a severe condition; they are not familiar with modern drainage systems, which allow them to protect their territories more effectively and at the lower cost. After drying lands that became non-operatal as a result of secondary marshing of soils, it is necessary to conduct special agrotechnical activities in order to fully restore the damaged areas. The rural population does not also possess information about this issue;
- Despite the existence of the relevant law in the country, no accurate, quantitative and qualitative land registration, which would include the land economic assessment, is so far undertaken nationawide or at the level of the municipality. The state registration of land users is not over. A large part of the agricultural lands still are not privatized and registered;
- It is still unclear who is responsible for the maintenance of the irrigation channels;

- The state focuses its attention on strategically important facilities and less important facilities are entirely left for the care of the local Administration and population, but they do not have necessary theoretical knowledge, practical experience and technical resources to resolve these problems.

2.6.3.7. Project Implementation Stages and Cost

The estimated project duration is approximately one year.

Activities	Implementing Link	Implementation Period (in months) and Budget (USD)	Estimated Results
First of all, it will be necessary to gather information about the modern drainage systems, to analyse them and select the best technologies for the pilot territory. It is possible that the rehabilitation of the old systems could the most optimal method for this particular territory. It should be also determined whether there is a need for adding the new systems (channels);	Project implementing unit, a consulting agency	5 70 000	The business plan necessary for the implementation of the project is developed
Cleaning of the conductor water channel from plantations and trees and ground (on 1.2 km). 36 000 m^3 humid soil will be excavated.	Gurjaani Section of Kvemo Alazani Irrigation Systems, Gurjaani Municipality	2 21 000	1200 m-long water channel is cleaned.
Cleaning of the existing irrigation canals, on 4 km. 12 000 m^3 wet soil will be excavated.	Gurjaani Section of Kvemo Alazani Irrigation Systems, Gurjaani Municipality	3 30 000	4 000 m water drainage channel is cleaned
Clearing land from trees, plantations and sod.	The population of the village Krdanakhi (300 affected families)	1 11 000	Land plots are cleared from trees, plantations and sod.
Biochemical analysis of the reclaimed area.	Ministry of Agriculture of Georgia. Information and Consultation Service of Gurjaani Municipality.	1 5 700	Biochemical analysis of the reclaimed area is conducted.
Raising public awareness-training on how to maintain and use the reclaimed areas,	Project implementing unit	3 20 000	Sustainability of project results is ensured

systematically taking care of the drainage and drying systems at the recovered areas.			
In total		**157 700**	

2.6.4. Development of Cattle Breeding-Food Production in Dedoplistskaro

2.6.4.1. Problem Description

In the sectoral structure of Dedoplistskaro Municipality, agriculture with its 70.5% has the largest share.Field-crop cultivation, livestock-food production (coarse forage), viticulture and horticulture remain the major traditional agricultural industries.Currently, arable areas covers 54 000 ha, perennials (vineyards) - 2 500 ha and pasture - 122 000 ha in Dedoplistskaro Municipality.Livestock remains the strategic sector in Dedoplistskaro Municipality and cow and sheep farming maintains their strong positions. However, climate change significantly increased problems and risks in this segment of the agricultural sector.

Until recently, farmers engaged in agriculture in a disorganized way, by disregarding environmental factors, including climate change.They do not have necessary information on the impact of climate change on agriculture, as well as on future scenarios and do not know what kind of measures to deploy to counteract these changes or other threats.At the transitional stage, the agricultural sector was not transformed with alternative and world-wide proven methods and its spontaneous development coupled with climatic factors resulted in disappearing production of some crops and industries. Livestock industry is in quite difficult state, today there are almost no large-scale pig farms, with the exception of private, family farms.Food production industry, which in fact is one of the main components of livestock production, is paralyred.Natural grasslands and hayfields are degraded by 90-100%, production of fodder, such as corn, beet, alfalfa and sainfoin are almost not stopped.Sillage and haylage are no longer produced. The crop rotation modes have been disrupted. Soil degradation and desertification trend determined by climate change have to be added to all these factors.Prolonged droughts became almost permanent during crops or hay-pasture vegetation periods, emergence and development phases (in 1986-2010 years, in comparison with the previous 25-year period, droughts in Dedoplistskaro increased by 11 and the number of very hot days by 17), unequal distribution of total precipitation and strong winds (strong spring wind speeds increased by 6 m/s respectively) were followed by an increase in the frequency of heavy rains and windy days, and therefore, the development of erosive processes and soil degradation.

Thus, the impact of climate change on soils and soil cover, in particular, hayfields and pastures and some food crops, require serious research and adaptational methodological approach.

Dedoplistskaro Municipality pastures can be divided into two categories:

A) Only winter pastures, which are located at 90-500 meters above sea level and B) Transitional grazing used in spring and fall.They are located at 500, 900 and 1 000 meters above sea level, respectively. The transitional pastures are also used in winters.Intensity of soils and collapse of rocks, wash offs and accumulative processes, in most cases, are caused by unsustainable agricultural activities. Xerophytization is becoming clearly stronger, which has theextremely negative impact on the formation and the development of vegetation cover and soil. They are not updated (applying fertilizer, surface treatment, seeding), land plot rotative grazing and maintaining grazing balance do not take place and lead to overgrazing. Reduction in grass cover, spread of weeds and pasture degradation are added to these factors.Since 2005, when redemption of the leased lands started, a part of pastures, together with farms, were sold and turned into the private property, the other part remained in the ownership of the Ministry of Economy, Dedoplistskaro Town and almost every village for so called permanent and common usage for the village cattle.Even today, preventive and remedial measures are not taking place on neither the private nor the common usage pastures.Given the growing trend of the impact of climate changes, the scale of potential threats will become more obvious.

No one is responsible for conducting the pasture inventory, as well as for their sustainable management, prevention, protection and recovery; land categories were confused.As a result of the land fragmentation, only 1 500 ha pasture were turned into the road.In addition, land plots and pastures were sold to people who previously had no experience to cultivate land and consequently, no knowledge and experience in this field.As mentioned above, unsystematic and irrational exploitation of hayfields and pastures led to the development of land erosion, dissolution of turfs, grass cover degradation and desertification.Spread of weeds to more territoriesisa strong indication of the degeneration of pasture herbage. Large amount of precipitation during the weed vegetation period contributes to this factor. It leads to the development of strong weed, to the abundant spread of weed seed to new areas and their speedy growth.From 122 000 ha land on the municipal territory, 64 083 ha are Dedoplistskaro's winter pastures (use by Dedoplistskaro District), while the rest is usedby other municipalities. 1 383 ha is a municipality cattle herding route, 258.9 ha is used for cattle resting places and the total length of the route is 159.4 km. Stronger droughts may lead to the reduction of the livestock drinking water sources debit and in the worst case to their elimination. Also, there are serious problems with regards to cattle bathing.Deterioration of the already poor infrastructure in turn will contribute to the spread of diseases and deterioration of the housing and living conditions of the population on the territories adjacent to the cattle herding routes.

Pastures located at the outskirts of the villages in Dedoplistskaro Municipality, traditionally, represent small land plots, which are scattered around the villages and cannot even minimally meet the demand for livestock forage.

In addition to sheep, 18 000 livestock heads and 893 horses use these pastures, especially in winters and the area is overloaded with a large number of animals.They are mainly concentrated in the drinking water areas and, therefore, are not evenly distributed in the pastures.

The municipalwinter pastures are not provided with irrigation water. They are not irrigated at all.Dali Mountain Hydro Reservoir which was built on Iori River is not utilized. The hydro reservoir allows to accumulate 70 million m^3 water. After the small-scale rehabilitation it would allow irrigation of 170 ha pasture and in case of building the irrigation network, an opportunity to water 17 000 ha winter pasture.In case of proper management, Dali Mountain Hydro Reservoir can play an important role in providing livestock forage base and increasing shepherds' revenues. The overgrazing factor makes watering of winter pasture even more urgent and necessary, because from September to May, 350 000 sheep are wintering on the territory of the municipality (including local sheep) and in case of irrigation, these pastures could be used in all seasons, which could significantly reduce risks for sheep death and sheep loss risks for shepherds.A simple calculation revealed that if we take an average 5-6 sheep per ha (1 020 sheep graze on 170 ha), by taking the overgrazing factor into account, the shepherd's annual profit per sheep is 30 GEL. Irrigation of pastures will considerably increase the profit rate.

Hayfield rotation and rotative land plot grazing are neglected in the process of pasture management.The cattle herding routes and the drinking places are not arranged and protected, pastures get damaged as a result of livestock herding. In conditions of existing degraded and low productive pastures, hay production, as well as creation of artificial insurance stocks have a great importance. The areas designated for hay production on the whole territory of the Municipality, significantly change in connection with the annual and seasonal fluctuations of climate conditions (mainly atmospheric precipitation).During years with droughts, because of underdeveloped herbage, the pastures are not mowed at their usual frequency.The main determinant of pasture yield is atmospheric precipitation. Water loss in this region was estimated according to the CropWat (FAO) model within the framework of Georgia's Second National Communication on Climate Change, which demonstrated that the total water loss on hayfields and pastures is 48%.High rates of spreading weeds negatively impact hay quality.In such circumstances, it is very important to restore a practice of cultivating drought-tolerant perennial crops, including sainfoin,in the crop rotation mode and its rotative growing on degraded soils, sillage, haylage and hay production.

All these factors had a negative impact not only on soil productivity, but also on the soil cover structure. Productivity of hay fields and pastures decreased significantly, forage was not artificially produced for several years, which negatively impacted livestock development, the number of sheep and livestock and consequently, meat and milk production decreased. As a result, we have meatand dairy production shortage and high prices, which along with other factors, affect the commodity bundle and deteriorate social conditions of the population.

By taking future forecast and climate parameters into account, in terms of vulnerability, Dedoplistskaro is one of the most vulnerable municipalities in Kakheti Region. Discussions on the adaptation of the agricultural sector of Kekheti Region in the process of preparing Georgia's Third National Communication revealed that there is a need to develop the adaptation action plan for promoting livestock-food production sector, which is one of the leading agricultural industries in Kakheti Region.

Results of studies undertaken in different countries of the world, as well as in Georgia, related to livestock development, demonstrate the necessity for implementing complex measures for the development of food production and improving hay fields and pasture, the role of meat and dairy production and their impact on the importance of economic efficiency.

2.6.4.2. Project Goal

The goal of the project is to demonstrate various possibilities for improving the forage basis by taking climate change threats into account.In particular, to increase the forage base throughrehabilitation and proper management of degraded natural food plots, hayfields and pastures, also, technological demonstration of producing artificial reserve forage when using abandoned and degraded soils. Implementation of the project will promote the growth of livestock forage base, reduction of hay field-pasture degradation, rehabilitation of degraded soils and livestock development.In addition, the recovery of 320 ha hay field and pastures in the first phase of the pilot measures (50 ha sainfoin, 100 ha seeding and 170 ha irrigation) will contribute to the annual reduction of 557 tons CO_2 emissions.

2.6.4.3. Project Implementation

Methodology

The methodology used in the project includes reducing soil degradation by taking climate change risks into account and increasing the forage base necessary for livestock production, planning and implementation of measures on the most vulnerable territory of the municipality.The final result of these measures should be the introduction of the sustainable management systems of degraded, abandoned hay fields and pastures adapted to climate change with the perspective of using these measures in other vulnerable municipalities.

Planned Activities:

- An inventory of the entire hayfield and pasture area, including degraded hay fields and pastures and other degraded (currently unused) lands within the administrative boundaries of Dedoplistskaro Municipality and preparation of cadastral maps;
- Studying problems existing in the livestock-food production sectors today (including spread of diseases and epidemic), the climate change risk assessment of the sector and provision of advice and recommendations to farmers on the risk reduction. Promotion of the establishment of the cattle farmers' cooperatives with the purpose of the effective implementation of complex measures;
- Studying proven adaptation methods and technologies to climate factors in advanced countries, analysis and preparing recommendations for Georgia, namely, for Dedoplistskaro Municipality and target groups within the pilot projects (300-500 ha agricultural land selected for the demonstration of Dedoplistskaro farmers);
- Implementation of the pilot livestock and food production development projects in farmers' demonstration plots by taking existing resources, local traditions and future scenarios of climate change and the international experience into account. Final selection of farmers on the basis of the tender with the maximum co-financing criteria.
- Preliminary research of soil fertility and the possible impact of climate change will be carried out in the process of implementing a) and b) pilot proposals, teaching advanced technologies and approaches to local farmers and their active involvement in the implementation process.

Planned pilot proposals:

A) Sowing drought-resistant perennial sainfoin to rehabilitatedegraded pastures and hayfields and other types of degraded lands and combining this process with the development of beekeeping.Locating bee hives during the blossoming period in the surrounding area to achieve complete pollination, which in turn will contribute to the development of beekeeping industry as sainfoin is honey producing plant (See Appendix 1 of this proposal).50 ha degraded land in Taribaa is pre-selected for sowing sainfoin.This area is experiencing desertification as a result of climate change.The area was abandoned due to low fertility.With 49-year lease agreement it is owned by farmer Elizbar Imerlishvili who is interested in the restoration of degraded areas and increasing its

agricultural productivity. Recovery of the area will increase chances of using the land for economic activities;
B) Seeding forage grass in 100 ha pasture land with ruined turf and fencing the territory by using an electric cattle guard with the purpose of introducing plot rotative grazing practices. Applying organic or mineral fertilizers. At this stage, 100 ha degraded pastures are selected in Karghacha. The land is owned by farmer Joseph Natroshvili (LTD Enamta). The pasture is 7 kilometers away from Dedoplistskaro, is located near the highway, near so called "little lake".It is designed for livestock, there is a pond for providing livestock with drinking water. This LTD plans to establish the cooperative unions in the vicinity of Dedoplistskaro meat factory. The factory will be a major supplier of live cattle.
C) Construction of sheep drinking places at the cattle herding route in Taribana and equipping them with the photo-electricity solar electricity system to protect about 200 ha pasture.This territory is in Taribana, at the sheep herding route, near the pasture (200 ha) belonging to the private farmer Bondo Tskitishvili. The land is systematically damaged by sheep flocks walking through the herding route.Shepherds and sheep walk through cultivated lands and pastures.If there are drinking places arranged at the herding routes, shepherds will herd flocks directly to water and will not damage pastures and cultivated areas. There is a water resource near this herding route, where drinking places and solar illumination could be arranged and the herding route could be marked.This pilot project will contribute to the development of the herding route infrastructure.
D) Rehabilitation of Dali Mountain Hydro Reservoir spillway tower and with its resources, through the tunnel from the reservoir, irrigation of 170 ha pastures in winterlocated on Iori Plain.This pilot proposal was prepared within Georgia's Second National Communication on Climate Change.This place was selected because it is located near the Dali Mountain Hydro Reservoir, at the steep slope. After the rehabilitation of spillway tower, until the final construction of the network of the irrigation system, gravity irrigation of winter pastures and its usage at all seasons will be possible (also, in summer). The main area of this pasture land is owned by farmer BachukiGonashvili, who is engaged in sheep farming business.If this pilot project is implemented, a new project proposal with the prospect of watering additional 17 000 ha pasture will be developed.17 000 ha winter pasture at Iori Plainis possible to irrigate using water from Iori River. The pastures belong to Dedoplistskaro, Akhmeta, Gurjaani, Kvareli and Sighnagi municipalities.It is possible to establish cooperatives working on irrigation of pastures and charge services fees.

- Development of the methodological guidelines for sustainable management of hay fields and pastures to protect farmers from the negative effects of climate change, which will facilitate revival of livestock and food production sectors. The guidelines will be mainly focused on natural food recovery, maintenance, improvement and rational use measures, which are generally listed in Annex 2 of this proposal;

2.6.4.4. Project Partners and Beneficiaries:

The main project partners are:

- Ministry of Environment and Natural Resources Protection of Georgia, which is responsible for implementing the principles of the UN Framework Convention on Climate Change in Georgia. One of the basic requirements of the Convention is to reduce the risks of climate change in different sectors of the economy. In addition, the Ministry establishedthe Land Resources Protection and Natural Resources Department with the functions to conduct the inventory of land pollution and degradationand facilitate mitigationof theseprocesses;

- Ministry of Agriculture with its function to promote development of various agricultural sectors.This project will facilitate increase of livestock forage base;
- Research institutes at theAgrarianUniversity of Georgia working on problems related to soils and livestock production, especially on providing cattle with high-quality forage;
- Ministry of Economy and Sustainable Development of Georgia. As explained above, pasture lands of common usage, currently used by local residents, are on the balance of the Ministry, but no institution is designated to maintain and take care of these lands;
- DedoplistskaroMunicipality Sakrebulo and Gamgeoba interested in facilitating sustainable development of the Municipality;
- Information-Consultation Service of the Ministry of Agriculture located in DedoplistskaroMunicipality, which has direct contacts with local farmers and at the same time, implements the policy of the Ministry of Agriculture;
- Information-Consultation Service of the Ministry of Agriculture;
- Various consultation centers established within the framework of different international programs, which are well aware about the existing local situation and study problems and risks. Kachreti Extension Center is serving Dedoplistskaro Municipality;
- Local farmers and farmers' unions engaged in livestock production, for whom this project will demonstrate the problem solution opportunities;
- Farmers and their unions owning hay fields and pastures, whose property is threatened by climate change and processes ongoing in livestock production.

Project Beneficiaries:

- Farmers owning abandoned and degraded land plots. Restoration of the tradition of producing sainfoin will improve soil fertility and farmers will be able to restart agricultural activities;
- Local farmers, who together with forgotten and traditional agricultural experience will be able to introduce proven modern technologies practiced in advanced countries (use of alternative energy – solar systems for electric cattle guard) and will more effectively protect their pastures from foreign cattle;
- Farmers from Akhmeta, Gurjaani, Kvareli and Dusheti municipalities who are using winter pastures in Dedoplistskaro Municipality and who will be able to produce more quality forage in the winter too.
- Development of livestock production and providing the sector with quality forage will improve supply of the local population with food products (milk, meat), especially this concerns to the milk market, which faces shortage of milk products;
- Ministry of Environment and Natural Resources Protection of Georgia, which will fulfil its international obligations;
- The Government of Georgia and the Ministry of Agriculture, which implements the state policy in the agricultural sector. Both agencies will be able to reduce risks related to the food program;

- Meat, milk, leather and wool receiving and processing enterprises that will be supplied with products of initial production. Today, there are 1 milk collection point and 5 milk processing enterprises in Dedoplistskaro. The tanneryis located in Rustavi and wool is sold to private salons and sewing workshops. The construction of the meat processing factory is ongoing and will be probably finished this year. The factory will buy meat and leather from farmers and the population.

2.6.4.5. Factors Contributing to the Successful Implementation of the Project

- Dedoplistskaro Municipality has large pasture area, but itssignificant share is degraded and more faces the degradation threat. Recovery and rehabilitation of the degraded pastures is a priority for the municipality and local farmers. The issue gains a special significance in the process of ongoing decentralization, when the municipality will be able to use its own resources;
- Production of agricultural products, among them, meat and milk production is one of the priorities of the Georgian Government and this project has the state support.
- Motivation of the local farmers (and not only their motivation) to develop the sector with new approaches on the background of expected threats;
- Importance of hay fields and pastures in terms of the climate change and the program of the Government of Georgia “On the Low Emission Development Strategy”, where agriculture and namely, rehabilitation of degraded lands are one of the main directions;
- Existence of the cow farms and milk collection points and milk processing small enterprises, which are interested in sustainable development and quality of the supplied products;
- Several years ago, an increasing demand from Muslim countries on Georgian sheep was observed, but afterwards this interest was diminished. An export perspective of the Georgian sheep will increase the motivation to sheep reproduction and will promote the development of the sheep farming and consequently, wool and leather production, textile manufacturing on the basis of felt, wool and half-woolen thread.
- Construction of meat processing enterprise in Dedoplistskaro, which will be one of the receiving and processing centers of meat products.

2.6.4.6. Barriers to the Implementation of the Project

- Non-existence/imperfection of the legal regulations. Issues regulating ownership and maintenance-care of hay fields and pastures, as well as cattle herding routes are not distributed. The first component of this proposal envisages harmonization of existing legislative framework. Implementation of other components will have a sense only after strengthening the legislative basis.
- There is no state sustainable management plan related to pastures. Some part of the pastures is owned by the Ministry of Economy. The party responsible for the maintenance-care of the pastures are not defined;
- Overall political instability at the level of regions and municipalities;
- Vagueness related to local self-government properties and other functional issues;
- The absence of a cattle farmer cooperatives. The association is established, but at this stage, itspotential is pretty weak and its rights are also limited. One of the main goals of this project is to demonstrate the role of the cooperatives in the fight against the common threat.

2.6.4.7. Project Implementation Stages and Budget

The expected duration of the project is 3 years.

Activities	Implementing Link and Parties	Implementation Period (in months) and Budget (USD)	Estimated Results
An inventory of the entire hayfield and pasture area, including degraded hay fields and pastures and other degraded (currently unused) lands within the administrative boundaries of Dedoplistskaro Municipality and preparation of cadastral maps;	Dedoplistskaro self-government body, cattle farmers' associations/cooperatives, Public Registry, Ministry of Agriculture, Ministry of Economy and Sustainable Development, Ministry of Environment and Natural Resources Protection.	24 300 000	Private and common pastures existing in Dedoplistskaro Municipality, their quality, cattle herding routes are registered, rights and obligations are separated and cadastral maps are developed
Studying problems existing in the livestock-food production sectors today (including spread of diseases and epidemics), climate change risk assessment of the sector and provision of advice and recommendations to farmers for the risk reduction. Promotion of the establishment of the cattle farmers' cooperatives with the purpose of the effective implementation of complex measures in the field;	Information-Consultation Service of the Ministry of Agriculture located in Dedoplistskaro Municipality, cattle farmers' associations/cooperatives, Dedoplistskaro self-government body, Kakheti Regional Veterinary Association, Ministry of Environment and Natural Resources Protection of Georgia, Kachreti Extension Center.	12 200 000	Climate change risks in the livestock-food production are assessed, reasons and dynamics determining livestock diseases are studied and appropriate adaptation measures are planned by taking EU best practices into account. The comprehensive action plan for the implementation of measures is developed.
Selection of demo-farmers and demo-territories and implementation of the pilot projects.	Cattle Farmers' Association/Cooperative.	36 231 000	Demonstration-farmers and territories are selected and 4 pilot projects are implemented.
3.1 Seeding sainfoin on 50 ha, fencing sainfoin crops with electric cattle guard: production of sillage, haylage, hay and seed materials at different stages. Locating bee hives near the crop areas during the blossoming period.	The Cattle Farmers' Association/Cooperative. Pasture owner.	6 40 000	Sainfoin is grown on 50 ha and the territory is fenced with the electric cattle guard. Soil restoration is in

			progress.
3.2 Seeding forage grass in 100 ha pasture land with ruined turf and fencing the territory by using an electric cattle guard with the purpose of introducing plot rotative grazing practices. Applying organic or mineral fertilizers to the area,	Cattle Farmers' Association/Cooperative. Pasture owner.	3 17 000	Forage grass is sown on 100 ha pasture, the territory is fecnced with electric cattle guard. Pasture productivity and quality is increased and is satisfactory.
3.3 Construction of sheep drinking places at the cattle herding route in Taribana and equipping it with the photo-electricity solar electricity system to protect about 200 ha pasture.	Cattle Farmers' Association/Cooperative. Pasture owner.	5 4 000	Initiating the development of thethe cattle herding route infrastructure.
3.4 Rehabilitation of Dali Mountain Hydro Reservoir spillway tower and with its resources, through the tunnel from the reservoir, irrigation of 170 ha pastures.	The Cattle Farmers' Association/Cooperative. Pasture owner.	12 170 000	The tower is rehabilitated, 170 ha pastures on Iori Plain is irrigated and the proposal to irrigate 17000 ha pastures is developed.
Development of the methodological guidelines forthe sustainable management of hay by taking climate changes into account.	Information-Consultation Service of the Ministry of Agriculture located in Dedoplistskaro Municipality, Kachreti Extension Center.	6 50 000	The document is developed, published and disseminated among the farmers.
In total:		**781 000**	

Annex 1

Sainfoin: Brief Description

Sainfoin, a selected plant, is less demanding towards soil, grows well in gravel and sandy soils and especially in black earth and lime-rich soils. It absorbs lime, phosphorus, potassium, magnesium from soil in large quantities and therefore, does not require large amounts of fertilizer, is adapted to all kinds of soil (less helpful in salted and wet soils in the proximity of groundwater). It is better adapted to drought, is a significant fallow crop, which frees the field at the early stage and enriches soil with organic substances. Sainfoin typically has a deep taproot system, which is strongly branched, goes down to 3-6 m deep in soil and has the ability to use water from deep soil layers in drought conditions. Sainfoin develops plenty of callus bacteria and intensively fixes nitrogen absorbed from the atmosphere in soil. It increases soil fertility, enriches soil and is considered to be the best predecessor for any crop. Hoeing crops and fine grain cereals are good forerunners for sainfoin. Its inclusion in the crop rotation will contribute to the improvement of soil quality and especially, the increase in grain productivity. Sainfoin is sown clean or with the use of cover crops, its seed begins to swell in the conditions of 3-4^{0}C, the optimum conditions are considered to be 18-20^{0}C. Seedlings survive frosts up to -8^{0}C. The South Caucasian sainfoin gives two hay cuts during the vegetation period. Sainfoin seed yield may be obtained from the first cut during the following year. Its green mass (juicy forage - silo and haylage) contains 18.2% protein and 18 food units calculated on 100 kg. With the harvest of coarse food – hay, sainfoin approaches alfalfa and exceeds clover. Hay made from sainfoin is highly productive and expensive; 1 kg hay contains 0.54 feeding units (one unit equals to 1 kg of oat with its nutritional value), with the digestible protein content it is close to alfalfa and the figure is 10.6% in hay. Green mass and hay (hay powder) is the best back-up food for the winter period. Sainfoin is a valuable food product for the use in the animal husbandry sector, it is well-digested by animals and unlike clover and alfalfa, it does not cause tympanitis (inflate) during grazing. Sainfoin is a honey crop, which contributes to the development of beekeeping. During the blossoming period it yields 100 kg honey on 1 hectare. Placing bee hives near crops strongly influences the increase in the harvest and encourages doubling of flower fecundation and seed growth. Introducing this crop in practice and its use will reduce farmers' expences and bring them more profit.

Annex 2

Some of the Measures Recommended for the Rehabilitation of Meadows and Pastures in Dedoplistskaro Municipality:

- To determine differentiated grazing dates for the recovery of the pre-existing grazing system by using modern technologies and the electric cattle guard protection system with the purpose of introducing the plot rotation grazing on winter and transitional demonstration pastures. In case of introducing grazing with a special scheme, pasture productivity increases by at least 13%. More growth is expected in the future, as with the introduction of this grazing system better sowing and the development of ephemeral plants[40] on winter pastures will be ensured, that can significantly reduce pasture turf ruins and create necessary conditions for the better development and protection of grass cover.
- Improvement of pastures and meadows by sowing grasses and using fast and efficient **solutions - mineral fertilizers**: a) Applying P60N120 in spring, in the beginning of the plants vegetation; b) Applying a mixture of manure previously accumulated near animal houses and a nitrogen fertilizer; c) Spraying stimulators-stimofungi with 2-weeks intervals.
- **Fight against weeds** in hay lands before their flowering by systematically mowing them. **Using herbicides**[41] (to be avoided on wormwood, alkaline-wormwood and saline pastures) on excess granular hayfields and pastures (were Andropogon ischaemum L. prevails) and later, when seeding grasses, for seeds and harrowing. In a semi-desert and dry steppe region, it is better to sow in autumn in the conditions of sufficient soil moisture.
- Irrigation of Iori Plain pastures with the use of Dali Mountain Reservoir resources.

[40] A group of annual plants. Their entire cycle of development takes a short period of time. They mainly grow in deserts and semi-deserts. There are spring and autumn ephemerals.

[41] Applying herbicides can significantly reduce weeds. It is recommended to spray herbicides to grass in spring, in the dry weather during the vigorous growth of main weeds. Pastures may be sprayed 3-4 weeks prior to starting mowing or 2-3 weeks later after mowing. Herbicides can be sprayed on pastures after 2-3 weeks from grazing, when weeds grow older, while after the treatment, during 10-12 days, grazing on these plots are not recommended as milk may acquire an unpleasant odor or lose its nutritional quality.

- Construction of watering places and the development of other elements of infrastructure on sheep herding routes.
- **Creating artificial meadows** of uncultivated lands in October by their deep processing. In case of lack of moisture in soil - sowing grass on congealed cultivated ground, re-cultivation of low-yield lands in early spring (March) and sowing of perennial grasses. **Prohibiting mowing and grazing** in the late fall (or setting the grazing period for autumn grazing by allowing at least 15 - 20 days for the preparation of winter herbage).
- Regulation of pasture loading norms with **the purpose of combatting erosion by observing 20-25 day interval necessary for repeated grazing**. This is necessary for strengthening herbage and accumulation of natural, green and herbaceous live nutrients and for surviving the winter period.
- As per standards, 1 cattle or 2 sheep shall be grazing on 1 hectare pasture. This is the case for standard pasture. Actually, 5 cows or 5 sheep are grazing on degraded pastures. Often both use the same pasture and in this case it turns out that 10 heads are grazing on 1 hectare. This is a disaster. For example, sheep cannot give the right amount of milk to lambs, that often leads to their death. The sheep surplus for such year decreased from 90% to 70-65%.
- Introducing the practice of mowing and stooking consistently and within the limited periods for reducing losses. As pastures are located in different zones, observing differentiated terms for hay production is necessary.
- Implementing strict measures against pasture burning practices.

Proposed Tentative Schedule:

Height in Meters above Sea Level	Mowing Type	Starting of Hay Cutting	Finishing of Hay Cutting
300-500	Forb-andropogon	10/06 – 15/06	20/06 – 25/06
	Forb-graining (with the surplus of early grain crops rather than andropogon)	1/06 – 5/06	10/06 – 15/06
500-800	Forb-andropogon	15/06 – 25/06	25/06 – 5/07
	Forb-graining (with the surplus of early grain crops rather than andropogon)	5/06 – 15/06	15/06 – 25/07
800 – 1 000	Forb-graining following wood (mostly Agrostis planifolia)	15/06 – 1/06	25/06 – 1-/07

As a result of implementing a variety of rehabilitation and preventive measures envisaged by the project, the pasture productivity is expected to increase by at least 25-35% in the next 5-7 years.

2.6.5. Storage of Perishable Products (Lagodekhi)

(Arrangement of cold storage facility in Lagodekhi Municipality and evaluation of various product storing methods)

2.6.5.1. Problem Description

Lagodekhi Municipality is located in the extreme Eastern part of Georgia. It covers the southern slopes of Kakhetian Caucasus down to the banks of Alazani River.

Lagodekhi Municipality is mostly agricultural settlement area. 68 settlements: 1 town and 67 villages are located on its territory.

Unlike neighbouring municipalities, Lagodekhi is characterized by moderately humid climate and a long vegetation period.

The study of change of the climate parameters demonstrated that in the years of 1986-2010, compared with the period of 1961-1985, the vegetation period in this municipality with 10^0C and 12^0C threashold temperature increased by 4 and 2 days respectively. Among other municipalities of Kakheti, Lagodekhi is on the first place by the duration of the vegetation period. The increase in the vegetation period and the sum of active temperatures is accompanied by 10% increase in precipitation in the vegetation period, which makes the local climate even more attractive and favourable for subtropical plants and fruits (kiwi, citrus, etc.). For the past 15 years, moderately humid climate in Lagodekhi became humid, that caused the corresponding change in aridity index.

Lagodekhi is known for its moderately cold winter. This is exactly why Lagodekhi Municipality consideres the development of agriculture and tourism as its priority. Due to such outstanding climate conditions in Eastern Georgia and in Lagodekhi in particular, in addition to agricultural sectors typical for municipalities of Kakheti Region, in Lagodekhi during the Soviet times, sericulture, tobacco and essential oils (geranium, basil, rose) production were developed.

These crops were produced only by Soviet collective farms. After the dissolution of the Soviet Union, these sectors were destroyed. However, after the breakup of the Soviet economy, melons and vegetable production began to grow especially rapidly.

New technologies and new varieties were introduced and watermelon harvest was increased from 40 tons per hectare (1976-1978) to 55 tons (2011-2013) and the areas also expanded. In the same years, cucumber and tomato productivity was increased from 7 tons to 15 tons per hectare. Accordingly, harvest of watermelons on one season is 71 500 tons, while the total cucumber and tomato production is 33 225 tons.

This produce is perishable. The process is further accelerated by increased hot days and tropical nights. The average seasonal temperature in the summer during the last 25 years increased by 0.6 ^{0}C, the average minimum temperature in the summer increased by 1.3 ^{0}C, the absolute minimum increased by about 6 ^{0}C and air humidity in the summer increased by 4%.

On the background of such changes more products perish in the process of sales. By rough estimates, farmers are unable to sell 20% of their harvests. It is very important to provide markets with short-term and long-term packaging and storage technologies. An industrial refrigerator is one of such technologies.

2.6.5.2. Project Goal

The place for implementing the project is one of the important markets of Kakheti Region - Kabala market, the territory of which is spread on 3 hectares. It serves several municipalities (Lagodekhi, Gurjaani, Signagi and Dedoplistskaro).

The market is located in 18 km from Lagodekhi in the direction of Gurjaani. Its territory belongs to Lagodekhi Municipality. 30% of total melons (21 450 t. watermelons) and 70-80% of vegetables (23 258 t. cucumbers and tomatos) produced in Lagodekhi are sold at this market. The rest is sold locally. Peaches from Gurjaani Municipality is also sold here (estimated 7 000 tons per season). The produce, of course, cannot be sold in a limited time and often is perished.

At present, there are 16 fridges in Kakheti Region, but only one is standard (300 t.), the rest are small and non-standard. At the same time, they are located far from selling places. Farmers know exactly the quantity of products they need until the full sale for the long-term, as well as for the short periods.

The goal of the proposal is to help municipalities and farmers using Kabala market in storing a surplus yield so that farmers could sell their standard harvest to the maximum extent in the conditions of any temperature regimes.

Offering the latest technology is very important for this process. Modern technologies enable to preserve quality and taste of the product to the maximum extent.

This process may be also linked with other activities, such as packaging, production of packaging material, ensuring sales, etc. But, the main goal of this proposal remains maintaining high quality storage.

Another important issue that will be discussed in the project proposal is ensuring energy efficiency of the refrigerator, as well as demonstrating the use of renewable resources in the refrigeration industry.

Privately owned 5 ha land and 1 200 m^2 buildings and constructions in Kartubani community (Lagodekhi) near the market are available for project implementation. It belongs to LTD "Inventor", the main current activity of which on this territory is to provide sellers with storage facilities. Ltd. "Inventor" has an interest in creating the refrigerator-storage facilities on this territory, which will help the farmers to store goods brought to the market in temporary, as well as long-term packaging and storing terms.

2.6.5.3. Project Implementation

Methodology

The project implementation methodology involves accurate assessment of the current state-of-the-art and the development on site of a modern and energy efficient fridge by taking obstacles and barriers into account and offering it to the private sector.

Planned Activities

1. Examination period. The following should be determined at this stage: The type and the quantity of the products (in tons) supplied to the Kabala market during the season. The share of the product sold at the market and the share which is difficult for the farmer to sell. Farmers should be asked if it is in their interest to provide refrigerator and packaging services near the market. The project considers not only the refrigerator facility, but also other modern technologies of storing perishable products. It is necessary to determine who will implement the project. According to the classical understanding, we are now considering the arrangement and the operation of the infrastructure. In this case there are two options: First, when one agency is responsible for arranging and operating the infrastructure and the second option, when one company is arranging the infrastructure and then it rents it out to the operator (or operators). In this case, the number of the operators selling fruits and vegetables could be several (in the case of this project, in case of having 8 units, maximum 8 companies);
2. At this stage, the total production capacity of all fruit and vegetable storage facilities in the country reaches 50 000 tons. One of the activities of the project will be to identify barriers faced by the fridge services in Georgia (300 t in Kakheti, 1 000 t in Adjara) and to plan ways to overcome these barriers. Searching for the most effective technology (refrigerator) existing on the international market that is relevant for this particular case, its procurement and installation and training of the local staff for ensuring sustainability of its operation will be also a project objective. Within this project, fresh fruit and vegetable packaging infrastructure will be improved. Taking into account the fact that fresh fruit and vegetable storage has a seasonal character, it is necessary to equip refrigerator storage with systems, which in case of necessity will ensure storage of frozen fruit, vegetables, ice scream and meat products (except fish). With this the infrastructure owning company will be able to fully use the capacity of the fridge all year round, that will allow the company to mobilize monetary means for the proper functioning of the infrastructure. Special focus is made on melons and stone fruits. The issue of the vegetables should be also taken into account – especially, supply of early cucumbers. In total, some products will be identified for which packaging and sorting lines will be arranged and the refrigerator system will be able to satisfy any temperature and moisture regimes.
3. Raising farmers' awareness on storage rules.

2.6.5.4. Project Partners and Beneficiaries

Partners of the project are:

- Ministry of Agriculture of Georgia and National Food Agency interested in supporting farmers in producing high quality food products, as well as in selling products fully.
- LTD "Inventor" interested in providing Kabala Market with modern storage facility (including the refrigerator);
- Lagodekhi and Gurjaani local administrations, interested in developing modern infrastructure locally and supporting local farmers in selling their products with minimum losses;
- Lagodekhi and Gurjaani-based farmers, who lose 20-30% of their products annually as these products are perishable, farmers are unable to sell them in a short-time and they don't have guaranteed storage conditions on the territory of the market.

Project Beneficiaries:

- Local farmers, for whom risks for selling manufactured products are decreasing;
- LTD "Invertor", which will further develop its business and implement modern energy efficient technology, thereby contributing to the development of local small businesses;
- The project will contribute to the development of the agricultural sector and solving important problems, which will activate family and farming businesses. Farmers will have more incentive to produce surplus products.

2.6.5.5. Factors Contributing to the Project Implementation

Factors contributing to the implementation of the adaptation measures:

- Existence of Kabala market infrastructure;
- Increasing quality and competitiveness of agricultural products is one of the priorities of the Georgian Government and therefore, the project can make a significant contribution to this process, hence it has the support on both - the central and local levels;
- Interest of local authorities in the project implementation and their support. The municipality officials consider the results of this project as an important step on the road to the sustainable development of agriculture in their municipalities, especially in terms of increasing competitiveness of the sector;
- Interest of small local farmers working on Kabala market and their demand for the implementation of such project;
- The farmer does not have to make a decision on how to store the product and how much to sell. he takes a decision based on the situation at the site.

2.6.5.6. Barriers faced by the Project

- Fridge capacity is estimated incorrectly, the owner may operate at a loss;
- Difficulties in finding co-finding;
- Seasonality of demand for the products. Entrepreneurs may not be able to find a buyer who would be interested in purchasing stored products throughout the year and not just during the season;

- Lack of experience in the refrigeration business.

2.6.5.6. Project Implementation Stages and Budget

The project is intended for 10 months

Activities	Implementing Link and Parties	Implementation Period (in months) and Budget (USD)	Estimated Results
1	2	3	4
- Designing and construction of infrastructure necessary for the refrigeration industry and 700 square meters hangar; - Arranging a concrete floor in the warehouse; - Installing windows and doors; - Installing communication systems at the facility; - Flooring of the fridge.	Private Sector – LTD "Investor"	4 250 000	Infrastructure necessary for the refrigeration industry is set.
8 pieces, storing 60 tons of finished products, purchasing and installation of the separate refrigerator.	Private Sector – LTD "Investor"	4 250 000	The refrigerator is purchased.
Purchase and installation of fruit and vegetable sorting universal line.	Private Sector – LTD "Investor"	2 100 000	Fruit and vegetable sorting line is purchased and installed.
Total		**600 000**	

2.6.6. Rehabilitation of Rose Plantations in Telavi Municipality

(Rose oil)

2.6.6.1. Problem Description

In 1880, under the order of the Russian Emperor Alexander II, a well-known Bulgarian scientist, rose oil specialist Kushilov arrived to Georgia, who selected Naphareuli estate for cultivating rose plantation. The soil was cleaned, processed and Kazanlik rose seedlings imported from Bulgaria were cultivated on first five hectares. Rose successfully developed in a new reality and in 5-6 years the first harvest was gathered; rose oil made from the rose petals[42] was sent to the Paris World Fair of 1895. To everyone's surprise, rose oil produced in Naphareuli, with its qualitative and organoleptic characteristics overshadowed not only native Bulgarian oils, but was also outstanding among French producs and was awarded a Gold medal. From 1895 starts cultivation of rose – completely new crop for Georgia and the creation of the history of the new Georgian export produce – the Rose oil.

[42] Rose oil is a complex mixture of organic substances, in which terpenes represent a key component, it also includes aromatic and phenolic compounds, ethers, aldehydes, ketones, alcohols and acids.

The area, where first plantation was planted is surrounded by mountains on three sides and is located at the left side of R. Lopota on sandy clay soils in such microclimate zone, which is perfect for Rose vegetation. Rose oil, which is produced from rose petals (the distillation is done using high-pressure steam) is one of the most valuable natural floral essence. It is a thick goldish liquid with the density of 950-990 kg/m^3 (20 ^{0}C) and has a rose scent. Rose oil is used for producing perfumes and valuable cosmetics, as well as in the Christian liturgical rituals for making holy water, also in medicine, pharmaceutical industry, veterinary services, cooking, food industry and others.

Natural Rose oil is multicomponent, which means that its scent will be set for one-and-a-half hour in 3 tons. During the first half hour, the main rose oil scent has light, soft and sweet tone. This is followed by a second moderate - and then a third – hard tones. Thanks to this characteristics, parfumers make aromas with different tones and intensity. Rose oil is an absolutely safe natural product. It is characterized by anti-viral, anti-inflammatory actions. It positively affects the central nervous system and is a good helper during stress, irritation and emotion, also is effective for increasing performance and promotes calm sleep. In case of observing quality standards, the natural organic Rose oil is quite competitive on the European market.

In 1900, the first essential oil factory in Georgia was built on the abovementioned territory (Naphareuli) and 50 ha area in the microclimate zone was completely covered with rose plantations. Rose oil was distilled under high pressure (5-6 atmospheres) using steam. The oil produced at the factory was mainly sent to St. Petersburg, Moscow and Paris.

With an increase of rose plantations are (from 1900 to 1940 plantations territory increased from 5 to 50 ha) oil production has increased from 3 kg to 35 kg. Planted areas grew in the vicinity of the essential oil factory.

The qualitative characteristics of Rose oil produced in Naphareuli microclimate zone turned out to be so important that in 1968 a completely new factory was built at the same place, the factory was equipped with modern equipment and advanced at that time technology. In the same year, the Essential Oil IV World Congress was held at the Naphareuli Factory.

Scientists from all over the world gathered at the conferences and other meetings during several days and once again emphasized the distinguishing features of essential oils produced in this microclimate zone and quality of essential oils produced locally. For that time, along with the rose oil, geranium, basil, fennel, lavender and other oils were also produced.

In 1984, a new technology for the production of Rose oil was introduced in the factory (this technology was introduced in all factories of the Soviet Union). In particular, if earlier picked rose petals were undergoing fermentation using 20% brine and oil yield was 900 grams per ton of rose petals, new technology changed the fermentation process. Brine was removed from the manufacturing process and instead, air-tight plastic bags were used.

As a result, oil production was increased from 900 grams to 1 100 grams per ton rose leaf. According to 1984 data, 184 tons of Rose plants were gathered on 61 hectares and the factory produced 200 kg rose oil.

The number of people employed during the rose collection amounted to about two thousand persons. Hence, this work was temporary and in fact lasted only for a month. After the developments in 1990s and the disintegration of the Soviet Union, the essential oil sector was fully destroyed, the main reason for which was the collapse of the main (Russian) market, incompetence of the local staff to continue production in conditions of a market economy, a deficit of auxiliary materials (sulfuric ether) and fuel oil.

As the factory management turned out to be completely unprepared for exporting the produce to foreign markets, the industry utterly has collapsed. The world-famous factory was completely destroyed, demolished and sold out, the export produce was lost.

Neglected rose plantations were abandoned and ran wild, after which washed out and eroded areas were covered with prickly hedge (100 ha). In addition, of course, thousands of jobs were lost.

Currently, the main buyers of this product on the world market are well-known companies (which buy organic natural rose oil): Weleda (Basel), Firmenich, Givaudan (Geneva), Manes, Charabot and Biolandes (France). The demand is rising in Asia and Russia. Therefore, high quality rose oil produced in favorable microclimate zones of Georgia has a perspective to be exported to a variety of markets. The territory of this factory and 100 ha land, where once the rose plantation was cultivated, in 2012 was bought by Lopota LTD, the owner of "Lopota Recreational Complex" (which is located nearby).

"Lopota" Ltd is interested in the restoration and the development of the sector. The recovery of the sector will create a certain number of permanent and even more seasonal jobs (e.g. for the collection of rose about 500 people per day are needed. Also, workers in the plantations are needed to carry out agrtechnical works).

At the same time it will be necessary to create a rose nursery. In case of restoring 100 ha plantation, 400 000 rose saplings will be planted (3 300 saplings are planted on 1 hectare, the pilot area is 100 ha), which on the one hand will promote recovery of the soil protection function (ongoing soil erosion will be suspended, cultivated soil will absorb excess moisture) and on the other hand carbon dioxide absorption and oxygen emission source will be increased. Originally recovery-update of 30-35 ha plantation is planned, which is capable of producing 90 tons of rose petals and about 100 kg of high-quality Rose oil.

2.6.6.2. Project Goal

The project aims to help stakeholders in the private sector in the rehabilitation of rose plantation by taking into account ongoing changes in climate parameters and in finding and importing advanced technologies for the restoration of the Rose oil production. One of the results of the project will be rehabilitation of additional 100 ha of degraded land and absorption of 612 tons of CO_2 per year.

Implementation of the project will contribute to increasing Georgia's export production, as a result of which new jobs will be created and economic growth will be stimulated. If successful, production of rose in similar microclimatic zones of Georgia could be replicated[43].

Climate. The place of the former essential oil factory near Lopota River and 100 ha land, which was earlier used for vineyards, are considered as the project implementation site. Relevant microclimate zone is located in temperate dry subtropical climate district.

According to Telavi weather station data, winter is moderately cold here and summer is hot, the average annual air temperature during the last 25 years has increased by 0.5 ^{0}C and amounts to 12.5 ^{0}C. The absolute maximum reaches 40 ^{0}C and the absolute minimum is -23 ^{0}C. Average precipitation is 770 mm per year. The meteorological station is located at an altitude of 568 meters above sea level. The zone on the average is at 450 meters above sea level. No observations were conducted on its micro-climate.

According to climate change forecast, the duration of the vegetation period in Telavi above 12 ^{0}C threshold will be increased by 13 days to 2050 and the average temperature of the period will be increased by 0.9 ^{0}C in comparison with the average of 1986-2010. The sum of active temperatures will be increased by 428 ^{0}C, while total precipitation will grow by 52 mm. It is clear that expected results of global warming will affect the technological cycle and the productivity of rose plantations.

Soils. This area is characterized by meadow forest alluvial non-carbonate loamy soils. Also, forest brown sand stone alternation is formed here, which has been forming for centuries on the banks of swollen Lopota River and is rich with nutrient elements (when the rose plantations were rooted out on the territory of the essential oil factory, it resulted in more or less washout of the nourishing layer of soil), which are necessary for creating strong aroma of Rose oil. The micro-climate territory is a moderately steep slope directed from north to south. The main Caucasus Ridge from the north creates a danger of mighty mudstream during heavy rains, which in turn leads to the washout and erosion of loamy and sandy soils, turning them into exhausted podsols (perennial plants protects soil from washing down).

According to the rose plantation cultivation scheme, the rose saplings should be planted at 2 m x 1.5 m distance, 1 ha area should be filled with 3 300 rose bushes and rows should be arranged from west to east. Such layout of the rose plantation fully (100%) protects the area from soil erosion, wash outs and mudflows. Also, if we take into account that ground should be cultivated quite deeply (20-22 cm) 3-4 times a year, it will lead to the accumulation of large amounts of water, which will contribute to plant growth as well as development and dissolution of nutrient elements and will serve a function of soil protection.

During dry periods, where irrigation is inaccessible, annual crops are in a difficult situation and wither easily, harvest almost halves in perennial crops. Today, it is possible to solve these problems with irrigation and the use of special agrotechnical methods, for instance, different loads during pruning, using different methods of land cultivation, deep processing during heavy rains and shallow cultivation during droughts, etc.

[43] Gallica and Damascena

The project envisages establishing a small farmers' union with the leadership of "Lopota" LTD. The farmers will plant rose saplings on small plots (1-2 ha) with modern methods shared within the project and processing of picked rose-petals will be a responsibility of Lopota Ltd.

2.6.6.3. Project Implementation

Methodology

The project methodology envisages considering climate change in the rehabilitation and the maintenance of rose plantations, searching for modern technologies of the Rose oil production, training of the local staff, the involvement of local small farmers in the process of rose production to the maximum extent and promotion of the idea replication.

The project proposal is divided into three stages. The first stage provides for complete rehabilitation of 5 ha rose plantation and arranging a technological process for the pilot production. Well maintained plantation gives 4-5 tons of rose petals on 1 hectare, but in this case it is assumed that the plantation would give no more than 3 tons on 1 ha. 15 kg of rose oil production is expected at 5 ha, which will be enough to examine initial samples and introduce quality correction. Only providing of quality assurance it will make sense to implement the second pilot phase of the project, which includes expansion of the plantation on 30 ha area, finding new markets and transferring a complete production cycle to modern technologies. For this stage, the rose bushes should be planted on 30 ha, which in case of having 4 ha nursery will require 1 year. Reaching the third stage, which envisages expansion of this plantation to 100 ha, will require at least 3 years (in case of having 4 hectares of nursery) and the inclusion of local population in the process, who have free lands in the same micro-zone and will be able to grow rose with relevant parameters.

The height of healthy and well-groomed rose bush reaches 1.5-2 meters and its life expectancy is 30-40 years. Accordingly, in case of implementing the second (pilot) phase of the project, 30 ha land will be rehabilitated, the plantation of at least 1.5 meters in height, which annually absorbs 183.6 t. CO_2 will be cultivated and in case of the rehabilitation of 100 ha, 612 t. CO_2 will be absorbed. As for the carbon accumulation in plantation biomass, after 10 years, 50 tons of C will be accumulated at 30 ha and 167 t of C on 100 ha will be deposited .

Planned Activities

The Rose oil production should be divided in two phases: the first level – cultivation of the rose plantation and the second phase - oil distillation and its delivery to customers. The first phase also includes the seedling production. The second phase includes verifying compliance of produced oil parameters with the relevant standards. In addition, the most important phase to be implemented within this project is the search for new technologies, the development of the business plan, studying additional raw material markets unavailable in Georgia and training of the technical personnel in case of making a positive decision.

- **Rehabilitation-planting of the Rose Plantation**. It is desirable to install the rose plantation in the area inclined from north to south. The optimal distance between the plants in one row is 1.5 m. and the intra-raw distance is 2-2.5 m. The rose bush height is 1.5-2 m., it gives harvest in 3-4 years after planting and the weight of one rose flower is 3-4 g. In the microclimate zone area, where the implementation of the project proposal is planned, 5 ha semi-thinned out poorly maintained and degraded rose plantation is remaining. At the first stage, this 5 ha plantation should be restored to the extent still possible. At least one year will be necessary for the reclamation of this land. The restoration will enable the owner to arrange the nursery and produce the rose seedlings for new territories as one year old cuttings, which should be cut from old rose bushes, are necessary for the production of the rose seedlings. If there are no rose bushes, the provision of the nursery with the rose cuttings and starting the rose seedling production becomes impossible. In case of omitting this step and destroying the remaining 5 ha, the seedlings should be imported to Georgia. 99 000 seedlings will be necessary for cultivating 30 ha rose plantation during the pilot phase. Cultivation of 1 ha new plantation costs around 2 900 USD.

The rose bushes should be trimmed, the roots should be cultivated and intra-row ploughing should be made in early spring. In the Soviet period, in addition, fertilization was applied to the soil and the plant was treated with the mixed fertilizer containing nitrogen, phosphorus and potassium. It should be noted that treating the rose bushes with fertilizers significantly decreases the rose quality and it is desirable to avoid it as much as possible. The increase in the amount of the fertilizer affects not only the rose quality, but also significantly reduces the yield.

- **Nursery Establishment**. 4 ha area with the silt saturated deep brown forest soil on the left bank of R. Lopota can be used for the nursery arrangement. Silt contributes to the moist maintenance in the soil at the moderate level and helps newly planted cuttings in taking root. The area is a property of Lopota Ltd. In case of arranging the plant nursery locally, the cost of a single sapling will be 30 Tetri, in the case of importing it from Europe (Bulgaria), the value will be one Euro. For seedlings it is necessary to select 7-8 mm thick rods when cutting one-year sprouts on rose bushes. Cutting is done in January-February. The length of cuttings is 30-35 cm. Cutting should be done 0.5 cm below from the first stem node and then 3 cm above the 5-6th stem node.

  Soil in the nursery deranged as a result of winter frosts should be tilled deeply at 70-80 cm depth in September. In February and March, soil should be loosened and cuttings could be planted from April 10 to April 25 period. The distance between the cuttings should be 8-10 cm. Cuttings done in February should be stored in a dark basement with wet silt until April.

  The distance between the rows in the nursery should be 1 meter. This is necessary to avoid systematic loosening of the soil with the relevant technique. 100-120 thousand cuttings on 1 ha could be planted in the nursery, from which 30-40 thousand high quality rose plants are obtained. It is sufficient for planting 10-14 ha rose plantation (cultivation of 10-14 ha rose plantation is planned in one year). In total, 4 ha nursery provides a possibility to cultivate 40-45 ha rose plantation in one year/season.

  The necessity to establish nursery is also determined by the fact that in case of the implementation of the project, the rose saplings will be necessary for the part of the population who will express their desire to plant the rose plantations on their territories.
- **Oil Distillation**. The rose collection time is from 6 am until noon, when flowers have the maximum oil content. According to the Soviet-era technology, flowers picked in the morning were placed in 10 kg plastic sacks for fermentation and were held in the oxygen-free environment for 12-14 hours, that contributed to the oil secretion. Afterwards the rose petals were place in the 3 000-liter double distillation tank, which distilled oil with 5-6 atmospheres pressure vapor. For the yield harvested from the existing 5 ha plantation,

the steam boiler producing steam of 4-5 tons per hour will be sufficient for the rose oil distillation (the first phase of the project proposal). The distillate got as a result of distilling is transferred to a special vessel containing activated birch charcoal crystals. The charcoal detains oil and distilled water is discharged separately. The type of fuel necessary for the boiler is to be decided. Mazut was used in the Soviet period. At the initial phase, natural gas is expected to be used as a source of energy in the rose production. The natural gas distribution line is a few kilometers (2-3) away from the facility. However, alternative sources of energy should be also discussed within the project and should be offered to the private sector. First of all, the use of secondary heat should be considered, which could to some extent increase the costs of the first stage, but in the long run will provide considerable savings to the company and will make an additional contribution to the greenhouse gas emissions reductions.

- **Discharge of Rose oil from of carbon crystals**. At the next stage, activated charcoal crystals are processed with sulphuric (which was imported from Russia). Coal crystals containing oil were placed in the stainless steel vessel and sulfur was poured on them. Coal crystals were held in sulfuric ether for 6-12 hours. In this period, oil accumulated in coal crystals was discharged. Rose oil dissolves well in alcohol, fats and other organic compounds and this feature is used in its production. Rose oil can be produced by its distillation on water vapor, with the solvent extraction (sulfuric ether) and the adsorption method. For the project implementation it will be necessary to select and purchase the high pressure (5-6 atmospheres) steam boiler with the efficiency of 4-5 tons per hour, the cost of which is estimated at EUR 180 000.
- **Removal of sulfur oil from Rose oil**. Discharged Rose oil is placed in a vacuum device, where evaporation takes place under deep vacuum at a temperature of 60 ^{0}C. At this temperature, sulfuric ether is removed from rose oil, because they have different evaporation temperatures. Oil is then filtered in a special laboratory.
- **Purification of oil from admixtures.** Dehydration with vacuum distillation, holding, processing with sodium sulfate and filtering with relevant filter paper is used to remove them.
- **Determining Organoleptic Indicators**. Rose oil international standard quality indicators are: 1) Organoleptic (colour, taste, odour and appearance) and 2) The physical-chemical properties (refractive index, density, etc.). For determining organoleptic characteristics, 30-50 ml rose oil is taken and is put in a 100 ml glass colourless glass, which in turn is placed on a white paper to note the colour. Odour is also determined in the same way: The sample is sprinkled on a thick paper and scent is periodically checked during 15 minutes. The smell of the product must comply with the standards of the sample product.
- **Physico-chemical parameters** should be also consistent with the standards: Density, which is the rose oil mass determining unit is defined by the picnometric method and the refraction index is determined by refractometrical method, using the refractometer.
- After establishing compliance with the distilled oil quality parameter standards, packaging in the special pressure-resistant glass bottles was done, which was used to transport oil to consumers.
- Developing the business plan for the second and the third implementation phases for all stages of the rose oil production using the modern technology.

2.6.6.4. Partners and Beneficiaries

The project partners are:

- Telavi Municipality leadership, whose one of the most important priorities is to promote the municipality's economic development and the local private sector; Creating new jobs and improving economic conditions of the population;
- Ministry of Agriculture of Georgia which is interested in the development of the local private sector operating in the agriculture and farming and implementing projects directed at the restoration of degraded agricultural areas;
- Ministry of Economy and Sustainable Development of Georgia, which has included restoration and promotion of the Rose oil production in its Green Economy Development Program (prepared by the Ministry under the UNDP support) as one of the promising areas for the production of export goods;
- Ministry of Environment and Natural Resources Protection of Georgia, responsible for the implementation of the principles of the UNFCCC in the country, as well as for the reduction of adverse climate impact risks in agriculture, and in particular on agricultural soils;
- International donor organizations helping the country to introduce new, efficient and clean technologies;
- The Lopota Ltd. as a major contributor to and partner of the project.

Project Beneficiaries:

- Ltd. Lopota, which will add one more direction to its existing tourism business and in case of implementing the project will strengthen its positions on the market;
- Laphankuri village residents, who had previously been involved in the essencial oil crop production and have ample experience. Most of them are likely to be involved in the rose production process with their own lands. These plots will be used for cultivating additional plantations with the use of the modern technology introduced by this project. Involvement of local communities in the process of picking rose petals reduces the risk of the labor shortage[44];
- Telavi municipality, as jobs will increase and consequently, the income of the people involved in the project will also increase;
- Government of Georgia, as the project will increase the country's export commodities and the greenhouse gases (carbon dioxide) absorption source.

2.6.6.5. Factors Contributing to the Implementation of the Project

- There are several zones in Georgia favorable for the rose plantation (where high quality rose oil production is possible) and one of them is considered in this project proposal;
- Georgia and in particular Kakheti has a successful Rose oil production experience. People who have been involved in the production are still available and they have some basic knowledge. Also, there are remnants of nearly 5 ha degraded rose plantation capable of producing this variety of rose seedlings;

[44] Specificity of the rose petal collection requires to necessarily collect it from 6:00 am to 12:00 pm. In other cases the quality of the material deteriorates as with the increase in solar activity, the oil composition in the flower decreases.

- 100 ha land required for the rose crops is available for the implementation of the project which today is owned by the Lopota Ltd;
- The Lopota Ltd is interested in the development of this business and is ready to make a significant investment in its production if the project assists the company in searching and purchasing modern energy efficient technology, training the staff and manufacturing the produce that meets international market standards;
- The local population living in surrounding villages, namely, in Laphankuri is deeply interested to participate in the project;
- High and rising Rose oil prices at the international market;
- The degraded plantation will be rehabilitated and the carbon dioxide sink will increase.

2.6.6.6. Barriers to the Implementation of the Project

- Climate parameters of micro zone may be changed, that is likely to affect the quality of rose petals and Rose oil. For example, in case of the hotter climate, the Rose oil quality decreases and the rose collection time is significantly reduced;
- Lack of basic knowledge in the country about ongoing changes in the sector and new technologies, which significantly increases the cost of the initial investment and technology-related risks;
- Lack of the local staff at the initial stage will complicate operation of the process and the system, which could affect the quality;
- Energy consumption is one of the most expensive components of this project, so it will be necessary to decrease the price of this component by using renewable resources;
- Searching for co-funding and the appropriate technology is not an instant process. Often existing conditions are radically changing in the process of the search. For example, if the project implementation is significantly delayed and the remaining 5 ha rose plantation is destroyed during this period, than it will be necessary to additionally import seedlings into the country and consequently, the cost of the project will be dramatically increased;
- Quality assurance, which largely depends on weather conditions.

2.6.6.7. Project Implementation Stages and Costs

The cost of only first phase and necessary activities are estimated in this project proposal.

Activities	Implementing Link	Implementation Period (in months)* and Budget (USD)	Estimated Results
1. Rehabilitation of the existing 5 ha rose plantation	Ltd. Lopota	5 1 ha - 10 000 5 ha - 50 000	The existing 5 ha rose plantation is rehabilitated
2. Establishment of the rose seedling nursery on 4 ha	Ltd. Lopota	24 10 000	The rose seedling nursery is arranged on 4 ha

3. Planting of the 30 ha rose plantation and its maintenance for 3 years	Ltd. Lopota	12 1-ha 5000 30 ha-150 000	30 ha rose plantation is planted
4. Development of the project proposal for the initial stage (establishment of the nursery, rehabilitation of the existing 5 ha and planting of the new 30 ha)	Hired consultant	310 000	The Business-plan for the first stage is prepared
5. Purchasing and installing the high pressure (5-6 atm.) steam boiler with the productivity of 4-5 tons per hour. The device of this capacity will be enough to produce oil from the yield of only 5 ha rose plantation (approximately 15 tons of rose). The price given here is only conditional as it is necessary to precisely determine which option will be more profitable – to first purchase the boiler required for processing 15 t. rose and to increase its capacity on the later stage or to select the boiler for 30 ha.	Ltd. Lopota/Hired consultant	7 200 000	The rose oil distillation device is purchased
6. Removing Rose oil from charcoal crystals	Ltd. Lopota	1 10 000	The technological process of removing rose oil from charcoal crystals is set up.
7. Removing sulfuric ether from rose oil (by taking the sulfuric ether price and transportation costs into account)	Ltd. Lopota	1 100 000	The process of removing sulfuric ether from Rose oil is set.
8. Cleaning the oil from impurities	Ltd. Lopota	1 5 000	The process of cleaning the oil from impurities is set.
9. Packing the Rose oil in the glass vessels safe for the transportation	Ltd. Lopota	1 3 000	The Rose oil in the glass vessel
10. Development of the Business plans for the second and third stages (expanding the production)	Ltd. Lopota	6 10 000	The Business plan for the second and third stages is prepared
11. Training of local technologists	Ltd. Lopota	12 50 000	Local personnel provides the full production cycle at the high level in line with international standards
Total		**898 000**	

2.6.7. Irrigation of Village Udabno in Sagarejo Municipality

2.6.7.1. Problem Description

The southern part of Sagarejo Municipality is the territory facing the threat of desertification, where there is a village Udabno (desert). The village is located on the Gareji Plateau, at an altitude of 750 m above sea level, 45 kilometers away from Sagarejo. In all, 186 families or 945 inhabitants live in Udabno Village. This is a bordering district and holds a specific meaning for the country.

The David Gareji Historical Monument is disposed nearly the village. This historical and religious center of feudal Georgia (built in the first half of VI century), includes the monastery complex with a small part on the territory of Azerbaijan.

The village has 27 607 ha agricultural land, including 699 ha arable land, 436 ha hey fields, 26 429 ha pastures and 43 ha perennial plantation. In the 1980s, when the irrigation system operated, 4 200 ha area was ploughed and sown here. In 1981- 1992, the Udabno irrigation system functioned in the village.

Since 1992, the existing irrigation systems including Udabno irrigation district, which provided irrigation of this territory with water pumps, collapsed and broke down. The maintenance of the system turned out to be economically very disadvantageous since the dismantling of the Soviet Union, followed by acute power shortage.

Currently, the population living on the territory of Udavno has 80 thousand heads of sheep and cattle. Approximately the same number of sheep existed here during the Soviet period, when a Soviet sheep farm operated in Udabno.

Today, the territory of Udabno is only used for livestock grazing and mowing, although before the settlement of eco-migrants in the village, mostly cereal production was developed. One of the sources of the income for the population is hay production and sale.

Now these areas are no longer being cultivated and winter and spring grain crops are not any more sowed. Due to a lack of irrigation systems in the area, vegetables, melons, fruit and cereal crops are not produced.

A large number of sheep is concentrated in the southern part of the municipality (in Udabno and on pastures of Sagarejo Town) leading to overloading of the pastures and overgrazing, as a result of which the land suffers from degradation.

As mentioned above, until 1995, 4 200 ha wheat and barley was sown on the territory of Udabno. As the duration of droughts increased and temperatures began to rise against the backdrop of decreasing rainfall, the risk of producing cereal crops gradually increased.

Due to the fact that in the period of 1986-2010 droughts became more frequent on the territory of Sagarejo Municipality, it turned out practically impossible and lost any sense economically to produce cereal crops.

In addition, expences for cultivating 1 ha land and harvesting due to the rise in increased costs of fuel, machinery, fertilizers and plant protection products. The magnitude of the desertification-prone areas as a result of global warming gradually shifts to and increases in the north.

The implementation of a variety of cost-effective measures to improve the eroded and degraded lands is necessary for the preservation of these territories. Effective pasture operation and management measures should be introduced. These areas should be supplied with irrigation and drinking water, which will significantly reduce the impact of drought and avoid the risks of full desertification of the area.

2.6.7.2. Project Goal

The place of implementing this provide proposal is Kakheti Region, Sagarejo Municipality, the territory of Udabno Village. In the beginning of the 1990s, Iori River irrigation water from Upper Samgori trunk channel (the Tbilisi Sea supply channel) through the territory of Sartichala via the irrigation canal was running by gravity to the territory of Udabno Village (unit №1 Karaduzi Pumping Station), from where with three 820-mm tubes it was pumped to Udabno Village and irrigated 4 263 ha arable land. The distance from the top of Upper Samgori main channel to the pumping station is 25 km. From the pump station to the village is another 15 kilometers. Karaduzi №1 pumping station was also supplied with Mtkvari River water from the Rustavi-Gardabani pumping station. The line length is 10 km and the pipe diameter is 820 mm. This irrigation system worked from 1981 until 1992 and till 2006 Udabno Lake was filled to provide drinking water for the livestock.

The aim of the project is to rehabilitate the irrigation system by transferring the pumping stations on drift, that consumes much less electricity and is effective.

The importance of implementing this project is also reflected in the title of the village.As already stated above, the project has versatile significance ranging from social (as the village is populated with the eco-migrants from Svaneti, who already have difficulties in accomodating with the existing unusual natural conditions) ending with climate change risks.

Droughts and loss of soil fertility in non-irrigation conditions and their use as pastures and hay lands represent a serious problem for Sagarjo Municipality in general and in particular for Udabno Village. The total number of different time scale droughts increased by at least 14 in 1986-2010 compared to 1961-1985 period. The longer the drought period is, the more they increase in the numbers. For example, 12-months drought (according to the SPI drought index respectively) increased by 28. Such increase has not been observed in other municipalities.

2.6.7.3. Project Implementation

Methodology

The methodology envisages transferring the irrigation system on existing pumping stations to the gravity irrigation with the following scheme: Udabno irrigation canal head source shall start from Sartichala upper territory. Water from Upper Samgori main channel (which flows into Tbilisi Sea) with 820 mm pipe flows along Chubathkhevi Channel (difference between the levels is 850 meters - 800 meters = 50 meters), runs through Karaduzi on Udabno territory where previously

338 ha was irrigated, then on Jangiri territory where previously 549 ha was irrigated and in enters to Udabno Village, where it irrigates an additional 3 376 ha, which in total makes 4 263 ha.

In case of implementing this project, it will be possible (with pipes) to irrigate 800 ha land in Udabno (the line length of 39.5 km.) 3 times during the vegetation period. Also during the fall-winter period it will be possible to fill Jangiri Irrigation Lake with the capacity of 4.7 million m^3, which in summer will irrigate 1 000-1 500 ha on the territory Gardabani District. Also, in the case of implementing this project, it will be possible to construct small power plant on the pipe near the former pumping station, at which electricity can be produced. The difference in levels during winter-spring period between the water source and Karaduzi #1 pumping station is 300 meters, the pipe capacity will be 1 000 m^3/h.

Planned Activities

1. Survey phase - detailed study of the project design process;
2. Purchase and transportation of 39 km pipes.
3. Building of roads, cutting trenches for laying pipes;
4. Welding and laying of pipes.

2.6.7.4. The Project Partners and Beneficiaries

The project partners are:

- Ministry of Agriculture of Georgia which is eager to develop infrastructure in such areas, as the project implementation will facilitate increasing the productivity;
- The United Reclamation Systems Company of Georgia, interested in providing the population with water and in developing its own business practice. This agency will be responsible for the maintenance and the operation of the system;
- The Municipal Development Fund of Georgia, which finances infrastructure projects and might become one of the co-financers of the project;
- Sagarejo Municipality leadership, who is also interested in improving living and working conditions of its population. The municipality could play a particularly important role in the conditions of the decentralization;
- Donor organizations (IFAD, World Bank, Green Climate Fund, CDM adaptation fund, etc.), which are particularly focused on reducing the risks of climate change by funding adaptation- social projects;
- The population of Udabno and other villages who will be supplied with water by this system. They take responsibility to provide internal communications.

Beneficiaries:

- Farmers and peasants living in the village of Udabno (186 families, more than 900 residents) who will get irrigation water, improve soil fertility, economic conditions and living environment;
- New investors who if provided with appropriate infrastructure will be more interested in the purchase of lands on this territory;
- Factors Contributing to the Implementation of the Project

- The system does not need electricity and water will be supplied by gravity, which will reduce the price of the irrigation water making these places attractive to investors;
- The ongoing state supported program to increase the scale of the rehabilitation of the irrigation infrastructure (funding increase);
- Interest of donor organizations (IFAD, World Bank) to support the state in the implementation of the necessary rural infrastructure development projects;
- Approval and support of the initiative by the municipality;
- Interest of foreign investors in this area, which will automatically increase the importance of rehabilitating the community infrastructure.

2.6.7.5. Factors contributing to the Implementation of the Project

- The system does not need electricity and water will be supplied by gravity, that will reduce the price of the irrigation water making these places attractive to investors;
- The ongoing state supported program to increase the scale of the rehabilitation of the irrigation infrastructure (funding increase);
- Interest of donor organization (IFAD, World Bank) to support the state in the implementation of the necessary rural infrastructure development projects;
- Approval and support of the initiative by the Municipality;
- Interest of foreign investors of the initiative in this area, which will automatically increase the importance of rehabilitating the community infrastructure;

2.6.7.6 Barriers to the Implementation of the Project

- The territories belong to the Ministry of Economy, although it is currently used by the inhabitants of Udabno Village;
- Budget deficit or budget cuts for the irrigation rehabilitation. General decline in agricultural investments;
- Reductions of the international donor funding;
- Migration of the population from this area. Also, despite great interest, an agreement with the local population on terms and conditions related to the rehabilitation of internal systems and water supply may not be reached;
- At this stage, the impact of climate change on water quantity is not calculated. Iori in general is quite deficient river, which fills several reservoirs, this is why unlike Alazani River, water shortage could be a serious problem for Iori.

2.6.7.7 Project Implementation Stages and Budget

Activities	Implementing Link	Implementation Period (in months)* and Budget (USD)	Estimated Results
1. Project development	Consulting Company	5 100 000	Project is prepared with the detailed design, calculations and the corresponding budget.

2.	Purchase and transportation of 39 km pipes.	Governmental or donor organization/The United Reclamation Systems Company of Georgia	4 4 300 000	Pipes are purchased and delivered on sites.
3.	Building of roads, cutting trenches for laying pipes;	Governmental or donor organization/The United Reclamation Systems Company of Georgia	4 1 700 00	Trenches for laying pipes are prepared
4.	Welding and laying of pipes	Governmental or donor organization/The United Reclamation Systems Company of Georgia	6 1 000 000	The irrigation system is rehabilitated and water is running in the system.
Total			**7 100 000**	

2.6.8. Irrigation of the Territory of Sagarejo Region

2.6.8.1. Problem Description

Georgian agricultural sector comprises 13 zones and 6 sub-zones. Sagarejo Municipality belongs to the 2nd zone (Outer Kakheti farming and wine-growing area), which means that cereal production, animal husbandry and viticulture are the main branches of agriculture in Sagarejo Municipality, to which environmental and climate conditions contribute. In the 1980s, the agricultural area in Sagarejo Municipality consisted of 94 872 ha, including 32 144 ha of arable land, perennial plants - 5 998 ha, vineyards – 41 325 ha, hay field – 1 325 ha, pastures - 55 405 ha. As for 2013, the agricultural land area is 94 373 ha, including 29 575 ha arable land, perennial crops – 5 205, hay fields - 1 398 ha, pasture - 58 195 ha, of which 22 044 has is winter, 17 021 – summer and 19 130 ha – a year-round pastures.

Results of the analyses demonstrated that the area of agricultural land has decreased by 499 ha, which was caused by its transformation into the non-agricultural land, namely bushes, sand stone and residence areas at the Iormughanlo territory.

Tilled land has decreased by 2 569 ha, the territory is converted mainly to pasture category, while the area with perennial plants has decreased by 793 ha, due to the decline of the vineyards. At the same time, hay fields increased by 73 ha and pasture by 1 924 ha.

In comparison with other municipalities, climate in Sagarejo Municipality is not very hot. The main problem of this municipality is severe and prolonged droughts, which increased by 14 cases in the span of 1986-2010 compared to the previous 1961-1985 period.

The duration of the vegetation period (≥10 ^{0}C) also increased by 7 days in this period, which is the highest indicator among 8 municipalities of Kakheti Region, but the increment of the sum of active temperatures (186 ^{0}C) is not high and therefore is not dangerous for yields.

These changes mainly have an impact on the increase in demand for water and irrigation of agricultural crops, respectively. The precipitation change between two periods was not observed.

2.6.8.2. Project Goal

The location for the implementation of this project proposal is Kakheti Region, Sagarejo District. The operational area of Lower Samgori Irrigation Systems Division covers main right and left irrigation canals.

Both irrigation canals originate from R.Iori in Ninotsminda Village.

The main right channel flows at the territory of Town of Sagarejo amidst the agricultural plots in the following villages: Ninotsminda, Giorgitsminda, Patara Chailuri, Duzagrami, Iormughanlo, Lambalo, Tulari, Kandauri and Badiauri and flows down to the territories of Gurjaani and Sighnagi.

The total length of the main right channel is 28 km. It has distribution launchers (G-1÷G-46), from which G-46 is broken and does not function, and the rest needs to be repaired, cleaned and restored.

The total length of the main left channel is 48 km. It irrigates Town of Sagarejo and agricultural lands in Ninotsminda, Giorgitsminda, Tokhliauri, Manavi, Didi Chailuri, Patara Chailuri, Kakabeti, Verkhviani, Kandaura-Badiauri and Shibliani villages. In 1980s, it also ran into Gurjaani District, namely irrigated agricultural farmlands in Kachreti, Makharadze, Arashenda and Melaani villages. It has launcher distributors from G-1 to G-42. G-42 is partially working and its 16 km-long section is completely out of order.

Currently, the right and left Lower Samgori main channels are being cleaned. 70% of the main right channel is cleared, as is the main left channel from Kachreti Village to Chailuri Village. Clean up is being done with heavy machinery - excavators.

2.6.8.3. Project Implementation

Methodology

All distribution small irrigation canals of the Lower Samgori main left and right channels have to be rehabilitated, which should serve the local agricultural sector, particularly in case of the increased duration of droughts and increase in temperature. It is possible to clean and restore (rehabilitate) G-8 and G-9 irrigation networks in Giorgitsminda Village. They can be used for the irrigation of 600 ha arable land, where cereals, vegetables, melons (watermelon, melon), forage crops (alfalfa and sainfoin), corn, sunflower are sown, as well as vineyards on large areas are cultivated.

All distribution networks, as well internal networks with gutters and reinforced concrete constructions at the Lower Samgori right trunk channel need to be repaired and restored. 7.2 km-long G-2 channel at the main right channel is important. It is built with concrete gutters, from where fields in Ninotsminda and Sagarejo are irrigated. 15 km long G-33 canal, which irrigates Iormughanlo lands and 15-km long G-46 irrigation network needs to be completely restored.

From Lower Samgori main left channel, 13 km-long G-9 and 5 km-long G-8 canals are important, they irrigate Giorgitsminda fields.

G-12 8 km-long irrigation network, which irrigated lands in Tokhliauri Village, 10 km-long G-22 network, which watered lands in Manavi, 7 km-long RE-30 canal, which watered lands in in Kakabeti Village need to be restored, in all, 4m x 1.25m reinforced concrete structures should be rehabilitated.

The rehabilitation of the abovementioned facilities requires large sums, that is why it is important to attract additional investments (grants) through the UNFCCC financial mechanisms.

Funds available at the Reclamation Division are mainly used for the purchase of fuel-lubricant materials and reinforced concrete structures, covering labor costs and other logistical expenses. Rehabilitation is not included in the budget of this phase.

Failure of the irrigation systems determines extremely low productivity of agricultural lands, especially in relation to the spring crops.

After the rehabilitation of the irrigation systems, agricultural production will increase, the structure of eroded and degraded land will improve, as will socio-economic conditions of the population. Irrigation is the most effective method to combat drought. It is desirable to be implemented using modern adjustable highly effective water saving technologies like, sprinkling, drip irrigation, etc. The project envisages cleaning and rehabilitation of 13 km-long G-9 irrigation network; 600 families will get irrigation water following its rehabilitation.

The Water Management Division is ready to participate in the rehabilitation of this section with its machinery, but as mentioned above, it is necessary to buy new water saving technologies, for which the attraction of co-funding will be necessary.

As mentioned above, the G-8 and G-9 irrigation canals in Giorgitsminda Village are very important. It is possible to rehabilitate the 5 km-long G-8 canal with open gutter patches. 12 km from the 13 km-long G-9 canal is the gutter system which is 7 m wide and 0.45 m high. The remaining one kilometer is 4 meters wide and 1.25 m high open gutters. The system needs to be completely cleaned, some sections are broken and need to be replaced. The G-9 canal has ten branches of the internal network, which needs to be fully restored.

Planned Activities

1. Examination phase – the development of the detailed project;
2. Cleaning channels;
3. Purchasing new reinforced concrete structures;
4. Installing the reinforced concrete structures;
5. Operation of the irrigation system.

2.6.8.4 Project Partners and Beneficiaries

Project Partners:

- Ministry of Agriculture which is eager to develop infrastructure in areas that will help to increase productivity;

- Georgian United Irrigation Systems Company interested in providing water to the population as much as possible and developing its own business practices. This agency will be responsible for the maintenance and the operation of the system after the implementation of this project;
- Municipal Development Fund of Georgia, which finances infrastructure projects and might be one of the co-financers of the project;
- Sagarejo Municipality, which is also interested in improving living and working environment of the population. The municipality can play particularly important role in conditions of decentralization;
- Donor organizations (IFAD, World Bank, Green Climate Fund, CDM adaptation fund, etc.) focused on reducing the risks of climate change and funding adaptation and social projects;
- The local population of Udabno Village and other villages, who will get irrigation water from the system. They take the responsibility for ensuring continuous operation of the internal network.

Project Beneficiaries:

- Farmers and peasants living in Udabno (80 farmers, up to 200 families, about 900 residents) who will obtain irrigation water, will improve soil fertility and their economic conditions and living environment;
- New investors in case of the existence of proper infrastructure in the area will be more interested in developing business in this area and purchasing land here.

2.6.8.5. Factors Contributing to the Implementation of the Project

- Support of the State to the irrigation infrastructure rehabilitation projects and increase in the scale of the support (funding increase);
- Interest of the donors (IFAD, World Bank);
- Municipality's approval and support of the initiative;
- Iinterest of the investors in the territory, that will encourage the increase in the importance of community infrastructure rehabilitation.

2.6.8.6. Barriers to the Project

- Budget deficit or budget cuts for the irrigation rehabilitation projects;
- Migration of population from the area;
- Undecided legal and technical issues related to the maintenance of the internal networks;
- Decrease in investments in the Agricultural sector.

2.6.8.7. Project Implementation Stages and Budget

Activities	Implementing agency	Implementation period (in months)* and Budget (USD)	Estimated results
Developing the project	Consulting Company	5 60 000	A detailed project with the budget is relevant calculations are prepared
Cleaning canals	Sagarejo Branch of Georgian United Irrigation Systems Company	2 150 000	canals are cleaned
Purchasing new reinforced concrete structures	Sagarejo Branch of Georgian United Irrigation Systems Company	2 300 000	Reinforced concrete structures are purchased and delivered to the sites
Installation of reinforced concrete structures	Sagarejo Branch of Georgian United Irrigation Systems Company	2 150 000	Reinforced concrete structures are installed
Puuting into operation of the system	Sagarejo Branch of Georgian United Irrigation Systems Company	1 5 000	The channel is ready for the operation
In total		**660 000**	

2.6.9. Establishment of the Modern Seed Farm in Sighnagi Municipality

2.6.9.1. Problem Description

In Georgia and namely in Kakheti Region, Dedophlistskaro, Sighnagi and Sagarejo districts are distinguished with the scale of cereal and grass crop production. In these three districts altogether, wheat and barley are sawn on an average of 50-55 thousand ha land annually, that forage crops are sawn on 2,000 ha. The average yield of wheat was significantly reduced in the last 20 years, which is mainly caused by low quality seeds.

Since 1990 the state only twice imported high quality seed material – first in 2000, when Jager&Copper seed materials were imported from the United States and second in 2011, when Ministry of Agriculture imported the initial reproduction Jagger seed material. As a result of these measures, an increase in the yield was observed in statistical reports and the average yield was increased to up to 2 tons per hectare. In the long-run, in order to ensure productivity and sustainability of the sector, the production of seed material in situ should be undertaken in Georgia and companies involved in the production at the initial stages should import high-end materials from developed countries accompanied by international certificates. This process is particularly important for the leading grain farming districts of Kakheti Region at the background of the climate change.

Analyses of the currently available wheat harvested areas showed that local residents and farmers annually require about 15 000 tons of seed material. On the background of high demand, primary, as well as industrial seed production is virtually non-existent.

Large commercial companies, such as Pioneer, Cozad, Monsanto and others are major primary seed producing companies in the world. This market is fairly concentrated. These companies are spending huge sums on research and use the world's scientific potential. In our country, taking the scale of the production into account, at this stage it is unlikely to reach the scale of the seed growing industrial production; however, it is still necessary to develop the initial seed-growing in the country.

The proposed project proposal envisages only primary seed production. A well-developed industrial seed production can entirely satisfy the local demand with the use of high-quality initial reproduction seed material.

So at the first stage it is necessary to revive industrial seed growing and in parallel, the initial seed production should be also developed.

It should be noted that at present, growing-cultivation of winter and spring cereal-legume crops and annual and perennial grasses and their development and improvement for the seed-growing industry is a serious problem.

Seed growing is a highly organized business. Unfortunately, currently we do not have the proper modern system, the connection between the rotation and the renewal of species is broken. Generally, seed breeding industry as a whole is in decline, a lot of the farmers are deprived of the opportunity to acquire high-quality seeds. The import of different crop seeds is spontaneous and the testing stations do not exist. Farmers use the seed material usually fit for general reproduction and this not only minimized productivity in the country, but considerably damaged the agricultural sector. Frequently, seeds are accompanied with quarantine weeds and various viral diseases, which have not been registered earlier not only in Kakheti Region, but also in the whole Georgia. They produce a negative impact on the productivity of any crop and afterwards on its quality. In addition, the seed sections are not included in the sown areas, breed weeding does not take place, the breed trial plots do not exist, without which the seed production is impossible. It is unfortunate but it is true that there are no laboratories and grain quality indicators are not determined (1 000 grain weight and other characteristics, proteins, gluten, etc.).

Taking into account the abovementioned information, we can confidently declare that the sowing of the agricultural crops, the development of the seed industry and cereal production are carried out spontaneously, unprofessionally and the end result of this process is extremely low productivity and qualitative indicators. Seed expenditures and productivity reword for cereal crops are almost the same. In such conditions, a lot of cereal producers discontinue cultivation of the grain crops. This trend is also confirmed by statistical data. Namely, 20-25 years ago, 65-70 thousand ha land was cultivated in Kakheti; The number has decreased to 58 000 for the present; The situation is deplorable and if continued, not only the grain crops sowing areas and yield per hectare cannot be increased, but our country will always be dependent on the import.

For the last 20 years, there is a serious deficit of high-quality and highly-reproductive cereals (wheat, barley, oat, etc.) and other crops (beans, annual and perennial grasses, etc.) in Kakheti developed according to the specific districts of the region (seed zoning).

In recent years, the areas sown for the basic food crops (mainly wheat) have significantly decreased in the region. Currently, only 58 000 ha land is cultivated for wheat, that is only 40% of the overall capacity. The situation is similar regarding barley, oat, and corn, as well with the annual and perennial grasses.

Seed breeding programs are crucial for increasing productivity of agricultural crops, including annual grain crops. As mentioned above, there is the acute shortage of the highly-reproductive elite breed seeds, grown and adapted to specific requirements of Kakheti's districts (seed zoning).

Clean, high quality seeds are no longer produced in Sighnagi and in general, in Kakheti region during last 20 years, seed-growing specialized enterprises no longer exist, breed testing is not taking place, we do not have transitional seed fund. And most importantly, in the agricultural country, we do not have a law on seed production.

The seed breeding system is destroyed. Time is running out, the situation is deplorable, this has not happened in any of the world's more or less grain producing regions.

With regard to the climate change, in the absence of the testing stations, the population lacks the opportunity to buy drought-tolerant and disease-resistant varieties.

Under the existing circumstances, attention should be paid to opportunities directed at solving the problems of the seed industry and its recovery. It is necessary to accelerate the industrial seed production or high-yield, highly-reproductive kinds and supply them to the land users.

As for the initial stages of seed farming or producing scientifically developed elite seed, it requires relatively long period (5-7 years), therefore, it is necessary to revive the industrial seed farming at the first stage and in parallel to develop primary seed growing.

2.6.9.2. Project Goal

The goal of the project is to produce high quality, seeds of cereals for primary reproduction, namely wheat seed in Kakheti Region, particularly in Sighnagi Municipality. The establishment of the primary seed farm is planned within the project. In case of working in line with the sensible, scientifically grounded plan, the agriculture sector in at least Sighnagi Municipality will be fully provided with the sufficient amount of certified wheat seeds in the near future[45].

The main objective of developing the winter wheat seed-growing is to facilitate the increase in the cultivated areas and the per hectare yield in Kakheti Region and specifically, to meet the demand of the land users in the region with the highy productive certified seed materials.

[45]As the Ministry of Agriculture is working on a certification of cereal seeds, it is assumed that the certification system necessary for starting the seed production process will be organized. This project is interested in and will contributes to the establishment of a certification system in Georgia.

2.6.9.3. Project Implementation

Methodology

Implementation of the project is planned in Sighnagi District. The methodology envisages high-quality winter wheat seed production using the latest technologies and through raising qualification and awareness of the local staff.

At the initial stage, the respective area (50-60 ha) should be identified and local climate and soil must be considered. For the successful functioning of the seed growing sector, it is also necessary to select virus-free areas, which are isolated from the settlements and plots with cereals. It is important to carry out seed zoning, testing and adaptation.

Arranging infrastructure in the seed farming area is planned at the next stage of the project, which among other things includes purchasing the machinery, other equipment and high-quality seeds, establishment of the mini-laboratory for monitoring seed virus and other diseases and analysing soil.

After setting up the infrastructure, the production process will start, during which soil preparatory works will take place, in addition, the elite materials will be imported and production of the primary reproduction seed will start. The process will be completed with seed production, packaging, labelling and distribution.

Planned Activities

- For the implementation of the seed farming program, 50-60 ha arable land is already selected for the pilot project in the winter wheat crop prevalence zone. The area was selected by taking into account its soil and climate conditions. But, in addition to the selected area, the same size of the territory is necessary for starting the implementation of the initial stage of the primary seed farming development;
- Demo testing plots should be arranged for testing various wheat varieties. Local farmers and other stakeholders will be directly involved in and contribute to the process (with plots, financially, with labour, knowledge, etc.), who are willing to have guaranteed provision with the certified seed material;
- Farming infrastructure (administrative building, warehouse, machinery and devices) should be arranged;
- The winter wheat local already adapted and foreign high-yielding varieties should be studied, tested and produced;
- The high class seed processing mini-factory should be purchased. Its capacity should ensure production of the required amount of wheat seed at the first stage;
- The laboratory, necessary for the development of the primary wheat seed farming should be organized, where it will be possible to conduct all types of analysis.

2.6.9.4. Project Partners and Beneficiaries

Project Partners:

- Ministry of Agriculture of Georgia, which is interested in developing the agricultural sector and producing high-yielding and high-quality products. In this regard, the Ministry is interested in setting up the the seed and seedling certification system in the country;
- Agricultural Research and Development Center, a function of which is to support farmers involved in agriculture with modern technologies. The relevant land areas, as well as seed material should be selected with their help. The project will work closely with this Centre to work out necessary recommendations;
- National Food Agency (LEPL established under the Ministry of Agriculture) as its main duty is to implement the state control on the food;
- The elite seed material importing companies, from which seed will be purchased;
- Sighnagi Municipality together with the Information and Advisory Service of the Ministry of Agriculture established in the Municipality, which are responsible for the promotion and development of the agricultural sector and provision of information and advisory assistance to the sector. Seed farming is the priority in Sighnagi Municipality;

Beneficiaries

- Farmers and agricultural cooperatives engaged in the seed farming, in particular, wheat production;
- Private companies involved in wheat and bread productions and food industry in general;
- Private companies producing other grain crops (including cattle forage) as in case of the successful implementation of this project, the experience will be used in other related sectors;
- The population of the Kakheti Region, who will be able to enjoy high-quality, weed and disease-free wheat seed;
- Kakheti Region, as it will be fully satisfied with the primary industrial seed growing and the whole Georgia, as 40% of its wheat consumption had been supplied from Kakheti Region in the past.

2.6.9.5 Factors Contributing to the Implementation of the Project

- Enactment of the law on the certification of the seed materials and the seed zoning, which will ensure promotion of the high quality seed material on the market and will prevent infected, low-quality products of unclear origin from accessing the market. Currently, the Ministry of Agriculture is working in this direction;
- The growing demand for high quality initial reproduction seed material at both the district and the regional levels;
- Programs to encourage local cereal crop production in order to promote food security, such the voucher program for wheat and maize;
- Interest on behalf of the state, namely, support of the Sighnagi Municipality management and the Agricultural Research Centre of the Ministry of Agriculture to the initiative;
- Support of the international donor community to the establishment and operation of farmers' cooperatives;

- Interest of the seed material suppliers, primarily importers of elite seed materials (plant protection measures, irrigation systems, fertilizers) in the successful implementation of this project, which will also contribute to the promotion of their products.

2.6.9.6. Barriers to the Project

- Cheap and low-quality wheat flour imports from Ukraine and Russia, which inhibits the local wheat production and therefore poses a threat to the country's food security indicators;
- Attempt of the state to disrupt the seed certification system. In order to reduce this risk, it is desirable to add an additional component to the project – the promotion to the establishment of the certification system;
- Lack of a legislative base, which contributes to poor quality and infected seed production and marketing. As a result, any investment in the seed and grain production can be regarded as wasted until the establishment and implementation of the legislative framework favourable for the high-quality, high-yielding seed production;
- Extreme weather events and the spread of diseases in the area where the seed farm should be established. In this regard, it will be necessary to study and introduce modern technologies for reducing the risk.

2.6.9.7 Project Implementation Stages and Budget

Project duration: 2 years.
Estimated budget:

Activities	Implementing agency	Implementation period (in months)* and Budget (USD)	Estimated results
1. Arranging the seed farm infrastructure (administrative building laboratory, warehouse, machinery and devices);	Agro News Ltd. and the farmers cooperative established on its base	12 360 000	The seed farm is organized and production of the primary reproductive wheat seed has started
1.1. Developing the seed farming project	Private consulting company/under the donors' funding	2 10 000	The project is developed (business plan, budget, construction work designs)
1.2. Purchasing and preparing the land for the nursery (120 ha in all)	Ltd. Agro News and the farmers cooperative established on its base	3 40 000	Land is purchased, from which 60 ha land under co-funding provided by Ltd. Agro News
1.3. Importing the certified seed material (15 tons)	Ltd. Agro News and the farmers cooperative established on its base	11 30 000	The elite seed material is selected, purchased and imported
1.4. Constructing and arranging the administrative building and warehouse (290 m^2)	Ltd. Agro News and the farmer cooperative established on its base	10 80 000	The buildings are built and equipped with relevant outfit, with office furniture and modern devices; Ltd. Agro News provides co-funding of the project

1.5. Organizating of the modern laboratory	Project Management	10 25 000	The modern laboratory is installed
1.6. Purchasing the machinery and tools (tractor, fertilizer and other machinery)	Project Management	5 110 000	The modern machinery is purchased
1.7. Purchasing modern mini-factory for cleaning and packaging seeds and loaders as well as their installation	Project Management	12 65 000	The mini-factory is bought and installed
2. Raising funds for covering operational costs necessary for the functioning of the seed farm	Ltd. Agro News and the farmers cooperative established on its base	24 25 000	Production packaging and selling of the seed material has started. The costs will be covered by Ltd. Agro News and the farmers cooperative established on its base
4. Hiring trainings, vocational training	Project Management, Scientific-Research Centre	12 25 000	The staff is trained, they have undergone the attestation and are ready to get involved in the operation
In total		**410 000**	

In case of approving the project, the Agro News Ltd. will allocate 200 000 USD as the co-funding to the project. The company will need to attract an additional capital worth of 210 000 USD from potential investors.

2.6.10. Establishment of the Modern Vine Nursery on the Territory of Kvareli Municipality

2.6.10.1. Problem Description

General Information

Geography. The specific Kindzmarauli viticulture zone is located in Eastern Georgia, Inner Kakheti, at the territory of Kvareli Municipality, on the southern slopes of the Greater Caucasus. Coordinates - Latitude: 41º30'N and Longitude: 45º50'E. Industrial vineyards are mainly located at an altitude of 250-550 meters above sea level on the left bank of R.Alazani. Alazani Plain is disposed at the bottom of the valley, which rises northward, is transformed into the foothill zone and is set against the steep slopes of the Caucasus Range.

The existing territory used for producing Kindzmarauli wine materials covers a part of Inner Kakheti and is represented on the left, second terrace of Alazani River, on the right and left sides of its tributaries: Duruji, Bursa, Chelti, Intsoba, Avaniskhevi and Shorokhevi. In the north it is set against the steep ending of the southern slopes of the Caucasus Mountains.

The western part of the territory, starting from the right side of R. Duruji with more inclined relief to the south-west is the plain with weak wave-like surface, while the rest of the area in the eastern direction is the plain sloping to the south. This zone covers the Kindzmarauli area and

Kvareli administrative district, the following villages to the west: the middle and upper parts of Shilda, Eniseli, Sabue, Almati, Gremi and Shakriani located at the second terrace of R.Alazani. Eastward, the following villages are covered: Fatmasuri, Sanavardo, Kuchatani, Tsitskanaant Seri, Chantlis Kuri, Zinobiani, Akhalsopheli, Tkhilis Tskaro, Mtis Dziri, Chikaani fully and partly, the territories of Gavazani and Balghojiani down to the first terrace of R.Alazani. The total area of the micro zone is about 2 400 ha.

Climate: In the Kindzmarauli micro zone, the formation of the weather is mainly determined by air masses developed in the sub-tropical and temperate latitudes, transformed under the influence of the high mountains systems and introduce from the west and the east. As a result of the peculiar reserved disposition of the valley, the wind speed is not high. The climate is moderately humid with mild winters and long warm summer.

The existing vineyards and vineyard areas are mainly located in the south and on its adjacent slope inclined with 2-30^0. In the grape formation and ripening periods, the sun altitude for Kindzmarauli latitude is within 60-70^0 and 40-50^0. The average annual duration of sunshine is 2 050 hours.

During the grape formation and ripening period in the zone, 8-10 magnitude cover of the sky with clouds is 20 and 18 days respectively, while the number of clear days with 0-2 magnitude cloudiness reaches 15 and 16. In addition, in the valley of the latitudinal direction, key climate factors emerging at the foothills of the southern sloping, such as solar radiation energy, the amount of heat, a moderate summer temperature, ample moisturing of the location together create favourable conditions for the high quality wine production.

On the blackish shale surface brought down by Duruji River, the temperature is high during the day; In the afternoon hours, temperature is 3-5 ^{O}C higher than the temperature of the surface of the alluvial-calcareous soils in the adjacent forest.

The blackish soil surface has a lesser ability for reflecting falling radiant energy (15%). As a result vineyard planted on these soils is characterized by 20% ability of reflecting solar rays. The average annual temperature in Kindzmarauli micro zone (where Saperavi wine variety is grown) is 12.5 ^{O}C, the average temperature of the warmest months (VII-VIII) is 23.6 ^{O}C. The average temperature of the coldest months is +1.0 ^{O}C. Given the multi-year data, the mean annual air absolute minimum temperature is -11 ^{O}C, the mean annual air absolute maximum is 35 ^{O}C, and extreme temperatures equal to -23 ^{O}C and +38 ^{O}C.

Above the average daily 10 ^{O}C air temperature, a stable transition occurs on 5.IV. Fall below 10 ^{O}C is observed on 4.XI, i.e. the duration of the warm period is 212 days. Saperavi bud starts opening in mid-April (from 15.IV). Flowering is observed at the end of May and the start of grape ripening - in the second half of August (from 20.VIII).

Technically, maturation of the grapes takes place at the end of September. Grapes should be picked in mid-October for getting naturally sweet wine. In the Kindzmarauli micro-zone, first autumn frosts starts from 21.XI and in every 10 years, the first frosts may start at the end of October.

In spring, last frosts, on the average, end from 26.III. In every 10 years, the late frosts may last until mid April. The duration of the non-frost period is 239 days. In Kindzmarauli micro-zone, within the altitude of 350-550 m, the sum of active temperatures (> 10 ^{0}C) varies in the range of 4 100-3 700 ^{0}C.

For producing naturally sweet wine (> 26% and 6.8 g/dm^3), at the altitude of 350 m, Saperavi gives up to the mark material 1 5 times in decade (50%); at the altitude of 400 meters - 3-4 times in decade (35%); at the altitude of only 450 m once in decade (10%).

As for the European type premium-quality table wine: At the altitude of 350 m - 7-8 times in decade (75%), at the altitude of 400 m - 5 times (50%), at the altitude of 450 meters once in every 4 years (25%) and at the altitude of 500 meters – once a decade (10%). During the rest of the year, good quality natural vintage wine is obtained.

The sum of the annual precipitation in Kindzmarauli micro-zone is 1 070 mm and during the vegetation period is 800 mm.

The relative annual air humidity value equals to 72%. The moist air saturation is the least (66-64%) during the summer months (June-July-August) and relatively higher (80%) at the end of autumn and in early winter. The snow cover is formed in the last decade of December (25.XII) and disappears in mid-March. The number of snowy days in the winter is not over 80. The snow cover is unstable in the micro-zone and its probability amounts to 87%.

The average annual number of days with hail equals to 2.1.

May is the month with most frequent hail fall (0.9 days); The number of days with hail separately for April, June and July does not exceed 0.3. The maximum number of days with hail per year may reach 8. The minimum temperature may drop as low as to - 15 ^{0}C in decade, that only slightly (30%) damages Saperavi fruit buds.

Mostly western (23%) and south-eastern (17%) winds are prevailing in the micro-zone. The number of windless days on the average equals to 157 annually. Wind speed is increased by mountain-valley winds arising here. Cold air masses coming down from the high peaks of the Caucasus Range at night, until the sunrise, increase winter frosts and the danger of spring frosts. This zone of Alazani Valley belongs to the 3rd group zone of adverse wind effects.

Exceptional geographic location of Kindzmarauli micro-zone - the micro-climate developed at the influence of the foothill set in the south of the high mountains of the Greater Caucasus, skeletal soils developed on the black shale brought down by the rivers, a very favourable thermal regime in vineyards and unique features of Saperavi grape variety, its ecological plasticity, determine specific taste qualities of the original high-quality naturally semi-sweet Saperavi wine.

Problem Description. A lack of virus-free sapling nurseries in Kindzmarauli micro-zone and Kakheti in general hampers the development of viticulture in Kakheti.

At present, Viticulture in Kakheti is represented with the vineyards planted in the 60-70-ies of the last century (80-85% of the total vineyard area) and new plantations (15-20% of the total vineyard area).

Rkatsiteli and Saperavi grape varieties dominate in the vineyards planted in the Soviet era, as well as in the recent periods. In Soviet period, viticulture was focused on grape quantities. Relatively less attention was paid to the characteristics of micro zones and the production of high-quality vintage wines. Other Georgian grape varieties, particularly Kisi, Khikhvi, Mtsvane, Mtsvivana and others were almost forgotten.

In the second half of the 1990s, new vineyards were intensively planted in Kakheti and the process was the most rapid in Telavi, Kvareli and Gurjaani municipalities as the world-renowned viticulture zones are located in these municipalities, namely: Kindzmarauli, Akhasheni, Mukuzani, Tsinandali, Vazisubani and Napareuli. Interest of investors was also quite high. Reportedly, 5 000 ha new vineyards were planted in Kakheti.

If we take into account that planting of 1 hectare vineyard requires an investment of 8-11 thousand USD, it appears that 40-55 million USD was invested in the cultivation of new vineyards in Kakheti. In 2006, the trend was slowed down by the closure of the Russian market. In 2013, after the opening of the Russian market, high grape demand and price encouraged local residents to actively start the planting of new vineyards. The price of the saplings nearly tripled. Currently, the purchase cost of 1 sapling varies from 1.5 to 2 GEL. The planting process is quite disorganized and develops spontaneously. No one takes into account the issue of politicization of the Russian market and the high probability of interrupting the export at any time.

The grape varieties in the new vineyards are represented with the following ratio: Saperavi - 96%, French red grape varieties, such as Cabernet Franc, Cabernet-Sovignon, Pinot Noir, Merlot, Malbec - 1.8-2% and the ancient Georgian grape vine varieties, namely: Kisi, Khikhvi and Kakhuri Mtsvane are represented on the remainning 2-2.2%.

Sparsity is high in the old vineyards and per hectare yield is low (2-2.5 t/ha). In order to improve the quality and profitability of grape vineyards, these vineyards need to be rehabilitated.

Given the fact that approximately ¾ of the old plantations (about 15 000 ha) require restoration, according to a rough calculation, at least 2 700 000 certified virus-free saplings are necessary for the rehabilitation of 1 000 ha only in Kakheti Region.

As planting new vineyards and rehabilitation of the old vineyards are connected to high costs (an average of 5-10 thousand USD per hectare), it is necessary to have a guaranteed quality of saplings, otherwise the investment is unjustified.

Currently, the grapevine nursery "Arivie-Georgia" is operating in Kondoli Village of Telavi Municipality, which produces Georgian and foreign vine variety saplings of European quality. Their annual production capacity is more than 1 million saplings. A large part of the saplings are exported and the part is sold locally. This nursery is the only modern nursery not only in Georgia, but also in the whole South Caucasus. This is the only nursery, where virus-free plants are produced. Its capacity is insufficient to meet current demand. There are also additional two or three large and peasant household nurseries in Kakheti. In general it can be said that the full technological cycle for producing the sapling is broken and therefore, high-quality vine saplings are not practically produced at these nurseries.

Based on the results of the market demand analysis, we can conclude that locally, there is a potential of selling at least a million seedlings annually. Two issues should be considered in connection with the development of the nurseries: The first issue relates to the need for the production of virus-free and disease free seedlings. Nowadays it is the only major problem not only in Kvareli, but in the entire Kakheti Region. This is a particularly sensitive issue for Kvareli, Telavi and Gurjaani districts, because it concerns the grape production in the micro-zones. The demand on grape produced in this districts, namely in Kindzmarauli zone of Kvareli District, is always high and resistance of vineyears (new, as well as old plants) to diseases is particularly important.

The second issue, which is no less important, is climate change.

Despite the fact that the decrease in the aridity coefficient in Kvareli is insignificant, the rise in temperature and drought have been observed in July and August in recent decades. It is necessary to implement the breed adaptation activities by taking these factors into account, which primarily should be implemented at the stage of the seedling production. In the modern nursery, it will be possible to observe the current varieties (Saperavi, Rkatsiteli) in the conditions of various climate change parameters. Therefore, it will be possible to determine the climate change adaptation ability of various species according to the different scenarios.

2.6.10.2. Project Goal

The goal of the project is to organize high-quality virus-free sapling production in Kvareli District for satisfying local and regional demands. In case of the successful implementation of the project, adequate infrastructure will be set up locally for producing virus-free seedlings. At the same time, modern rootstock material and grafting technology will be tested againsts the diseases and climate change for producing sustainable seedlings on the basis of the nursery. The nursery can play a role of the testing station as well, especially for seedlings required for Kindzmarauli micro-zone. In the future, together with the operation of the nursery at the full capacity, it will be also possible to export saplings. This is successfully implemented by "Arivie-Georgia", which is located in the neighboring Telavi District and annually exports 500 000-700 000 (2011-2012) high-quality saplings to Ukraine and Azerbaijan.

2.6.10.3. Project Implementation

The project will be implemented in Kvareli District, Kindzmarauli micro-zone. Relevant territory will be identified at the initial stage taking into account logistical factors, as well as characteristics of the micro zone. Arrangement of the proper infrastructure necessary for vine nursery is planned in this area, including 5 ha for mother materials and 30 ha nursery area (production of 500 000 seedlings annually). In addition, the greenhouse farm and the mini-laboratory will be built to monitor the seedlings on viruses and other diseases. After setting up the infrastructure, the production process will start, during which the preparatory work will take place on the soil, as well as planting of mother materials and procurement and grafting of rootstocks. Finally, the process will be completed with the seedling breeding, the product packing, labeling and distribution/sales.

Planned Activities

- Selecting an area for nursery arrangement. For this, it will be necessary to conduct a special study and find a place on the territory of Kvareli Municipality, which with its climatic and soil characteristics meets all the needed requirements. An existence of future expansion opportunities in case of the subsequent project development is necessary to consider during the selection process.
- The project proposal development process at this stage revealed that 23 ha area has been pre-selected (5 ha for mother plants and 18 ha for the nursery). The area is owned by the newly formed cooperative "Kvareli". In case, the "Kvareli" cooperative will be selected for the implementation of the project (whose founders have significant experience in this area), the soil and climate parameters will be repeatedly checked before commensing the project implementation;
- Designing the nursery, which includes designing all necessary infrastructure, among them laboratories, administrative offices, warehouses and other buildings and irrigation systems. Preparing the business plan is the part of the designing process, which includes at least a five-year production and sale period by taking into account market practices and products promotion measures. The business plan should be accompagnied with a detailed budget;
- Construction of the nursery, which envisages the arrangement of the abovementioned necessary facilities and irrigation systems;
- Purchasing machinery and devices, auxiliary materials, equipment, laboratory equipment and various and stock and agricultural implements;
- Hiring qualified personnel and their training in case of a need;
- Starting the production process, which includes setting up of the mother plant and the rootstock plots and later, the organization of the grafting process and seedling production;
- Distribution and marketing of the produce.

2.6.10.4. Project Partners and Beneficiaries

Project Partners:

- Ministry of Agriculture of Georgia, which is a primarily responsible for facilitating the establishment of agricultural cooperatives (and it is the Ministry's declared current priority), the development of the agricultural sector in the country and the sustainable development of viticulture in Kakheti;
- Agricultural Scientific-Research Center with its important function to promote the sustainable development of the agriculture sector. In this case, the sustainable development of viticulture implies the simultaneous review and assessment of many elements, such as soil, climate, micro-zone, variety, yield, taste, etc. This multi-criteria analysis requires a deep knowledge of each element and the joint analysis methodology, which should be provided by the abovementioned Centre;
- Ministry of Environment and Natural Resources Protection of Georgia responsible for correctly directing different branches of economy, including the agricultural sector to reduce climate change risks, for facilitating the inclusion of the climate change risks in strategies and concepts prepared by various agencies and for raising awareness of various interested parties, including the private sector on risks related to the climate change;

- “Kvareli” cooperative (if it will be selected as the implementing agency), as it will be supported in receiving new knowledge and technologies, which will give the company a serious advantage in comparison to other competitors. At the same time, the “Kvareli” cooperative will be obliged to disseminate among and share the knowledge with other stakeholders.

Project Beneficiaries

- Agricultural cooperative “Kvareli”. The project will assit the company in introducing modern technologies, which will help to demonstrate strong cooperatives;
- Other private companies and agricultural cooperatives in the viticulture industry, which can benefit from modern technology and knowledge sharing, as well as high-quality saplings;
- Small and medium-scale farms, which will have a desire to increase the high-quality vineyard areas and the volume and quality of the production;
- Wine manufacturers and exporters, as more high-quality grapes will be accessible to them.

2.6.10.5. Factors Contributing to the Implementation of the Project

- Enactment of the planting material certification and zoning law[46], which will ensure promotion of the high-quality planting material on the market and will prevent the low quality products of unknown origin from gaining the access to the market;
- The growing demand for high-quality virus-free saplings in the region, as well as the existence of the export markets (Ukraine and Azerbaijan);
- Diversification of export markets and increased demand for high-quality brand wines;
- Interest on behalf of the state, namely, approval of the initiative by the Kvareli Municipality and support from the Agricultural Research Centre of the Ministry of Agriculture;
- Support of the Ministry of Agriculture and international donor organizations to the establishment and strengthening the farmers' cooperatives;
- The existence of the specific recipient party interested in the project implementation. The “Kvareli” cooperative is ready to co-finance the project with its 23 ha land area and in kind (labor) contribution.

2.6.10.6. Barriers to the Project

- Lack of knowledge about modern technologies, elimination of which is one of the functions of this project (at least partially);
- Market, where probability of politically motivated embargo at any time exists. If the Russian market is closed again, the demand on seedlings will be reduced dramatically. This barrier should be neutralized by constantly monitoring the trends of the demand on high-quality saplings and relevant production planning. There is a lack of this type of knowledge in the country.
- Lack of the legal framework that promotes production and sale of low quality infected seedlings. As a result, any investment in the production of new seedlings, as well as the

[46]The law is under preparation and discussions will soon begin.

rehabilitation of old outdated vineyards can be regarded as wasted as the sapling quality is not guaranteed;

- Climate change risks, which may alter characteristics of these micro zones and spread disease to the area, where the nursery should be organized.

2.6.10.7. Project Implementation Stages and Budget

Estimated project duration: 2 years

Estimated implementation stages and budget:

Activities	Implementing agency	Implementation period (in months)* and Budget (USD)	Estimated results
1. Assessming suitable areas valid for the high and medium quality wine production in Kvareli Municipality, identification of the agro-climatic zones and selection of territories.	Private consulting company	2 3 000	The territory is selected (at this stage, 23 ha area has been pre-selected for the nursery and mother plants. The territory is owned by Cooperative "Kvareli").
2. Setting up the nursery (infrastructure and territory, machinery-devices, laboratory, warehouse, administrative building)	Cooperative "Kvareli"	12 325 000	The nursery is set up and the production of saplings has started
2.1 Developing the nursery project	Private consulting company	2 10 000	The project is developed (business plan, budget, construction work designs)
2.2. Arranging organization of mother plants farm on 5 ha area	Cooperative	11 50 000	The vine mother plant area is prepared
2.3. Arranging the nursery on 18 ha area	Cooperative	11 50 000	The vine nursery area is prepared
2.3. Greenhouse construction and maintenance, operating costs	Cooperative	6 100 000	Greenhouse is constructed
2.4 Establishment of the laboratory	Cooperative	10 25 000	The laboratory is purchased and set up
Purchasing the machinery and tools (tractor, fertilizer and other machinery)	Cooperative	5 50 000	Equipment is bought
2.6. Setting up administrative and storage facilities	Cooperative	12 50 000	Facilities are built and set up
3. Operating costs necessary for the functioning of the nursery		24 100 000	The sapling production and sale has started
4. Hiring consultants, training the personnel	Donors, Scientific Research Center	25 000	Personnel is trained
In total		**453 000**	

3. Healthcare and tourism

3.1. The impact of climate change on the tourism potential of the Kakheti region

Diverse climate zones and landscapes, as well as rich historical heritage of Kakheti conditions high tourism-recreational potential of the region that has been utilized just partially over the past period. Mtatusheti is to be noted from among the resort zones on the Kakheti territory, high tourism-recreational potential of which has remained actually unutilized due to the lack of the road. There are resort places in certain locations (Gombori, Tsivi Koda, Tetri Tsklebi, Akhalsopeli, Torghva Bath, Arkholiskalo, Ujarma, Akhtala, etc.) of Tsiv-Gombori Ridge and the southern slopes of the Great Caucasus Range as well, of which the last two are famous for the therapeutic muds. The high mountainous zone of the Caucasus Range is prospective for the development of mountain climbing and mountain sports tourism. The Kakheti territory is rife with historical monuments; therefore, large part of the region is the educational tourism zone as well.

High tourism potential of Kakheti is essentially conditioned also by high number of protected areas (Lagodekhi, Vashlovani, Mtatusheti, Batsara, Babaneuri, Mariamjvari Nature Reserve, Ilto, Iori and Chachuna Managed Reserves, Alazani Floodplain, Artsivi gorge, Takhti-Tepa Nature Monuments, etc.)

The Figure 3.1 shows the distribution of the mentioned tourism-recreational zones at the Kakheti territory; the chart has been drawn based on the information about the above-listed factors available by the 1980’s.

Over the three decades since the above-mentioned period climate has undergone notable changes as a result of the impact of global warming, evidenced by the results provided in the Second National Communication of Georgia to the UNFCCC and the studies performed in the present report. Therefore, it became necessary to assess possible changes in tourism-recreational potential of Kakheti in light of the already started and anticipated change of climate elements, using modern methods and criteria. Recent experience of analogous studies for the Ajara region was used for the achievement of this objective.[47]

At the first stage, the change of the potential of tourism-recreational resources of the Kakheti Region between two equal 25-year periods was assessed (1961-1985 and 1986-2010). At the second stage the assessment of estimated change of the potential in the current century was performed in relation to the projected change of climate elements.

[47] Climate Change Strategy of Ajara. UNDP in Georgia, Tbilisi, 2013

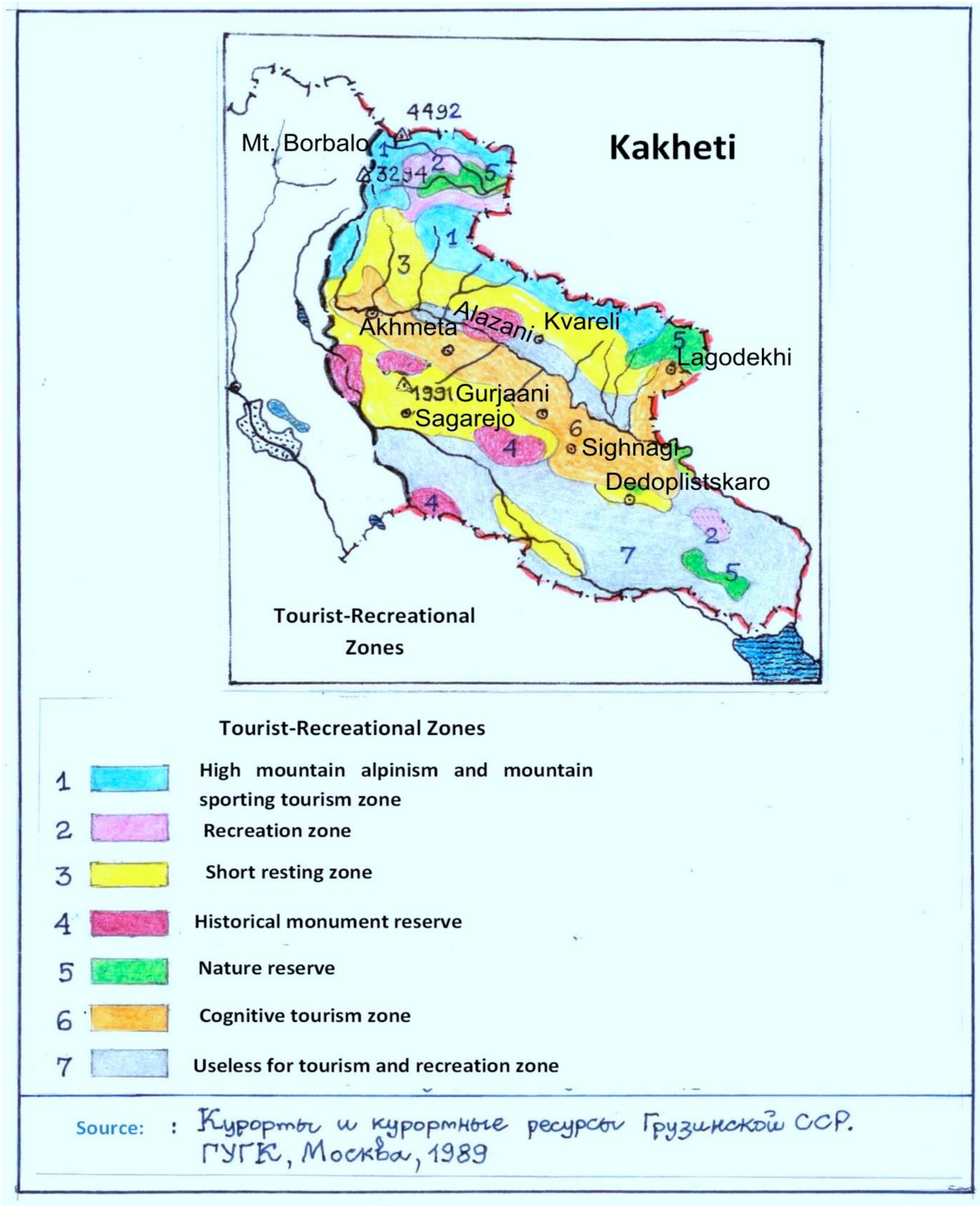


Fig. 3.1 The distribution of tourism-recreational zones on the Kakheti territory, as of 1980's

Tourism-recreational zones
1-High mountainous zones for mountain climbing and sports mountain tourism zone
2-Rezort zone
3-Short-term rest zone
4- Historical preserve
5-Nature reserve
6-Educational tourism zone
7-Zone unfit for tourism and recreation
Source: Resorts and Resort Resources of the Georgian SSR, Moscow, 1989

Complex climate parameter -- TCI (Tourism Climate Index) has been used for the assessment of recreational potential of tourism. TCI was developed by the World Meteorological Organization (WMO) to describe the climate conditions affecting tourism in various regions and countries. Tourism Climate Index is a combination of 7 variables. These variables include air temperature and humidity parameters, total precipitation, duration of sunshine and average wind velocity. TCI is measured in degrees from 100 to 30 and comprises such categories as, for example, “ideal” (90÷100 degrees), “good” (60÷69), “unfavorable” (30÷39), and “unacceptable” (-30÷9). TCI categories relevant to the conditions of Georgia are provided below in the Table 3.1.1.

Table 3.1.1. TCI categories

#	TCI categories	TCI interval (degrees)
1	Excellent	70÷79
2	Good	60÷69
3	Pleasant	50÷59
4	Acceptable	40÷49
5	Unfavorable	30÷39
6	Extremely unfavorable	10÷19
7	Unacceptable	-30÷9

For the assessment of TCI change at the Kakheti territory due to the impact of the global warming over the past half a century average values of TCI were calculated based on the data of 5 meteorological Region stations of Kakheti for the two above-mentioned periods. The results are given in Table 3.2. Elevation above the sea level is indicated in brackets the in this Table, the numbering of TCI categories matches the numbering of the Table 3.1.1 provided above.

In addition to average values of TCI index broken down by months in Table 3.1.2 relevant extreme values are also of certain interest. These extreme values are presented in Table 3.1.3.

The analysis of the last two tables enables to draw important conclusions. In particular:

TCI index categories have not changed between the two periods subject to the study at all of the studied meteorological stations in Kakheti. This evidences that the global warming that started from the 1970s has not had substantial impact on the conditions favorable for tourism in the Kakheti Region yet. Detailed analysis of variation of each parameter (daytime and daily comfort indices, total precipitation, and duration of sunshine and wind velocity) of the TCI has shown that monthly values of these parameters vary insignificantly between the examined periods. Although, the change of specific parameters may be noticeable at the separate meteorological station. In particular, monthly values of precipitation index fell from 9 to 7% in June in Telavi between the first and the second periods, while increased from 19 to 21% in October, but such variations have not affected TCI monthly average values.

It is worth noting that derived result differs from the specificities identified for the Ajara region using the analogous approach, where the change of TCI categories between the same periods of time has been observed on all three seasons of the year (other than winter) at seashore and high mountainous stations;

Table 3.1.2. Distribution of TCI index categories in Kakheti by months over the period of time 1961-1985 (first period Δ), 1986-2010 (second period +) and 2071-2100 (forecast period ●) data.

Meteorological station	Sagarejo (802 m)				Telavi (568 m)				Kvareli (449 m)				Sighnaghi (795 m)				Dedoplistskaro (800 m)			
TCI / Month	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
January			●	Δ +			●	Δ +		●		Δ +			●	Δ +			●	Δ +
February			●				●				●					Δ● +				Δ● +
March			Δ● +			●				●					Δ● +				Δ● +	
April	●		Δ +		●	Δ +			●	Δ +			●	Δ +			●	Δ +		
May	Δ● +				Δ +	●			Δ +	●			Δ● +				Δ● +			
June	Δ +		●		Δ +		●		Δ +			●		Δ +	●		Δ +		●	
July	Δ +			●	Δ +				●►	Δ +		●►		Δ +		●	Δ +			●
August	Δ +			●	Δ +			●		Δ +		●►		Δ +		●	Δ +		●	
September	Δ +	●			Δ +	●			Δ +			●		Δ● +			Δ● +			
October	●	Δ +			●	Δ +				Δ● +			Δ● +				●	Δ +		
November		●	Δ +			●	Δ +	●			Δ +			●	Δ +			●	Δ +	
December		●		Δ +		●		Δ +	●			Δ +			●	Δ +			●	Δ +

Table 3.1.3 The distribution of extreme values of the Tourism Climate Index in Kakheti, by months, 1961-2010

Meteorological station	Sagarejo		Telavi		Kvareli		Sighnaghi		Dedoplistskaro	
TCI / Month	min	max	min	max	min	max	min	max	min	max
January	29	56	37	55	31	54	33	59	33	53
February	27	58	37	60	31	62	36	62	33	57
March	37	72	37	71	31	78	37	79	33	63
April	40	88	40	89	40	91	46	92	40	87
May	57	90	54	87	63	88	63	92	56	93
June	65	92	55	90	53	87	44	82	57	90
July	65	89	56	88	54	80	45	74	58	88
August	69	91	57	84	44	81	42	81	59	90
September	65	96	62	90	63	87	60	90	63	91
October	42	88	42	89	39	90	41	87	36	87
November	29	71	37	67	37	73	40	71	37	84
December	29	62	31	60	31	60	32	60	29	58

- Average monthly TCI values at the reviewed meteorological stations of Kakheti do not fall below "Acceptable" category the year round. This evidences fairly high tourism development potential in the Kakheti region. In this regard, the derived result also differs from the result in Ajara, where average TCI values in winter months have moved into category 5 ("Unfavorable"). As for the extreme values of categories, their values on the reviewed stations rarely fall below the "Acceptabale" category (less than 40 degrees) during the winter and spring months. Then, from April through October TCI values often move into "Excellent" and "Ideal" categories (above 80 degrees).
- In Gare (Outer) Kakheti and Telavi from May through September TCI values are in the "excellent" category and in Kvareli and Sighnagi in July-August TCI category is reduced by one step.
- The fact that in winter months average TCI value does not fall below "Acceptable" category at all reviewed meteorological stations can be explained by the factor that in winter in Kakheti, except for the high mountainous zone, average minimum temperatures usually do not fall below minus 3, minus 5 ^{0}C, the precipitation is not abundant (monthly totals vary between 20-40 mm, which is about 5% of annual norm), total duration of sunshine is 100-150 hrs. a month, average relative air humidity does not go above 70-80%, while average wind velocity varies between 2-3 m/sec. Due to all of the above the climate conditions at the majority of Kakheti territory is fairly comfortable even in the winter season.

During winter total number of snowy days during the 1960's varied between 10 (Lagodekhi) and 30 (Sagarejo). It has to be mentioned also that in conjunction with the warming of the climate over the past 25 years these figures should have fallen significantly.

As for the Kakheti high mountainous zone, due to the lack of relevant data TCI categories were calculated for reference purposes at the weather station Omalo only based on the data available for 1950-1965. According to derived results, just January and February appeared in the "unfavorable" category. March, April, November and December fell under "Acceptable" and "Pleasant" categories, while 5 months from May through October fell in the "Excellent" category. Considering that over the past half a century since the collection of the data from the meteorological station, subject to analysis climate in Omalo should have become warmer, it is quite possible that currently even April and October are tightly closer to the "Excellent" category. As for the winter months, due to the fair amount of precipitation (15% of annual norm) over this period, the development of mountain skiing sports should be considered as prospective here.

In addition to the past two periods, projected values of TCI categories have been calculated for 2071-2100 period as well, using the climate change forecast model. Average monthly values of these values are also marked in Table 3.1 with a ● symbol. In three cases the values that fell under the following, 5th, "Unfavorable" (degrees range 30÷39) category are marked with an asterisk ●► symbol.

Based on the analysis of provided data it is expected that by the end of the current century in relatively cold period (from October through April) TCI index will move into a higher category at all five meteorological stations of Kakheti under the impact of the warming and its attendant processes, i.e., it is expected that the climatic conditions favorable to tourism will improve. At the same time, during the warm period of the year (May through September) we have to expect a reversed process, when uncomfortable conditions related to increased temperature cause the shift of TCI values to a lower category. This trend is especially vivid during July-August when in Telavi and Kvareli the indices have moved to Category 5 -"Unfavorable"-- that has not been included in the Table.

Therefore, similar to the Ajara region, in the Kakheti region, too, given the forecasted global warming conditions it is expected that the conditions favorable for tourism will improve in winter and during transitional periods while they will worsen during the summer months.

3.2. The impact of climate change on the health care sector in the Kakheti region

Based on the results of the research performed the framework of Georgia's Third National Communication of Georgia to the UNFCCC it has been identified that the frequency of a number of climate-dependent diseases, for example, cardio-vascular pathologies increases significantly in Kakheti municipalities. Such change may be due to the identified changes of climate parameters. In particular, the highest increase of average annual air temperature between the two periods – 1961-1985 and 1986-2010 is observed in the Dedoplistskaro municipality and it equals 0.7 °C. With the rise of the number of hot days, when the temperature goes above 25 °C Dedoplistskaro is leading again: total number of SU25 days over the 25 year period rose by 459. Akhmeta municipality ranks second with 394, followed by Telavi with 310.

Another indicator that was determined under the project and which enables us to assess the significance of climate comfortable for health is the Tourism Climate Index (TCI). It is a complex indicator and comprises 7 parameters of climate[48].

The value of TCI varies slightly for various municipalities of Kakheti. According to the analysis performed for 1961-2010, climate is excellent or ideal for tourism in almost all municipalities during summer. So, for example, during summer the value of the TCI is "Excellent" in Telavi, while in August the value is even higher and is "Ideal" in Sagarejo. Situation is similar in the Dedoplistskaro municipality where throughout the entire summer climate is "Excellent" and in September reaches "Ideal". There is slight difference in the Kvareli municipality where in July and August climate is "Good", but in May and September it is "Excellent".

It can be said based on these data that in the Kakheti region the climate is favorable for health and this has positive impact on the recreation potential of the region and respectively, on tourism. At the same time, it is important to know future values with TCI that will enable various sectors (tourism, healthcare) to accurately determine future needs and as necessary, plan adaptation activities.

The World Health Organization (WHO) has compiled the list of diseases that are especially related to the climate change and they are referred to as climate-dependent diseases. These are: water, food and insect/animal borne infections, as well as diarrheal diseases are separated as a separate group along with, cardiovascular and respiratory system diseases, pathologies caused by

[48]The index is a combination of seven parameters, three parameters are independent, and two ones are bioclimatic combination. $TCI = 8 \cdot Cld + 2 \cdot Cla + 4 \cdot R + 4 \cdot S + 2 \cdot W$, where, Cld – is a daytime comfort index that comprises average maximum of air temperature - Tmax (°C) and minimum relative humidity - Fmin(%), Cla - is a daily comfort index that comprises average air temperature T(°C) and average relative humidity f (%), R – is total precipitation (mm), S – is hours of sunshine, W- is average velocity of wind (m/sec). Unlike other climate indices, each parameter of the TCI is measured in degrees.

extreme events (including, traumas, post-traumatic mental disorders and epidemiological outbreak of infectious pathologies), pathological conditions caused by extremely high temperature and heat waves.

The already observed change of climate over the past decades in Kakheti enables us to make first estimation of the impact of the change of specific climate elements on the prevalence and incidence of the above-listed diseases, as well as to forecast their trends in the current century in conjunction with the expected climate change. The derived results should be taken into account for the plans of the Healthcare sector development in the Kakheti region.

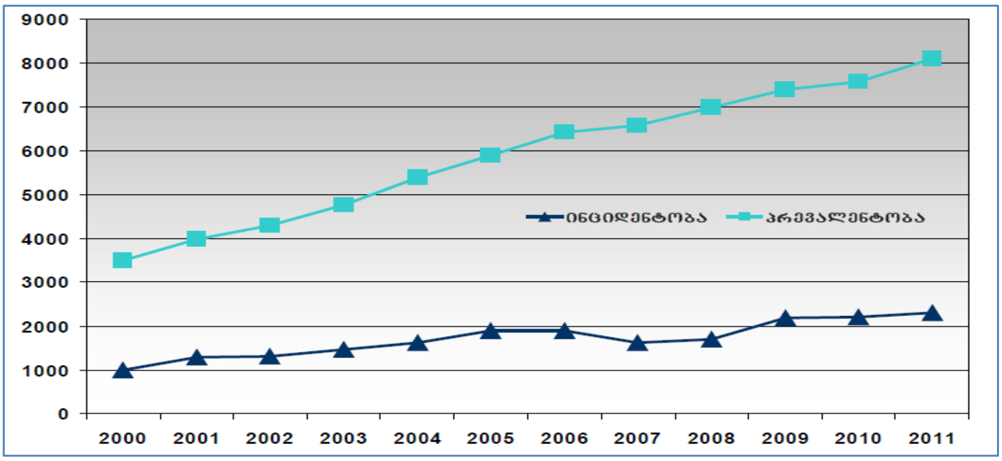
The prevalence of climate-dependent diseases in the Kakheti region. Based upon the results of the research performed as part of Georgia's Third National Communication cardio-vascular diseases, especially arterial hypertension, ischemic heart disease, acute myocardial infraction should be considered as the most pressing out of the climate-dependent diseases in Kakheti. Moreover, cerebrovascular disease is also important, less important – respiratory system diseases (specifically lethal outcome caused by those). The rise in frequency of malignant cancers, endocrine system and infectious diseases (especially brucella, hepatitis A, B, C) can be observed in the region, although at a lower intensity than in case of cardio-vascular diseases. Furthermore, such climate-dependent disease as Malaria should be noted; malaria had been a problem for Kakheti for years, but currently it is strictly controlled by the public health and no cases of this pathology are detected. Therefore, the report will mainly focus on the trend of the prevalence of cardio-vascular diseases in the Kakheti region and its correlation to climate change.

The prevalence of cardio-vascular diseases in Georgia and correlation with climate change. In general, cardio-vascular diseases and arterial hypertension, in particular, is one of the most prevalent pathologies in Georgia. According to 2010 data by the prevalence[49] indicator arterial hypertension ranked first among the most prevalent diseases, and ranks second[50] in terms of incidence (acute respiratory diseases of the upper respiratory system rank first).

In addition to cardio-vascular diseases, leading in terms of frequency (incidence and prevalence) the rise in their frequency can be observed throughout Georgia (Fig. 3.2).

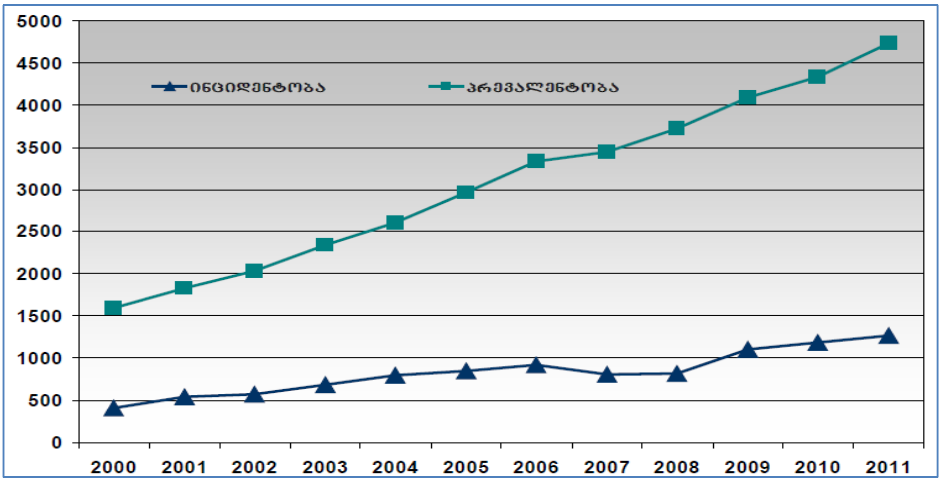
[49] Incidence – initial morbidity; prevalence – overall morbidity;

[50]Healthcare. Statistical directory, 2010.



/Rectangle line – prevalence
Triangle Line – incidence/
Fig. 3.2 Trend of the prevalence of cardio-vascular diseases, Georgia, 2000-2010

The same can be said about arterial hypertension as well (Fig. 3.3) which is half of the cardio-vascular disease cases and which is a leading cause of morbidity and mortality in Georgia. Hypertension prevalence indicator increased by 9.2% in 2011 as compared to 2010, while the incidence indicator increased by 7.2%.



/line of rectangles – prevalence
Line of triangles – incidence/
Fig. 3.3. The trend of the prevalence of arterial hypertension, Georgia, 2000-2010

A fairly close correlation is identified between the climate change and cardio-vascular diseases. According to the same WHO, on the basis of the international data[51] climate has direct and indirect impact on the functioning of the cardio-vascular system. According to the USA National Institute of Environmental Health Sciences and the Center for Disease Control (CDC) the cases of referrals of patients with heart diseases at outpatient and in-patient facilities increases during extremely hot and cold weather. According to the WHO data there is direct correlation between high and low temperatures and heartbeat and the blood pressure. Similarly, extreme heat causes the aggravation of pathological process among the patients with chronic cardio-vascular diseases. The number of referrals by patients suffering from climate-associated hypertension is especially

[51] A Human Health Perspective on Climate Change; A Report Outlining the Research Needs on the Human Health Effects of Climate Change; April 22, 2010; www. niehs.nih.gov/climate report

frequent among elderly: with the temperature change blood vessels expand and narrow, which in turn, becomes the reason for the change of arterial tension. And among elderly, adaptive capacity of whose body is relatively deteriorated, the process of tension regulation is complicated, and it contributes to the development of hypertension.

According to the IPCC Third Assessment Report the frequency of cardio-vascular diseases and the mortality indicator is highly dependent on the intensity and duration of heat waves.

The content of ozone and solid weighed particles in the atmosphere increases with the rise of air temperature and it has negative effect on the functioning of cardio-vascular, as well as respiratory systems. Such negative change of atmospheric air increases the load on heart functioning, further, the turnover of gases in lungs becomes more complicated, which can be considered as the mechanism activating the development of various pathologies.[52] Furthermore, the increase of concentration of solid weighed particles significantly increases the number of hospital referral and mortality caused by cardio-vascular diseases[53].

Thus, it can be said that in the region where climate change, specifically, temperature rise, is pronounced, the rise in the number of cardio-vascular diseases is not surprising, and is to be expected in the future.

Cardio-vascular diseases prevalence indicator in Kakheti. There is the highest indicator of cardio-vascular diseases in the Kakheti region, as compared to other regions of Georgia.

According to 2010-2011 data[54] Kakheti falls among top three regions in terms of the prevalence of cardio-vascular diseases (prevalence per 100 000 residents), due to the arterial hypertension (Tables 3.2.1 and 3.2.2). As for the lethal outcome caused by the cardio-vascular diseases in Kakheti there is a significantly higher indicator in the Kakheti region than in Tbilisi[55] (For Kakheti – 11.3, for Tbilisi – 5.2).

Table 3.2.1. Three most prevalent diseases in Georgia, 2010

	Disease	Prevalence
1	Hypertensive disease	4 335.9
2	Some conditions developed during the perinatal period	3 533.8
3	Ischemic heart disease	1 993.7

Table 3.2.2 Three most prevalent diseases in Georgia, 2011

	Disease	Prevalence
1	Acute respiratory infections of the upper respiratory system	7 600.2
2	Hypertensive disease	5 710.9
3	Some conditions developed during the perinatal period	3 428.8

[52] Gong H, et al., American Journal of Respiratory and Critical Care Medicine; 1998. p.920-927
[53] Pope, cA, et al. Journal of the Air and Waste Management Association, 2006, p. 709-742.
[54] Healthcare, Statistical Reference Book, 2010 and 2011.
[55]For Kakheti – 11.3, for Tbilisi – 5.2.

In addition to the high indicator of cardio-vascular diseases in Kakheti, the trend of the increase of prevalence can be observed as well (Fig. 3.4).

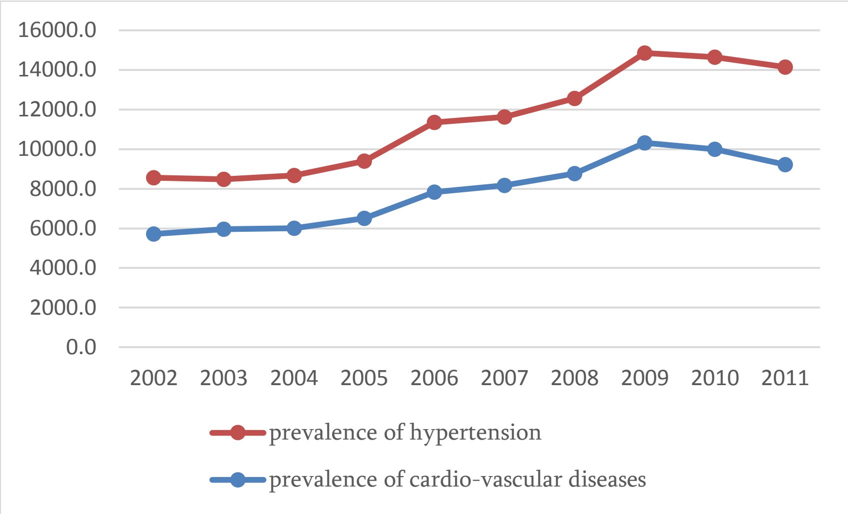


Fig. 3.4. The dynamics of prevalence of Cardio-vascular diseases and arterial hypertension; Kakheti, 2002-2011

The rising trend of cardio-vascular disease prevalence may be sustained, and climate change, specifically, the rise in air temperature, intensification of heat waves, and fall of precipitation may contribute to this rise.

The correlation of cardio-vascular diseases with climate change in the Kakheti region. The trend of the rise of average as well as extreme temperature in the Kakheti region is clear. For showcasing the correlation between cardio-vascular diseases and the climate change two 5-year periods, 2001-2005 and 2006-2010 were compared and the trend was assessed (the difference between the periods is expressed in percentages). Three municipalities of Kakheti were taken for comparison: Telavi, which is a regional center of Kakheti and where the highest indicators of cardio-vascular diseases and hypertension are observed; Kvareli, which is also distinguished by fairly high indicator of cardio-vascular diseases and Dedoplistskaro, where climate change (the change of average annual temperature and the number of hot days) is relatively more pronounced as compared to other municipalities (see Table 3.2.3).

Table 3.2.3. The change of arterial hypertension and climate parameters during the period of 2001-2010 in three municipalities of Kakheti

Municipality	Rise in arterial hypertension cases (%)	Average annual temperature increase (° C)	SU25 (increase of days/y)	SU30 (increase of days/y)
Telavi	188	0.3	6	21
Kvareli	173	0.5	5	33
Dedoplistskaro	15	0.6	28	57

Average annual temperature and the number of extremely hot days are taken from climate parameters: the number of days when maximum daily temperature exceeds 25⁰C and 30⁰C. As can be seen from the Table sharp rise in the frequency of arterial hypertension can be observed at all three examined municipalities. While from the climate parameters, the sharpest change is observed in the Dedoplistskaro District. Since Dedoplistskaro is the municipality susceptible to droughts, it is expected that the same trend will be sustained (sub-chapter: future analysis) and it may result in further increase in the frequency of cardio-vascular, as well as respiratory system diseases, for this group of the diseases is highly sensitive to high temperature and low humidity (see sub-chapter "The prevalence of cardio-vascular diseases in Georgia and correlation with climate change").

For better illustration, we have compared the number of myocardium infraction and extremely hot days by years in Kvareli (because in this municipality there is the highest indicator of cardio-vascular diseases among Kakheti municipalities) (Fig. 3.5).

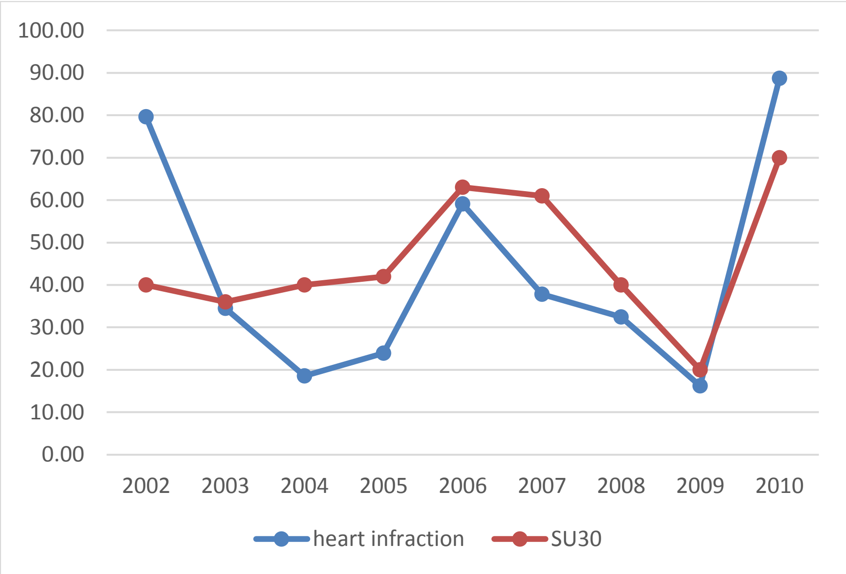


Fig. 3.5. The correlation between myocardium infraction and hot days (SU30). Kvareli, 2002-2010

As can be seen from the chart there is certain positive correlation between myocardium infraction and the number of hot days with the temperature above 30 ⁰C. Correlation ratio between the reviewed two variables equaled 0.62.

Assessment of the potential of the healthcare system

From April 1, 2013 the universal healthcare state program was launched in Kakheti, as well as throughout Georgia; this system is aimed at the provision of free of charge primary healthcare and emergency assistance to the entire population of Georgia. There are 122 rural outpatient facilities in Kakheti. In 2011, Kakheti ranks fourth with 1.3% according to the referrals per capita among the regions of Georgia and this is the lowest indicator for the past 6 years. Primary healthcare[56] infrastructure is not organized, large number of these organizations do not meet international standards[57].

[56]Primary healthcare sector
[57]Information provided during the working meetings

In the primary healthcare sector, there is 1 physician per 1 000 persons In Kakheti, which is a fairly high indicator. At the same time, there is the lack of mid-level medical personnel (there are 0.9 nurses per physician). The indicator of training of physicians is average: 198 primary healthcare physicians and 209 nurses were retrained as family doctors, which represents 49% of the entire medical personnel of Kakheti. There are well-renovated and adequately equipped in-patient facilities in all municipalities. According to the data of the Ministry of Labor, Health and Social Protection of Georgia the indicator of availability of beds per 100 000 residents at in-patient facilities in Kakheti is 95.4, which is the lowest indicator after the Mtskheta-Mtianeti, throughout Georgia[58].

According to the research performed by IOM and USAID during February-June, 2011 there is the lack of specialist physicians at in-patient sector in Kakheti. This problem requires complex approach and the higher educational institutions have to be actively involved in addressing this problem, along with the Ministries of Health and Education[59]. According to Geostat data, emergency medical assistance was provided to 56 3 177 persons in 2012 in Kakheti; this is a fairly high indicator (falls behind Imereti, Kvemo Kartli, Shida Kartli and Ajara), which, in the first place, is a result of the increase of the quality of emergency medical services and the effective state program.

Other problems prevalent in the healthcare sector are as follows: low remuneration for the physicians in the in-patient sector, delayed payment of salaries, high level of self-treatment and self-medication of residents.

Analysis of Future

According to the forecast data it is expected that the average annual air temperature will increase by 1 °C during 2021-2050 as compared to 1986-2010 in Dedoplistskaro, while in other municipalities estimated increase is slightly higher and it equals 1.1-1.2 °C. The number of hot days (SU25 number) over a 30 year period is expected to increase most drastically in Sagarejo district, by 1 107, while in Dedoplistskaro district the expected increase is 937.

The change of climate parameters in the future may cause the increase or fall of the number of climate-dependent diseases. So, for example, the rise in the number of hot days in Sagarejo district may cause the increase in the frequency of cardio-vascular diseases. It is impossible to calculate exact percentage rise in the incidence and prevalence in various municipalities although it can be said with certainty that if no preventive actions are taken it is expected that the frequency of climate-dependent diseases, particularly, cardio-vascular pathologies, will increase.

Such factors as age structure of the population of the municipality, condition of medical infrastructure, employment indicator, etc. have to be considered for making accurate forecast. For making a future forecast, it is also necessary to take into consideration the factor of medical personnel and the state of infrastructure. As it is known, Kakheti experiences the lack of specialists in the in-patient sector, which may have a very negative effect on the management of such climate-dependent diseases as cardio-vascular pathologies.

[58]Statistics of the Ministry of Labor, Health and Social Protection, National Center for Disease Control and Public Health, 2011
[59]Kakheti Region Development Strategy

Further, it is equally important to strengthen in the future monitoring and preventive activities of such infectious pathologies as malaria. This antrhopozoonotic disease had been recorded in the borderline area of Kakheti over years, although due to the preventive activities taken by the public health authorities not a single case has been detected over the past three years. Although, given the above-mentioned climate change (high temperature and humidity) favorable environment may be created for the spread of malaria and unless monitoring and preventive activities are strengthened, it is expected that there will be new advance of this infectious pathology.

Based on the future TCI indicators (2071—2100) a number of changes have been identified that may appear unfavorable for tourism development and in general, may be less comfortable for health. So, for example, in the Telavi municipality TCI indicator is expected to worsen drastically during the summer months: in July climate becomes “Unfavorable”, in other months it is expected to be “Acceptable” and even “Good”, although still sharp worsening can be observed compared to the current situation. The same can be said about Sagarejo where in July TCI indicator is minimal – “Unfavorable”. In other months, too, the index is expected to worsen as compared to the present. In Dedoplistskaro this indicator decreases compared to the current value, although “Unfavorable” value is still not observed in summer months: TCI is acceptable and average. Index value is expected to further fall in the Kvareli municipality where unfavorable climate is expected in July and August.

Based on these data it can be said that TCI indicator throughout the Kakheti region is worsening in the future; and this will be unfavorable for the development of the tourism sector of the region and in general, for human health. Such change of climate may cause the worsening of health condition and increase the incidence of a number of diseases. Among them, cardio-vascular diseases, the incidence and prevalence of which is high in the region, and that are highly sensitive to climate change (especially towards air temperature change).

Using the multi-criteria analysis method[60] overall vulnerability of the healthcare sector to the climate change for all eight municipalities on the Kakheti region territory was assessed under the project. A total of 25 indicators were assessed (please refer to the list of parameters and their description in Annex 6). Vulnerability was assessed in three directions: the impact of climate change on the healthcare sector, the sensitivity of the healthcare sector to changes and the adaptive capacity of the residents of the municipality to current and future climate changes. Climate change parameters were taken for two 25-year periods: 1961-1985 and 1986-2010, as provided in the climate scenarios chapter. Observation results of eight meteorological stations (Annex 1, Table 1.1) and the tourism comfort index (TCI, Tables 3.2 and 3.3) calculated based on those results were used. The used meteorological stations more or less well reflect the relevant climate zones. As is mentioned in the climate chapter (1.2.7) Sighnagi municipality described using the Tsnori meteorological station data.

[60]A version of this method adapted for agriculture was provided by the EU project implemented by the Caucasus Environmental Regional Center (REC Caucasus). Identification and Implementation of Adaptation Response to Climate Change Impact for Conservation and Sustainable Use of Agro-Biodiversity in Arid and Semi-Arid Ecosystems of South Caucasus http://www.rec-caucasus.org/projects.php?lang=en. The model was adapted for the healthcare sector in the course of the preparation of the Third National Communication of Georgia about Climate change.

Kvareli and Telavi are the municipalities that are most vulnerable to climate change in the current period. In case of Kvareli, high vulnerability is due to high sensitivity of the healthcare sector to current changes, and in Telavi special contribution of any component is not well defined (See, Figure 3.6 and Table 3.2.4).

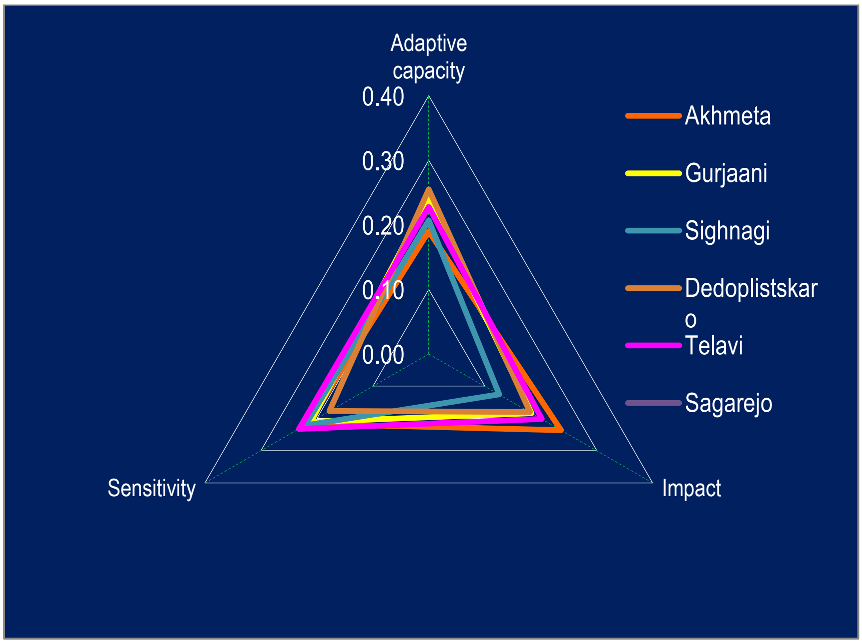


Fig. 3.6 Vulnerability indicators in the healthcare sector identified through the multi-criteria analysis

Furthermore, using the multi-criteria analysis method future vulnerability of the Kakheti healthcare sector was assessed. Climate parameters and TCI forecast values were used for the assessment of future condition. Consequently, it was established that in the future along with Kvareli Telavi is the most vulnerable that is mainly associated with the risks caused by climate change. And Akhmeta will become less vulnerable in the future because the negative impact of climate on this territory is expected to be reduced (Fig. 3.7).

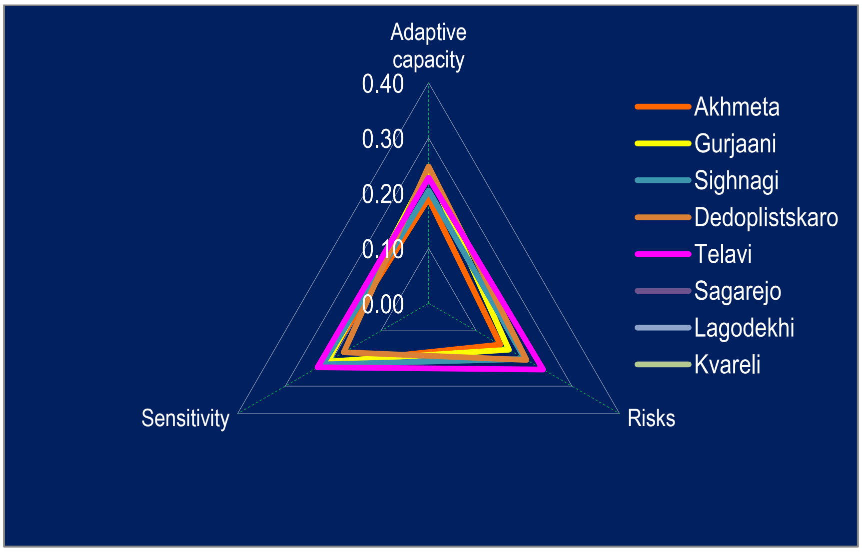


Fig. 3.7. Vulnerability indicators in the healthcare sector identified through the multi-criteria analysis

For obviousness, the same figures are provided in the form of the Table 3.2.4.

Table 3.2.4. Adaptive capacity of municipalities and the risks assessed using the multi-criteria analysis method (healthcare sector)

Municipality	Adaptive capacity	Sector sensitivity	Risks during the periods of 1961-1985 and 1986-2010	Total	Adaptive capacity	Sector sensitivity	Risks 2071-2100	Total
Akhmeta	0.19	0.22	0.24	0.64	0.19	0.22	0.19	0.56
Gurjaani	0.24	0.21	0.18	0.64	0.24	0.21	0.17	0.62
Dedoplistskaro	0.25	0.18	0.18	0.61	0.25	0.18	0.20	0.63
Telavi	0.23	0.23	0.20	0.66	0.23	0.23	0.24	0.70
Lagodekhi	0.21	0.19	0.13	0.53	0.20	0.19	0.20	0.59
Sagarejo	0.24	0.18	0.20	0.63	0.24	0.18	0.22	0.64
Sighnaghi	0.21	0.22	0.13	0.55	0.20	0.22	0.20	0.63
Kvareli	0.21	0.30	0.21	0.71	0.20	0.30	0.20	0.70

It has been established as a result of the assessments that climate change (using the above-mentioned three parameters) currently is most prominent in the Akhmeta, Telavi and Kvareli municipalities, and least prominent -- in the Lagodekhi and Sighnagi municipalities.

Recommendations

It is desirable to perform the following activities in order to reduce the vulnerability of the healthcare sector to climate change in the Kakheti region:

- Undertake a more detailed study of the impact of climate change on the spread of climate-dependent diseases in the region, and the following activities have to be performed to this effect:
    - the study of the concentration of particular matter in air and its correlation to cardio-vascular and respiratory system diseases;
    - The assessment of the impact of climate change on the spread of infectious diseases in the region and the analysis of future in relation to malaria.
- Prepare and implement pilot projects in the most vulnerable municipalities. Pilot projects should be directed to the prevention of cardio-vascular diseases (training of medical personnel, mobilization of primary healthcare sector, for example, the representatives of emergency medical service during the heat waves period);
- Determine the needs of the in-patient sector, as of the weakest element, in conjunction with the management of climate-dependent diseases (provide trainings and facilitate the provision of the equipment necessary for treatment);
- Support the development of the tourism sector via establishing comfortable, healthy environment for the holidaymakers: provision of medical personnel (trained medical personnel, including the representatives of emergency medical service) at recreational complexes (e.g., Lopota, Kvareli Lake) who will take care of the health of the holidaymakers during the heat wave period.
- Support raising the awareness about climate change and climate-dependent diseases among the representatives of healthcare and tourism sector of the Kakheti region as well as among the population.

Annexes

Annex 1. Changes of climate parameters and Aridity index of the territory

Table 1.1. Changes in climate indexes between the periods of 1986-2010 (III) and 1961-1985 (II) according to the data provided by 8 meteo stations in Kakheti

Station \ Parameter	Winter						Spring						Summer						Autumn						Year					
	T,^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T,^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T,^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T,^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T,^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day
Akhmeta	0.5	7	26	–	–	–	0.3	-4	-24	39	–	–	1.0	-18	–	236	198	–	0.4	6	9	119	15	-1	0.6	-5	-55	394	213	-1
Gurjaani	0.2	9	111	–	–	–	0.0	3	4	-4	–	1	0.6	-20	–	117	87	-1	0.4	11	30	89	7	–	0.3	-2	79	202	94	0
Dedoplistskaro	0.5	9	20	–	–	–	0.1	10	-52	41	–	1	1.4	-22	–	272	112	-1	0.8	20	-4	146	4	–	0.7	±0	-122	459	116	0
Telavi	0.3	5	75	–	–	–	0.1	2	-15	27	–	–	0.8	-17	–	172	121	-1	0.3	13	31	111	11	1	0.4	-3	19	310	132	0
Lagodekhi	0.4	13	-107	–	–	–	-0.1	11	-43	-46	2	–	0.6	7	–	32	379	-3	0.4	6	-27	53	39	–	0.4	8	-246	39	420	-3
Sagarejo	0.4	-9	-12	–	–	–	0.3	-8	-36	12	–	1	0.8	-25	–	142	111	–	0.5	9	11	46	10	–	0.5	-10	-117	200	121	1
Kvareli	0.5	7	-28	–	–	–	0.2	-3	-14	42	1	–	0.8	-7	–	138	145	-2	0.5	4	0	104	17	–	0.5	-2	-105	284	163	-2
Tsnori	0.7	14	-7	–	–	–	-0.2	±0	-5	5	–	–	0.6	-15	–	94	163	–	0.7	12	-76	134	8	–	0.5	±0	-165	233	171	–
Average	0.4	7					0.2	1					0.8	-15					0.5	10					0.5	-2				

Table 1.2 Changes in climate indexes between the periods of 2021-2050 (III) and 1986-2010 (II) according to the data provided by 8 meteo stations in Kakheti

Station \ Parameter	Winter						Spring						Summer						Autumn						Year					
	T, ^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T, ^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T, ^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T, ^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day	T, ^{0}C	P,%	FD0, day	SU25, day	TR20, day	R90, day
Akhmeta	1.1	31	-230	-	-	-	1	-13	54.5	296	9	0	0.9	7	0	306	628	-	1.2	11	18	230	85	0.9	1.1	11	-139	832	722	0.9
Gurjaani	1.3	32	208	-	-	-	1.3	-20	48.5	332	21	-1	1.3	14	0	376	744.5	-	1.3	0	18	281	131	0	1.2	0	-127	991.5	896	-1
Dedoplistkaro	1.1	16	182	-	-	-	1.2	-25	136.5	292	0	-1	0.7	14	0	402	444	-	1	-4	12	234	7	0	1	-4	346	937	451	-1
Telavi	1.3	43	-258	-	-	-	1.2	-14	29	304	9	0	1.1	6	0	328	628	-	1.3	-5	24	244	83.5	0	1.2	-5	-202	875.5	721	-1
Lagodekhi	1.2	28	-16	-	-	-	1.2	-22	81	352	27.5	0	1.2	-16	0	391	475	-1	1.4	5	55	328	96	0	1.2	-6	144	1068	598	2
Sagarejo	1.1	44	2	-	-	-	1	-10	122	328	0	-1	1.2	14	0	467	604.5	0	1.2	5	-8	312	32	3	1.1	8	134	1106	640	2
Kverali	1.1	39	-161	-	-	-	1.1	-11	61.5	254	6	0	1.1	-6	0	356	642	-1	1.1	3	30	292	70	0.9	1.1	1	-55	904	716	-0.1
Tsnori	0.9	6	88	-	-	-	1.4	-24	67	390	15	0	1.3	9	0	392	710	0	1.3	2	16	298	69.5	0	1.2	-5	178	1070	794	0
Average	1.1	+22					1.2	-17					1.1	+5					1.2	+2					1.1	0				

Symbols and explanations:

T – average seasonal/annual air temperature, ^{0}C
FD0 – average number of seasonal/annual days during the period, when the daily temperature comprises minimum Tmin<0^{0}C
ID0 – average of seasonal/annual days during the period, when the daily minimum temperature comprises Tmax<0^{0}C
SU25 – average of seasonal/annual days during the period, when the daily temperature comprises Tmax>25^{0}C
SU30 – average of seasonal/annual days during the period, when the daily minimum temperature comprises Tmax>30^{0}C
TR20 – average of seasonal/annual days during the period when the daily minimum comprises Tmin>20^{0}C
P – average sums of seasonal/annual precipitation (change, %)
Rx1day – maximum of daily precipitation, mm
Rx5day – maximum of precipitation fallen on 5 consequent days, mm
R50 – average of sesonal/annual days with heavy precipitation (≥50mm) during the period
R90 – amount of days with anomalous heavy precipitation (≥90mm) during the period
CDD- average of consequent dry days
CWD – average days of consequent precipitation
0 – unchanged value
(-) – not fixed

Table 1.3. reference evapotranspiration and meanings of aridity index and changes among the periods 1986-2010 (II) and 1961-1985 (I), 2070-2099 (III) and 1986-2010 (II) as per data of 8 municipalities of Kakheti

Parameter	Season / Period	Winter	Spring	Summer	Autumn	Year
1. Akhmeta						
Reference evapotranspiration, mm/day*	1961-1985	0.96	2.88	4.83	2.09	2.69
	1986-2010	0.77	2.76	4.44	1.80	2.44
	2070-2099	1.17	2.84	4.48	2.00	2.63
	Difference (II-I)	-0.19**	-0.12	-0.39	-0.29	-0.25
	Difference (III -II)	0.40	0.08	0.04	0.20	0.19
Aridity index***	1961-1985	1.13	0.91	0.59	0.88	0.78
	1986-2010	1.51	0.91	0.52	1.08	0.81
	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	0.38	0.00	-0.07	0.20	0.03
	Difference (III -II)	-0.65	-0.27	-0.04	-0.16	-0.16
2. Gurjaani						
Reference evapotranspiration mm/day	1961-1985	0.60	2.54	4.32	1.64	2.27
	1986-2010	0.57	2.59	4.22	1.56	2.24
	2070-2099	0.78	2.32	3.90	1.46	2.12
	Difference (II-I)	-0.03	0.05	-0.10	-0.07	-0.04
	Difference (III -II)	0.20	-0.27	-0.32	-0.11	-0.12
Aridity index	1961-1985	1.82	1.08	0.65	1.22	0.95
	1986-2010	2.07	1.10	0.53	1.41	0.95
	2070-2099	0.86	0.64	0.48	0.92	0.65

* For each period its median value is taken
** Grey background indicate the changes where sustainable trends have been revealed
*** Aridity index represents ratio between the average daily precipitation and reference evapotranspiration

	Difference (II-I)	0.24	0.02	-0.12	0.19	-0.01
	Difference (III -II)	-1.21	-0.46	-0.05	-0.49	-0.29
3. Dedoplistkaro						
Reference evapotranspiration, mm/day	1961-1985	0.66	2.44	4.22	1.63	2.24
	1986-2010	0.63	2.42	4.20	1.59	2.21
	2070-2099	0.76	1.92	3.95	1.51	2.04
	Difference (II-I)	-0.03	-0.02	-0.02	-0.04	-0.03
	Difference (III -II)	0.13	-0.50	-0.25	-0.09	-0.17
Aridity index	1961-1985	1.29	0.86	0.55	0.86	0.74
	1986-2010	1.48	0.95	0.43	1.05	0.76
	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	0.18	0.09	-0.12	0.19	0.01
	Difference (III -II)	-0.62	-0.31	0.05	-0.14	-0.10
4. Telavi						
Reference evapotranspiration, mm/day	1961-1985	0.74	2.66	4.45	1.81	2.42
	1986-2010	0.63	2.53	4.25	1.62	2.26
	2070-2099	0.96	2.83	4.23	1.78	2.46
	Difference (II-I)	-0.11	-0.13	-0.21	-0.19	-0.16
	Difference (III -II)	0.33	0.30	-0.01	0.16	0.20
Aridity index	1961-1985	1.33	1.00	0.69	0.99	0.88
	1986-2010	1.65	1.08	0.60	1.25	0.92
	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	0.32	0.08	-0.09	0.25	0.04
	Difference (III -II)	-0.79	-0.44	-0.11	-0.33	-0.27
5. Lagodekhi						
Reference evapotranspiration, mm/day	1961-1985	0.52	2.46	4.21	1.53	2.18
	1986-2010	0.50	2.48	4.12	1.49	2.15

	2070-2099	0.76	2.53	4.05	1.47	2.21
	Difference (II-I)	-0.02	0.02	-0.09	-0.04	-0.03
	Difference (III -II)	0.27	0.05	-0.07	-0.02	0.06
Aridity index	1961-1985	2.66	1.33	0.77	1.85	1.23
	1986-2010	3.13	1.46	0.84	2.01	1.35
	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	0.47	0.13	0.07	0.16	0.12
	Difference (III -II)	-2.27	-0.82	-0.36	-1.09	-0.70
6. **Sagarejo**						
Reference evapotranspiration, mm/day	1961-1985	0.84	2.65	4.39	1.86	2.44
	1986-2010	0.77	2.66	4.19	1.73	2.34
	2070-2099	0.94	2.06	3.86	1.70	2.15
	Difference (II-I)	-0.07	0.00	-0.20	-0.14	-0.10
	Difference (III -II)	0.17	-0.60	-0.33	-0.03	-0.19
Aridity index	1961-1985	1.37	1.09	0.66	1.04	0.91
	1986-2010	1.36	1.00	0.52	1.21	0.85
	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	-0.01	-0.08	-0.14	0.18	-0.06
	Difference (III -II)	-0.50	-0.36	-0.03	-0.30	-0.20
7. **Kvareli**						
Reference evapotranspiration, mm/day	1961-1985	0.59	2.53	4.30	1.64	2.27
	1986-2010	0.55	2.48	4.09	1.53	2.16
	2070-2099	0.88	3.09	3.99	1.55	2.38
	Difference (II-I)	-0.04	-0.05	-0.21	-0.11	-0.10
	Difference (III -II)	0.33	0.61	-0.11	0.02	0.21
Aridity index	1961-1985	2.28	1.32	0.79	1.59	1.18
	1986-2010	2.64	1.30	0.77	1.77	1.21

	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	0.36	-0.02	-0.02	0.18	0.03
	Difference (III -II)	-1.78	-0.66	-0.29	-0.85	-0.56
8. Tsnori						
Reference evapotranspiration, mm/day	1961-1985	0.52	2.54	4.32	1.56	2.24
	1986-2010	0.63	2.70	4.47	1.69	2.38
	2070-2099	0.68	2.09	4.09	1.38	2.07
	Difference (II-I)	0.12	0.16	0.15	0.13	0.14
	Difference (III -II)	0.05	-0.61	-0.39	-0.31	-0.31
Aridity index	1961-1985	1.69	0.86	0.48	0.93	0.73
	1986-2010	1.57	0.80	0.39	0.96	0.69
	2070-2099	0.86	0.64	0.48	0.92	0.65
	Difference (II-I)	-0.12	-0.06	-0.09	0.03	-0.05
	Difference (III -II)	-0.72	-0.16	0.09	-0.04	-0.03

Table 1.4. Limites of the aridity index[61]

Super-arid	Hyper-arid	Arid	Semi-arid	Semi-damp	Damp	Hyper-damp	Super-damp
<0.03	0.03-0.08	0.08-0.20	0.20-0.50	0.5-1.33	1.33-2.67	2.67-5.33	>5.33

[61] http://www.fao.org/docrep/t0122e/t0122e03.htm#3. arid zone climate

Table 1.5 Changes in agro-climatic parameters between the period of 1961-1985 and 1986-2010 according to the municipalities and priority crops

Municipality	Leading field (branch)	Hot days during the year (SU 30)	Precipitation during the vegetation period (%)	Vegetation period (day) and sum of active temperatures (^{0}C)	Number of days without frost (day)	Draughts (severe and extreme) (amount of cases)	Priority culture and limit temperature (^{0}C)
Akhmeta	Animal husbendry	+16	-8	+5 190	-4	+9	maize (8 ^{0}C)
Gurjaani	Wine-growing	+9	-6	+2 103	-7	+9	Peach and grapes (12 ^{0}C)
Dedoplistkaro	Crop breeding	+17	0	+3 213	-2	+11	Wheat (5 ^{0}C)
Telavi	Wine-growing	+12	-9	+2 115	-9	+5	Grapes and rose (12 ^{0}C)
Lagodekhi	Gardening (Vegetable-gardening, water-melon, melon and gourd growing)	+3	+9	+4 107	+8	-9	Water melon (10^{0}C)
Sagarejo	Cattle breeding	+3	0	+7 186	-5	+14	Ionja and oats (0^{0}C)
Sighnaghi	Plant-growing	+10	-4	+5 126	+2	+9	wheat (5 ^{0}C)
Kvareli	Wine-growing	+12	-1	+5 169	0	+8	grapes (12 ^{0}C)

Annex 2. Changes in vegetation period of agricultural crops

Beginning of vegetation +5 ^{0}C (wheat, current)

Municipalities	Duration of vegetation day			Sum of the active temperatures (^{0}C)			Number of days without frost (day)			Precipitation (mm)		
	1961-1985	1986-2010	Δ[62]	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	274	284	+10	4345	4538	+193	245	241	-4	654	620	-5
Gurjaani	277	279	+2	4505	4597	+92	247	240	-7	678	661	-2
Dedoplistkaro	249	252	+3	3805	4018	+213	223	221	-2	486	486	0
Telavi	270	269	-1	4291	4389	+99	243	234	-9	670	647	-4
Lagodekhi	278	283	+4	4638	4744	+106	246	254	8	848	916	+8
Sagarejo	260	261	+1	3962	4091	+129	231	226	-5	665	593	+11
Sighnaghi	274	279	+4	4609	4736	+126	226	228	2	519	497	-4
Kvareli	276	279	+3	4495	4630	+135	240	240	0	841	820	-2

Beginning of vegetation +5 ^{0}C (wheat, future)

Municipalities	Duration of vegetation (day)			Sum of the active temperatures			Number of days without frost (day)			Precipitation (mm)		
	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ %
Akhmeta	284	270	-14	4538	4718	+180	241	235	-6	620	620	+0
Gurjaani	279	281	+2	4505	4939	+342	240	243	+3	661	645	-3
Dedopliskaro	252	270	+18	4018	4431	+413	221	224	+3	486	485	-0
Telavi	269	268	-1	4389	4669	+279	234	235	+1	647	622	-4
Lagodekhi	283	276	-7	4744	5008	+264	254	246	-8	916	807	-12
Sagarejo	261	274	+13	4091	4492	+401	226	237	+11	593	637	+8
Sighnaghi	279	343	+65	4736	7248	2512	228	185	-41	497	545	+10
Kvareli	279	266	-13	4630	4801	+171	240	241	+1	820	774	-6

Beginning of vegetation +8 ^{0}C (current)

Municipalities	Duration of vegetation day			Sum of the active temperatures (^{0}C)			Number of days without frost (day)			Precipitation (mm)		
	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	235	240	+5	4082	4272	+190	245	241	-4	599	552	-8
Gurjaani	238	238	+0	4241	4319	+78	247	240	-7	615	582	-5
Dedoplistskaro	210	216	+6	3554	3786	+232	223	221	-2	442	436	-1
Telavi	232	232	-0	4039	4135	+96	243	234	-9	616	586	-5
Lagodekhi	244	242	-1	4412	4475	+63	246	254	8	771	831	+8
Sagarejo	224	222	-2	3724	3838	+113	231	226	-5	602	528	-12
Sighnaghi	235	240	+5	4356	4488	+131	226	228	2	467	452	-3
Kvareli	240	238	-1	4250	4340	+89	240	240	0	759	733	-3

Beginning of vegetation +8 ^{0}C (future)

[62] Difference between these 2 periods.

Municipalities	Duration of vegetation (day)			Sum of the active temperatures			Number of days without frost (day)			Precipitation (mm)		
	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ %
Akhmeta	240	238	-2	4272	4507	+235	241	235	-6	552	576	+4
Gurjaani	238	240	+2	4319	4678	+359	240	243	+3	582	593	+2
Dedoplistkaro	216	232	+16	3786	4185	+399	221	224	+3	436	433	-1
Telavi	232	238	+6	4135	4482	+347	234	235	+1	586	592	+1
Lagodekhi	242	241	-1	4475	4779	+304	254	246	-8	831	746	-10
Sagarejo	222	231	+9	3838	4215	+377	226	237	+11	528	576	+9
Sighnaghi	240	289	+49	4488	6714	2227	228	185	-41	452	483	+6
Kvareli	238	237	-1	4340	4619	+280	240	241	+1	733	715	-2

Beginning of vegetation +10 ^{0}C (current)

Municipalities	Duration of vegetation day			Sum of the active temperatures (^{0}C)			Number of days without frost (day)			Precipitation (mm)		
	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	212	216	+4	3878	4058	+180	245	241	-4	560	507	-10
Gurjaani	217	219	+2	4056	4153	+97	247	240	-7	570	553	-3
Dedoplistksaro	190	193	+3	3372	3579	+207	223	221	-2	400	379	-5
Telavi	208	211	+3	3822	3946	+123	243	234	-9	573	545	-5
Lagodekhi	219	223	+4	4192	4298	+106	246	254	8	717	782	+9
Sagarejo	194	201	+7	3460	3646	+186	231	226	-5	541	474	-13
Sighnaghi	215	219	+4	4180	4297	+118	226	228	2	438	416	-5
Kvareli	215	220	+5	4034	4187	+152	240	240	0	706	696	-2

Beginning of vegetation +10 ^{0}C (future)

Municipalities	Duration of vegetation (day)			Sum of the active temperatures			Number of days without frost (day)			Precipitation (mm)		
	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ %
Akhmeta	216	220	+4	4058	4351	+293	241	235	-6	507	546	+8
Gurjaani	219	222	+3	4153	4513	+360	240	243	+3	553	563	+2
Dedoplistkaro	193	210	+17	3579	3986	+407	221	224	+3	379	396	+5
Telavi	211	219	+8	3946	4315	+370	234	235	+1	545	565	+4
Lagodekhi	223	223	+0	4298	4616	+318	254	246	-8	782	710	-9
Sagarejo	201	213	+12	3646	4049	+404	226	237	+11	474	533	+13
Sighnaghi	219	264	+45	4297	6484	+2187	228	185	-41	416	454	+9
Kvareli	220	220	0	4187	4468	+280	240	241	+1	696	674	-3

Beginning of vegetation +12 ^{0}C (current)

Municipalities	Duration of	Sum of the active	Number of days	Precipitation (mm)

	vegetation day			temperatures (^{0}C)			without frost (day)					
	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	188	196	+8	3612	3827	+215	245	241	-4	506	463	-8
Gurjaani	192	194	+3	3780	3883	+103	247	240	-7	513	482	-6
Dedoplistskaro	171	172	+1	3156	3341	372	223	221	-2	360	335	-7
Telavi	187	189	+2	3586	3701	+115	243	234	-9	529	483	-9
Lagodekhi	197	199	+2	3952	4042	+89	246	254	8	646	710	+10
Sagarejo	175	178	+3	3253	3396	+144	231	226	-5	490	404	-17
Sighnaghi	197	198	+1	3978	4061	+83	226	228	2	402	379	-6
Kvareli	192	197	+6	3775	3944	+169	240	240	0	637	631	-1

Beginning of vegetation +12 ^{0}C (future)

Municipalities	Duration of vegetation (day)			Sum of the active temperatures			Number of days without frost (day)			Precipitation (mm)		
	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ %
Akhmeta	196	205	+10	3827	4191	+364	241	235	-6	463	511	+10
Gurjaani	194	207	+13	3883	4347	+464	240	243	+3	482	519	+8
Dedoplistskaro	172	185	+14	3341	3712	+372	221	224	+3	335	355	+6
Telavi	189	202	+13	3701	4129	+428	234	235	+1	483	535	+11
Lagodekhi	199	210	+11	4042	4473	+432	254	246	-8	710	654	-8
Sagarejo	178	190	+12	3396	3802	+405	226	237	+11	404	484	+20
Sighnaghi	198	243	+45	4061	6255	+2194	228	185	-41	379	435	+15
Kvareli	197	206	+9	3944	4326	+382	240	241	+1	631	424	-7

Beginning of vegetation +13 ^{0}C (current)

Municipalities	Duration of vegetation day			Sum of the active temperatures (^{0}C)			Number of days without frost (day)			Precipitation (mm)		
	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	179	183	+4	3500	3671	+171	245	241	-4	489	429	-12
Gurjaani	182	184	+2	3650	3753	+103	247	240	-7	497	466	-6
Dedoplistskaro	157	162	+4	2991	3213	+222	223	221	-2	331	311	-6
Telavi	175	176	+1	3436	3537	+101	243	234	-9	504	450	-11
Lagodekhi	188	188	0	3833	3899	+66	246	254	8	617	65	+6
Sagarejo	164	165	+1	3226	3650	+124	231	226	-5	439	364	-17
Sighnaghi	187	187	0	3850	3928	+78	226	228	2	385	355	-8
Kvareli	183	184	+1	3667	3776	+110	240	240	0	586	594	-5

Beginning of vegetation +13 ^{0}C (future)

Municipalities	Duration of vegetation (day)			Sum of the active temperatures			Number of days without frost (day)			Precipitation (mm)		
	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ %

Akhmeta	183	205	+22	3671	4186	+515	241	235	-6	429	509	+17
Gurjaani	184	196	+12	3753	4210	+457	240	243	+3	466	495	+6
Dedoplistkaro	162	177	+16	3213	3613	+400	221	224	+3	311	340	+9
Telavi	176	191	+15	3537	3990	+454	234	235	+1	450	515	+14
Lagodekhi	188	199	+11	3899	4331	+432	254	246	-8	653	616	-6
Sagarejo	165	178	+14	3226	3650	+423	226	237	+11	364	447	+23
Sighnaghi	187	234	+47	3958	6143	2215	228	185	-41	355	420	+18
Kvareli	184	195	+11	3776	4176	+400	240	241	+1	586	594	+1

Beginning of vegetation +15 ^{0}C (current)

Municipalities	Duration of vegetation day			Sum of the active temperatures (^{0}C)			Number of days without frost (day)			Precipitation (mm)		
	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	155	161	+6	3165	3366	+201	245	241	-4	421	375	-11
Gurjaani	161	163	+2	3357	3459	+102	247	240	-7	432	384	-11
Dedoplistkaro	133	139	+6	2649	2901	+251	223	221	-2	272	256	-6
Telavi	153	153	0	3133	3213	+80	243	234	-9	439	379	-14
Lagodekhi	168	168	0	3556	3619	+63	246	254	8	549	575	+5
Sagarejo	136	143	+6	2720	2912	+193	231	226	-5	360	303	-16
Sighnaghi	166	167	+1	3560	3649	+89	226	228	2	341	310	-9
Kvareli	161	162	+1	3356	3468	+112	240	240	0	532	511	-4

Beginning of vegetation +15 ^{0}C (future)

Municipalities	Duration of vegetation (day)			Sum of the active temperatures			Number of days without frost (day)			Precipitation (mm)		
	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ	1986-2010	2020-2050	Δ %
Akhmeta	161	173	+12	3366	3760	+394	241	235	-6	375	440	+17
Gurjaani	163	175	+12	3459	3908	+450	240	243	+3	384	443	+15
Dedoplistkaro	139	154	+14	2901	3273	+372	221	224	+3	256	287	+12
Telavi	153	172	+19	3213	3729	+516	234	235	+1	379	479	+26
Lagodekhi	168	178	+11	3619	4046	+427	254	246	-8	575	552	-4
Sagarejo	143	158	+15	2912	3362	+450	226	237	+11	303	387	+27
Sighnaghi	167	220	+53	3649	5942	2293	228	185	-41	310	390	+26
Kvareli	162	176	+14	3468	3908	+440	240	241	+1	511	534	+5

+20 ^{0}C (period of sugar accumulation in grapes) transition (current)

Municipalities	Duration of vegetation day			Sum of the active temperatures (^{0}C)			Number of days without frost (day)			Precipitation (mm)		
	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ	1961-1985	1986-2010	Δ %
Akhmeta	81	94	+13	1852	2195	+343	245	241	-4	184	193	+5
Gurjaani	92	96	+4	2147	2292	+145	247	240	-7	217	184	-15

Dedoplistkaro	81	108	+17	1395	1835	+439	223	221	-2	81	108	+34
Telavi	78	88	+10	1808	2078	+270	243	234	-9	191	185	-3
Lagodekhi	97	104	+6	2310	2493	+183	246	254	8	272	309	+14
Sagarejo	65	77	+13	1449	1772	+323	231	226	-5	138	127	-8
Sighnaghi	100	108	+7	2387	2603	2734	226	228	2	176	166	-6
Kvareli	90	99	+9	2091	2347	+256	240	240	0	260	265	+2

+20 ^{0}C (sugar accumulation period in grapes) transition (future)

Municipalities	**Duration of vegetation (day)**			**Sum of the active temperatures**			**Number of days without frost (day)**			**Precipitation (mm)**		
	1986-2010	**2020-2050**	**Δ**	**1986-2010**	**2020-2050**	**Δ**	**1986-2010**	**2020-2050**	**Δ**	**1986-2010**	**2020-2050**	**Δ %**
Akhmeta	94	108	+14	2195	2615	+420	241	235	-6	193	249	+28
Gurjaani	96	117	+20	2292	2874	583	240	243	+3	184	268	+45
Dedoplistkaro	62	79	+15	1395	1835	+382	221	224	+3	108	142	+31
Telavi	88	108	+20	2078	2612	+534	234	235	+1	185	317	+72
Lagodekhi	104	124	+20	2493	3075	+581	254	246	-8	309	336	+9
Sagarejo	77	96	+19	1772	2269	498	226	237	+11	127	196	+54
Sighnaghi	108	185	+77	2603	5336	2734	228	185	-41	166	335	+105
Kvareli	99	114	+16	2347	2805	+460	240	241	+1	265	308	+17

Annex 3. Demand on irrigation by different agricultural crops in Kakheti municipalities

Tsnori, autumn wheat

SalSTR/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	445	167	501	33%	2.3	3.8	62%
1986_2010	442	210	543	39%	2.3	4.3	86%
2070_2099	385	156	452	35%	3.5	6.1	77%
diff._21	-4	43	42		0.0	0.6	
ratio._21	-1%	26%	8%		0%	15%	
diff._32	-56	-54	-91		1.1	1.8	
ratio._32	-13%	-26%	-17%		49%	41%	

Akhmeta, spring wheat

FC/RAW50	Precipitation	Demand on irrigation	Evapotranspiration	Irrigation/evapotranspiration	Harvest only with precipitation	Harvest under irrigation	Harvest only with rain/under irrigation
1961_1985	mm	mm	mm	%	t/ha	t/ha	%
1986_2010	341	240	513	47%	1.9	5.1	164%
2070_2099	292	239	496	48%	2.0	6.5	232%
difference._21	-64	-4	-34		-0.2	0.5	
ratio._21	-16%	-2%	-6%		-11%	11%	
diff._32	-49	-1	-17		0.0	1.4	
Ratio._32	-14%	0%	-3%		1%	27%	

Tsnori, sunflower

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	343	295	554	53%	1.6	3.9	144%
1986_2010	314	344	578	60%	1.2	4.3	252%
2070_2099	272	276	484	57%	1.9	5.5	194%
diff._21	-30	49	23		-0.4	0.4	
ratio._21	-9%	17%	4%		-24%	10%	
diff._32	-42	-68	-93		0.6	1.2	
ratio._32	-13%	-20%	-16%		52%	27%	

Akhmeta, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	403	267	551	48%	8.3	13.4	62%
1986_2010	345	267	513	52%	8.9	13.9	56%
2070_2099	292	269	486	55%	7.7	14.9	94%
diff._21	-58	0	-38		0.7	0.5	
ratio._21	-14%	0%	-7%		8%	4%	
diff._32	-53	2	-27		-1.3	0.9	
ratio._32	-15%	1%	-5%		-14%	7%	

Gurjaani, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	397	230	499	46%	9.4	13.5	44%
1986_2010	360	238	489	49%	10.3	14.0	36%
2070_2099	294	208	421	49%	11.6	14.9	28%
diff._21	-37	8	-10		0.9	0.5	
ratio._21	-9%	3%	-2%		10%	3%	
diff._32	-66	-30	-68		1.3	0.9	
ratio._32	-18%	-13%	-14%		13%	6%	

Dedoplistkaro, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	319	264	484	55%	8.3	12.8	55%
1986_2010	287	284	478	59%	8.9	13.5	51%
2070_2099	252	234	412	57%	7.7	14.8	94%
diff._21	-31	20	-7		0.7	0.7	
ratio._21	-10%	7%	-1%		8%	5%	
diff._32	-35	-50	-66		-1.3	1.3	
ratio._32	-12%	-18%	-14%		-14%	10%	

Telavi, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	429	210	510	41%	9.3	13.4	43%
1986_2010	382	222	484	46%	11.4	13.9	22%
2070_2099	316	231	466	49%	10.4	14.9	43%
diff._21	-47	12	-25		2.1	0.5	
ratio._21	-11%	6%	-5%		22%	4%	
diff._32	-67	8	-18		-1.0	1.0	
ratio._32	-17%	4%	-4%		-9%	7%	

Lagodekhi, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	458	191	488	39%	10.7	13.6	27%
1986_2010	507	154	478	32%	12.8	14.1	11%
2070_2099	370	186	446	42%	12.0	15.0	25%
სხვაო._21	49	-38	-10		2.1	0.5	
diff._21	11%	-20%	-2%		19%	4%	
ratio._32	-137	32	-32		-0.7	0.9	
diff._32	-27%	21%	-7%		-6%	6%	

Sagarejo, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	415	225	505	45%	8.7	13.1	51%
1986_2010	336	253	486	52%	9.6	13.6	42%
2070_2099	289	204	411	50%	12.5	14.9	19%
diff._21	-79	27	-18		0.9	0.6	
ratio._21	-19%	12%	-4%		11%	4%	
diff._32	-47	-49	-76		2.9	1.2	
ratio._32	-14%	-19%	-16%		31%	9%	

Kvareli, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	476	174	498	35%	11.1	13.5	21%
1986_2010	463	174	474	37%	12.5	14.0	12%
2070_2099	359	175	447	39%	12.4	14.9	20%
diff._21	-14	0	-24		1.4	0.5	
ratio._21	-3%	0%	-5%		13%	4%	
diff._32	-104	1	-27		-0.1	0.9	
ratio._32	-22%	1%	-6%		-1%	6%	

Tsnori, maize

TAW50/ RAW50	Precipitation mm	Demand on irrigation mm	Evapotranspiration mm	Irrigation/evapotranspiration %	Harvest only with precipitation t/ha	Harvest under irrigation t/ha	Harvest only with rain/under irrigation %
1961_1985	302	289	498	58%	7.1	13.6	91%
1986_2010	272	326	514	63%	5.5	14.0	153%
2070_2099	243	263	436	60%	8.0	14.9	86%
diff._21	-29	38	17		-1.6	0.4	
ratio._21	-10%	13%	3%		-22%	3%	
diff._32	-30	-64	-79		2.5	0.9	
ratio._32	-11%	-19%	-15%		45%	7%	

Annex 4. The criteria used in the multi-criteria analysis (Agriculture)

1. CALCULATION OF INDICATOR VALUES

1.1. Adaptive capacity of communities to climate change

1.1.1. Social capital

Social capital is determined suing two indicators: farm organisations and female work participation.

Farm organisations

The number if collective agricultural ventures (= co-operatives, joint ventures, partnerships, share-holding companies, etc.) are taken as a proxy for private social networks. We assume that in case/time of severe climate hazards, the potential for adaptation is higher by a group, rather than an individual. The coefficient is obtained by dividing the number of co-operatives, joint ventures, partnerships and share-holding companies by the total number of farms. Region with the lowest share of organised farm operations in the total number of farms is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Female work participation

Female work participation is an indicator of the level of development of society. We take the percentage of the employed women in the pilot regions (incl. those employed in (semi)-subsistence agriculture). Region with the lowest percentage of female work participation is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

1.1.2. Human capital

We use two indicators to determine human capital: education level and agricultural education.

Education level

It is worth to notice that in case education level (= secondary school, college and university graduates) of the five regions in Georgia there is not much difference. For this reason and hoping to get more distinction between the regions, primary school is not included in the calculation. Only the summed up percentages of finished secondary school, colleges and universities are used to determine the value of the education level. Region with the lowest value for the education level is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Formal agricultural education

Figures on formal agricultural education (= secondary agricultural school or university) are taken from the Excel files provided by national experts. Region with the lowest formal agricultural education is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

1.1.3. Financial capital

Financial capital is assessed by livestock and average salary:

Livestock units per capita

Livestock is an asset for a family as it provides inputs in various forms (transportation, means of work in agriculture, manure, milk, etc.). In case of disasters or any impact on agriculture, livestock can serve as means of coping mechanism. It can be a source of alternative or additional income for the farmers. Thus, more livestock would indicate higher adaptive capacity. Livestock capital is expressed as the number of livestock units per capita. Excel data on livestock (= number of cattle, sheep, goats, pigs and poultry) are automatically converted in Excel into so called Livestock Units. The indicator on Livestock units per capita is obtained by dividing Livestock Units by the number of inhabitants. Region with the lowest livestock density is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Average salary

Average salary: regions with higher average salary are assumed to be wealthier and therefore better able to prepare for and respond to adversity. Calculation of values for average salary is explained in Chapter **Error! Reference source not found.**.

1.1.4. Physical capital

Physical capital is assessed by giving rating to infrastructure development and access to market.

Infrastructure

Infrastructure is calculated in the following way: number of inhabitants is divided by the number of preliminary, primary and secondary schools, as well as the number of colleges & universities, hospitals and Internet connections. This tells us how many inhabitants we have per one school, college, university; hospital and Internet connections. The sum of these numbers makes the infrastructure value. Region with the highest value (= number of inhabitants per one school, hospital, etc.) is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Access to market

Access to market is calculated by summing up values for the farmers' markets and asphalt roads. Farmers' markets value is assessed by:

1. Calculating the number of people living in rural areas (=number of inhabitants multiplied by the percentage of rural population)
2. Dividing above figure with the number of reported farmers' markets.

Asphalt roads are calculated by dividing the area of the region ('000 km^2) with the total number of asphalt road kilometres. Region with the highest access to market value (= number of rural inhabitants per one farmers' market and km of asphalt roads) is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

1.2. Exposure of communities to climate–hazards

In our methodology, systems' exposure to variable/changing climate is defined by the change of temperature, rainfall and occurrence of droughts.

Change in temperature Change in temperature is expressed as the difference between average annual temperatures of two different periods. Because the availability of historical meteorological data of five regions differs, the two reference periods were determined for each region individually as follows:

The data are taken from the Excel files provided by the national climate expert. Region with the highest change in temperature is considered to be most vulnerable and is assigned factor 1.00.

Ratio of dry to rainy days during vegetation According to the opinion of Georgian experts, from the perspective of impact of aridization on agriculture, the change in annual rainfall, which was originally proposed to be used as an indicator, is not the most suitable indicator showing the situation with rainfall. Instead it was decided to use another indicator: a ratio of dry to rainy days. It is obtained by dividing the number of dry days (= days with < 0.1 mm rainfall) by rainy days (= days with > 0.1 mm rainfall) during vegetation for the first and the second period. The length of vegetation is crop-and region dependent. Generally, it is determined as a period (days) with the average temperature above 5 degree C. This data is provided by national experts. It is calculated in the same manner as above for temperature. Region with the lowest ratio of dry to rainy days is considered to be most vulnerable and is assigned factor 1.00.

Droughts Droughts are ideally calculated from the figures on Aridity Index (more about it can be found in the separate report on methodology and the subsequent E-mails on evapotranspiration formulas). However, in case of Georgia precise data on the number of droughts were available for each meteorological station and their respective first and second periods. So we have used this data to calculate the difference between the number of droughts in the second and first period (= sum of the number of droughts in the second period minus that in the first period). Region with the highest value is considered to be most vulnerable and is assigned factor 1.00.

1.3. Sensitivity to climate–hazard exposures

1.3.1. Ecosystems sensitivity to climate–hazard exposures

Plant cover Plant cover value is calculated as the percentage of permanent grassland (= meadows and pastures) in the total agricultural area. The data are taken from the Excel files provided by national experts. Region with the lowest percentage is considered to be most vulnerable and is assigned factor 1.00.

Land cover status Land cover value is assumed to be the ratio between forest and agricultural land. It is calculated by dividing the number of hectares under forest with the number of hectares under agricultural land and multiplying this value with hundred. Region with the lowest value is considered to be most vulnerable and is assigned factor 1.00.

No. of local varieties Originally, it was assumed that an indicator would be the number of threatened butterfly, vertebrate and flowering species of a region. However, in the absence of these data, the number of local varieties is used instead. The data are taken from the Excel files provided by national experts. Region with the lowest number of local varieties is considered to be most vulnerable and is assigned factor 1.00.

1.3.2. Local community sensitivity to climate–hazard exposures

Women Climate variability is likely to have disproportionate impacts on females as compared to males. Greater reliance of women on natural resource dependent activities such as agriculture is a common feature in many countries. Changes in natural resources due to changes in the climate are more likely to affect women through various direct and indirect means such as water and fuel wood availability. The data on the percentage of women in the total population are taken from the Excel files provided by national experts. Region with the highest percentage is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Children Children are likely to be more vulnerable to natural disasters and extreme climate change events. The percentage of children between 0 and 7 years old are calculated by dividing their number by the number of total inhabitants. Region with the highest percentage is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Below poverty line households The data on below poverty line households in the pilot areas are calculated by multiplying the number below poverty line households with four (we assume that they have four family members in average). This is further divided by the number of total inhabitants and multiplied by hundred.

Population growth

Region with the highest value is considered to be most vulnerable and is assigned factor 1.00.

Unfortunately, in case of the five regions in Georgia, there were no reliable data on population growth. Consequently, in all five regions the population growth is assumed to be the same and all five were assigned factor 1.00.

1.3.3. Agriculture

Percent small-scale farms

Small-scale farmers, generally subsistence farmers, are more sensitive to climate change and variability because they have less capital-intensive technologies and management practices. Estimated number of subsistence farms is divided by the total number of farms and multiplied by hundred. This gives us percentage of small-scale farms. Region with the highest percentage is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Rural population

The data on the percentage of rural population in the total population are taken from the Excel files provided by national experts. Region with the highest percentage is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Land degradation

Land degradation is calculated as the number of hectares of degraded land – comprising land:

- With less than 2% soil organic matter
- With pH value less than 5
- Classified as "saline"
- Pasture classified as overgrazed
- Classified as prone to medium to severe erosion
- With >33% surface overgrown with shrubs/bushes
- With >10% surface overgrown with alien species

The area of the above hectares is summed up and divided by the total area of the region. Unfortunately, in case of the five regions in Georgia, there were no reliable data on land degradation. Consequently, in all five regions the population growth is assumed to be the same and all five were assigned factor 1.00.

Agricultural production

Changes in agricultural production are calculated using historical data on agricultural production in the pilot regions, provided by national experts. Both crop and livestock production is taken into account. Production for the respective periods has been expressed in terms of cereal units. One cereal unit is a natural measure allowing comparison of different agricultural produce. It allows comparing not only “apples” and “pears” but also crop and livestock produce. One cereal unit (CU) is equal to nutritional value of 100 kg barley and its specific protein and starch content. Cereal units of other crop products are based on their nutritional equivalent against barley. Sugar beet for instance contains 0.27 CU, oats 0.85 CU, soyabeans 2.6 CU, etc. Cereal units of livestock products are determined as the equivalent of crop cereal units that are (hypothetically) required to produce 100 kg livestock produce (meat, milk, eggs, and wool). Agricultural productivity is assessed by multiplying data on the tonnes of crop and livestock produce with the relevant CU factors for those produce. The CU factors are taken from the German Federal Ministry of Agriculture[63]. The final value is expressed in thousand CUs. Region with the lowest value is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Crop diversification An agricultural region with more diversified crops will be less sensitive to climatic variations than for instance a region predominantly growing 1-2 crops only. Crop diversification value is calculated by deducting from 100 percent agricultural area, percentage of area under cereals and permanent grassland. Region with the lowest percentage of diversified crops is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Irrigated area Percentage of irrigated area out of the total agricultural area cultivated area gives an indication of the dependence on rainfall as well as utilization of surface and groundwater. Data on the number of irrigated hectares of agricultural land were provided by national experts. Region with the lowest percentage under irrigated area is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Agricultural labour The ratio of agricultural workers to the rest of the working population is an important indicator. This is used in order to check if there is a significantly large population having high dependence on agriculture for livelihoods, which is a climate sensitive sector. The percentage of agricultural workers is calculated by dividing the number of agricultural workers with the total number of employed and multiplying it by hundred. Region with the highest percentage of agricultural workers is considered to be most vulnerable and is assigned factor 1.00.

Livestock density per hectare One of the main threats to pastureland in arid and semi-arid areas is overgrazing. Consequently, regions with high livestock density are likely to have more degraded pastureland and thus be more sensitive to climate–hazard exposures. In order to calculate this indicator, Excel data on livestock (= number of cattle, sheep, goats, pigs and poultry) are automatically converted in Excel into so called Livestock Units. Livestock density is obtained by dividing Livestock Units by the number of hectares of agricultural land. Region with the highest livestock density (= highest number of Livestock Units per ha) is considered to be most vulnerable and is assigned vulnerability.

[63] Statistik und Berichte des Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz. Bonn. See at: http://www.bmelv-statistik.de/de/statistisches-jahrbuch/kap-c-landwirtschaft/

Annex 5.[64] Agricultural and degraded lands by municipalities

Region	Total agricultural area (ha) 1976-78	Including hayfields and pastures (ha)	Total agricultural area (ha) 2013	Including hayfields and pastures (ha)	Currently degraded agricultural land	Comments
Akhmeta	80 266	62 113	80 266	62 113	2 500 ha bogging, overgrazing 1 000 ha- exhaustion	
Gurjaani	45 900	19 377	39 400	9 938	1 500 ha mainly arable land 600 ha –cut off 540 ha windbreak	About 6 500 ha transferred to other municipalities
Dedoplistskaro	122 000	68 200	124 736	67 422	4 000 ha salinized and abandoned agricultural lands; 55% of pastures degraded by 100%. Cut off 1 000 ha windbreak	
Telavi	18 343	5 000	19 555	5 000	500 ha – river banks, ravines and alpine pastures; 100 ha windbreaks cut off.	
Lagodekhi	39 287	11 127	39 287	11 169	380 ha - mostly captured by rivers; 50% of 84 108 m windbreaks required rehabilitation	
Sagarejo	94 872	56 730	94 373	59 593	47 ha, including 15 ha forest. Degradation degree everywhere is high (landslides)	
Sighnagi	105 000	54 213	96 580	54 121	9 000 ha degraded due to wind erosion and salinization. Windbreak from the 700 ha remaining 60 ha.	Transferred to neighboring municipality
Kvareli	35 084	10 775	35 084	10 775	92 ha mostly river bank;	
Total	**524 243**	**287 535 (55%)**	**529 281**	**280 131 (53%)**		

64 Information of degraded areas is provided by local experts and needs verification.

Annex 6. Description of criteria used in multicriteria assessment of health sector

1. **Assessment of adaptation capacity**

1.1. Social capital:

Social capital is defined via using the following indicators (index): according to the number of persons who get existing (living) aid, pensin and people with healthcare police (insurance), also according to the number of employeed women.

Persons receiving existing minimum aid, pension and owners of medical insurance (police): Presumably, people who get social financial aid from the Government should be more protected and accordingly, possess more adaptation capacity rather than those, not having such kind of support. the municipaliyt, where the share of the socially protected people is the lowest should be considred as the most vulnerable and will be rated with coefficient 1.00. The coefficient of vulnerability decreases when the number of socially protected people increases.

Emplyment of women: Participation of women in labor is the indicator of level of public development. We tried to gain information regarding the percentage of employeed women per each municipality, though we failed to get this info. We decided that all municiaplities are aqual and rated all of them with coefficient 1.00.

Human capital:

For defining the human capital three indicators are used: reading and writing skills, amount of qualified staff and qualified medical personnel.

Level of reading and writing skills: The municipality, where the indicator of writing and reading skills is the lowest, is considered to be the mostly unprotected (vulnerable) and is rated with coeffcient 1.00. Unfortunatelly, no reliable data regarding the writing and reading skills in Ajara region existed. Due to the above, we assumed, that the level of writing and reading skills was equal in all of the 4 regions and all of them were rated with the equal coefficient 1.00.

Level of high education: Municipality, where the educational level is comparatively low, can be assessed as more vulnerable and be rated with vulnerability coefficient 1.00.

Qualified staff: We considred, that the municipality, having more qualified personnel, possesses more economic potential and higher capacity. The municipality with the lowest indicator, is considered as the most vulnerable and is rated with coefficient 1.00.

Qualified medical personnel: We used the level of qualified personnel as the general indicator of the development of sociaty and municipality. We included doctors and medical nurses into the qualified medical personnel. The staff engaged in the municiaplity medical field are considered as the most vulnerable and are rated with coefficient 1.00. With the increase of the medical personnel this coefficient will dicrease.

Financial capital:

Financial capital is evaluated by the amount of the owners of private medical insurance number of people below the poverty margin and annual average salary/income.

Private medical insurence: The owner of the private insurance package is either the family or the individual who can use corporative insurance, accordingly is either employeed or pays for the insurance himslef, i.e. is the owner of certain capital that allows him to use the expensive priviledge. Such kind of population can easily adapt. Those municipality that is less covered vy such kind of private insurance package is considered as the most vulnerable and is rated with coefficient 1.00.

Average salary: Regions with high average salaries are considered to be rich, thus the population has more bilities to get prepared for negative conditions and be ready. Municipalities with the lowest average salaries were rated with the coefficient 1.00.

Population below the poverty margin: Those part of population that according to the rating points are below the poverty margin possess low potential for adaptation, accordingly, their vulnerability coefficient was rated as 1.00.

Physical capital:

Physical capital is evaluated according to the development of infrastructure, accecc to medical services and amount of emergency medical centers.

Infrastructure: Infrastructure is calculated as follows: the amount of population of the municipality is divided to the number of preliminary, beginning and interim schools, also to the number of colleges, universities and hospitals. Via this we get information on how many person come per school, college, university and hospital. The region with the higest indicator is considered as the most vulnerable and is rated with the coefficient 1.00.

Availability on medical services: The acceccability to the medical services is calculated by summing up of indicators of medical centers and roads. Accordingly, the more medical services are and the more asphalted roads are the higher is the access to the high medical service. The calculation of accessibility to medical services is calculated as follows: the amount of medical centers in the municipality is divided to the amount of the population; the indicator of asphalted roads is calculated by dividing the whole length of roads (km) to the area of the municipality (sqm). So, the higest indicator corresponds to the most protected munucipality. At the same time, the lowest indicator of accessability corresponds to the most vulnerable municipality and was rated with the coefficient 1.00.

Medical emergency centers: Emergy medical centers are assessed as physical capitals needed for adaptation of the municpalities. Municipalities with the lowest indicator of centers were rated with the coefficient 1.00.

EXPOSURES

According to our methodologies, different/changing impact of climate change on systems is defined via average temperature changes, heat index, tourism climate index and extreme events.

Changes in average temperature: Changes in temperature is expressed as difference between the temperature between the years 1981-2005 and 1956-1980. We took the changes of indicators of the average temperature for Summer, since climate related diseases mostly occur in summer and can serve as the most exact indicator. The municipality with the highest indicator of temperature change is considered to be the most vulnerable and is rated with the coefficient 1.00.

Heat Index (HI): Heat index gives opportunity to define exactly what temperature is accepted by the human in humuduity conditions. Special tables show how high temperature can affect the human organism. We selected maximal indicators of heat index per municipalities ("dangerous" days) and those municipalities having the highest amount of days were considered as the most vulnerable and granted with vulnerability coeffcient 1.00.

Tourism climatic index (TCI): Tourism climatic index is used for the assessment of tourism potential of the region and describes the level of climatic comfort. Those municipalities that have high indicators are more profitable for tourism development. The municipalities with the lowest indicators were rated with vulnerability coefficient 1.00.

Extreme events: According to the experts, increase of extreme events is linked to climate change. The more such kind of events occur, the higer is the number of health problems. So, the municipality with the highest number of such extreme events is rated with the coefficient 1.00. The extreme events related to climate change are the following: draught, intensive precipitation, flashfloods, landslide, mudflow, avalanches, strong winds, storms.

1.2. Vulnerability to climate change RISKS

Other environmental risks:

Contamination of water: High indicators of water contamination refer to non-profitable environment conditions and accordingly, the municipalities with high indicators are more vulnerable to climate change risks. Relevantly, these municipalities were rated with the coefficient 1.00.

Pollution of air: Similar to contamination of water, municipalities with high indicators of air pollutions were rated with vulnerability coefficient 1.00.

Contamination of land: Similar to contamination of water and air, municipalities with high indicators of land contamination were rated with coefficient 1.00.

Vulnerability of local communities to climate change risks:

Women: Climate chnage most probably has unproportional affect on women, compared to men.

Changes of natural resources caused to climate change most probably more affect women via direct or indirect ways. For example, women's organism is physically less prepared against extreme events, especially during the pregnancy period, when the woman becomes more sensitive to climate changes. The municipality with the higest percentage indicator is considered to be the most vulnerable and is rated with the coefficient 1.00.

Kids: Tentatively, kids are even more vulnerable to extreme events. The municipality with the highest percentage amount is considered the most vulnerable and is rated with the coefficient 1.00.

Older people: According to the International experts, older people, like kids, are seperated as the most vulnerable group to climate changes. In the older age the number of chronical diseases (cario-vascular) is higher and more vulnerable to the climate change. So the municipality with the ighest indicator is considered as the most vulneravle and is rated with the coefficient 1.00.

Increase of population: Increase of popualation is assessed as the positive trend and thus, the municipality, where the increase of population has the lowest indicator, was rated with the coefficient 1.00.

Healthcare sector:

Assessment of healthcare sector was carried out according to diarrhea diseases, phychological disorders, zonal infections, indicators of health problems and death.also according to the number of people injured by the extreme events and amount of general profile doctors.

Diarrhea diseases: Diarrhea diseases are included into the climat-related group and are more frequent in Ajara region, compared to other regions of Georgia, especially, in Summer. Increase of diarrhea diseases can be linked to worsening of natural cooditions (extremely high temperature) and to improper work of the healthcare system in the region. The municipality with the higest indicator of diarrhea diseases was assessed as the most vulnerable and accordingly, was rated with the coefficient 1.00.

Psychological disorders: Psycholigical disorders, like diarrhea diseases, belongs to the climate-related group of diseases. According to the international experts, increase of the number of phychological disorders are noted especially after extreme events (catasropes). Increase of phycholocal disorders is possible due to the same reasons as in case of diarrhea diseases. The municipality with the highest indicator was considered as the most vulnerable and rated with the coefficient 1.00.

Zonal diseases: From the zonal diseases in Ajara we can mention Borelosus and Leptospirosus. These are the diseases directly linked to climate change.the municipality where such diseases are expressed is considered as the most vulnerable and is rated with the coefficient 1.00.

Diseases: According to the diseases we can judge on the general status of health of the population. The condition of the helathcare sector can be assessed as well. The municipalities with high indicators of diseases were rated with the coefficient 1.00.

Death: Indicator of death, is similar to disease indicator. The municipality with the higher death indicator was rated with the coefficient 1.00.

Injured by extreme events: People, injured due to extreme events, often suffer fomr different health problems (traumas, phychological disorders, etc) and need financial support fomr the Government. These kind of municipalitiea are the most vulnerable and were rated with the coefficient 1.00.

Doctors of general practice: Doctors of general practice mainly represent the integral part of the primary healthcare group addressed by the population when the health problems occur. Accordingly, adequate amount of such centers is necessary for proper helathcare system. Those municipalities that have the lowest amount of general practice doctors were rated with the coefficient 1.00.