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

Vulnerability Assessment of Selected Semi-Arid Regions and Agrobiodiversity to Climate Change in Georgia

Tbilisi, 2012

Contents

1. Intoduction

Vulnerability Assessment of Selected Semi-Arid Regions and Agrobiodiversity to Climate Change in Georgia has been prepared within the project 1`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``.

The project has the regional scope and is implemented by RECC in all three South Caucasus Countries (Armenia, Azerbaijan, Georgia) with the financial support of European Union. The project is co-financed by German International Cooperation Society (GIZ). The project started in March 2011 and will continue until 2014.

The Caucasus Region is exceptional for its agricultural species and a large variety of its wild relatives. Preservation of existing agrobiodiversity has a great importance for agricultural sustainability and the welfare of local community. This has become especially noticeable since climate change . Because of the climate change impacts, the serious decrease of agrobiodiversity in arid and semi-arid ecosystems is expected, the vulnerability of which is confirmed by the number of studies in all three South Caucasus countries.

The project is contributing to the promotion of sustainable livelihood and alleviation of poverty via better understanding of problems related to climate change impact, its socio-economic dimension particularly affecting ecosystem integrity, rural production and food security by introducing of adaptation practices, developing regulatory and institutional framework to consider climate change issues in planning, enhancing local capacities for sustaining their livelihood level in face of climate change and developing the replication strategy to extend results of the activities and upscale best practices in other regions of the South Caucasus.

Overall objective of the project is to build adaptive capacities in the South Caucasus countries to ensure resilience of agro-biodiversity of especially vulnerable arid and semi-arid ecosystems and local livelihoods to climate change.

In order to achieve its objective, the project includes the following activities:

- Clarifying of major threats to agro biodiversity in arid and semi-arid ecosystems posed by climate change, development of vulnerability profiles for agro resources as well as identification and implementation of pilot projects on adaptation targeted to increase of ecosystem resilience and to reduce risk for food production in six selected communities of South Caucasus countries.

- Revision of regulatory framework and conduction of gap analysis of the regional/local development strategies and plans related to conservation of biodiversity and agriculture in light of climate change aspect. Based on analysis conducted set of measures to promote adaptation to climate change and conservation of agro-biodiversity will be defined and include into local development plans.

- Awareness campaigns to make local population aware about importance of agro-biodiversity conservation and climate change impact related problems. Educational module for schoolchildren to conduct public ecosystem monitoring for assessing climate change risk will be developed and introduced.

- Revision of existing institutional capacities at national/local levels to mainstream agro-biodiversity and climate change adaptation issues into development policies and plans. Series of training programmes for decision makers and local population on value of agro-biodiversity and sustainable agricultural practices to reduce climate change risk will be organized.

This study aimed at identification of semi-arid areas in Georgia, most exposed to climate change impact, assessment of biodiversity status in these areas and definition of trends of current changes.

The study was conducted in three selected districts - Shida Kartli, Kvemo Kartli and Kakheti and namely in five municipalities - Kareli, Gori, Gardabani, Sagarejo and Dedoplistskaro, the largest parts of which are semi-arid areas. Initially, the semi-arid areas were identified using the aridity index, measured with help of the basic climatic parameters that were in force before 1960 and the Map of Natural Landscapes of the Caucasus Region[1]. Then, at a working meeting, experts specified, based on study area selection criteria, the geographic area of the study to be conducted within the scope of the project.

Chapter 1 of the report offers general geographic and socioeconomic characteristics of the selected municipalities.

Chapter 2 reviews historic aspects and the current status of agricultural sector development in the selected municipalities.

Chapter 3 presents results of assessment of the status of floristic complexes and crop varieties in the selected municipalities and describes the changes that developed there in 1950s-1970s. The chapter analyses dynamic of cultivated plants and species during a 50-year period and highlights the priority of representative species of local flora and wild varieties of cultivated plants. It contains information on climate change impact on cultivated plants, provided by residents of the selected areas.

Chapter 4 includes results of assessment of changes in climatic parameters, based on historical data provided by six meteorological stations, located in the semi-arid areas (Gori, Gardabani, Sagarejo, Udabno, Dedoplistskaro, Eldari). The changes of climatic parameters are divided in four periods: from the station's opening to 1960 (basic norm), 1956-1980 (first period), 1981-2005 (second period) and the future (2020-2050).

Chapter 5 describes climate change susceptibility indicators by municipalities, measured through a simultaneous analysis of many indicators that contain information on changes in natural and socioeconomic environment of the target areas.

[1] Map of Natural Landscapes of the Caucasus Region, by Prof. N Beruchashvili, An Ecoregional Conservation Plan for the Caucasus, WWF, May, 2006

2. General Overviw of Selected Areas

2.1. Kareli and Gori Municipalities

Gori and Kareli municipalities is situated in the east Georgia – on the territory of the historical-geographic **Shida Kartli.** The area of Gori Municipality comprises 2327 km^2, from here 766 km^2 is situated in semi-arid zone, which comprises 33% of the total area of municipality.

The area of Kareli Municipality comprises 1099 km^2, from here 489 km^2 is situated in semi-arid zone, which comprises 44% of the total area of municipality

Map 1. Semi Arid Zones in Kareli and Gori municipalities

Relief Geographically semi-arid zone of Gori and Kareli Municipalities is situated on the Tiriponi-Saltvisi section of the Liakhvi River basin, on the Middle Kartli plains. The section in the beginning is bordered by the Kvernaki Ridge from the south-east and from the north-west – by the south-west edge of the Ruisi (the Malkhazi Summit) Ridge. Four main morphological elements are selected in Gori and Kareli municipalities: **Gori plains,** which engages approximately 40% of Gori and Kareli municipalities, it is situated at 745 m a.s.l., **Mtkvari Middle valley**, with large terrace plains spread on the bottom. Along with the accumulation forms we meet denudation and landslide forms of relief here. **Kvernaki Ridge,** it rises to 100-120 m from the surface of the plain, the biggest elevation a.s.l. reaches 879 m; **North Slope of the Trialeti Ridge**, with branch ridges directed to the north and with deeply cut valleys among them, north slopes of the Trialeti Ridge are characterized with stepped, old, flat surface. Generally the relief is soft and slightly cut with ravines and gorges. The elevations here range from 620 m to 875 m. The Malkhazi Summit is situated on the highest elevation and the lowest elevation coincides with the riverbed height in the Liakhvi River valley.

Climate Moderately warm steppe-to-humid climate. Average annual temperature is 10,9 ^{0} Average air temperature in January is 1,2-1,7 ^{0}C, while in July – up to 22,5 ^{0}C. Absolut maximum is +40^{0}C and absolute minimum is -28^{0}C. The region is characterized with lo precipitation with average annual precipitation being 500 mm, maximum – 760 mm an minimum – 330 mm. Maximum precipitation (70-100 mm) falls to May and minimum (1 20 mm) – to January. Snow cover in Shida Kartli plain is unstable.

Hydroligy

There is 5 lake, 3 water reservoirs and 10 rivers in the municipalities. Semi-arid zone of the municipalities, characterized by a slight inclination to the south, is crossed by five rivers, having a meridian direction from the north to the south. These rivers are: Tortla, Mejuda, Pshana, Cherabula and Didi Liakhvi. The mentioned rivers have high water discharge due to snow melting in spring and seasonal rains in autumn. They have stably low discharge in winter and unstably low in summer (depending on precipitation). Certain areas are flood-prone, especially in spring, when water can overcome the floodplain and cause damage to agricultural lands and infrastructure.

Soils

There are four types of soils spread within Gori and Kareli Municipalities: brown soils, meadow brown soils, brown-carbonate soils and alluvial-carbonate soils. Brown and meadow brown soils have the widest spreading area. Spreading area percentage comprises approximately 50-55%. Brown-carbonate soils have smaller spreading area (30-40%).

Semi Arid Alndscapes

According to the landscape map of the Caucasus (1979) and according to N. Beruchashvili's classification, there are 2 semi-arid type landscapes:

- Foothill landscapes with hornbearn-oak (Carpinus orientalis) forest, "shibliak", partially with open woodlands, "frigna" and Botriochloa steppes sometimes with badlands ;
- Foothill accumulative landscapes with botriochloa and stipa steppes, "shiblijak", partially meadows.

Land use

Agricultural lands in ***Gori municipality*** cover 61 902 ha, including 22 293 ha of arable lands, 11 000 ha of perennial plantations, 1 988 ha of hayfields, and pastures cover 27 621 ha. State Forest Fund's land covers 44 939 ha, including 35 311 ha of forests; 1 902 ha of shrubbery, 852 ha of fields.

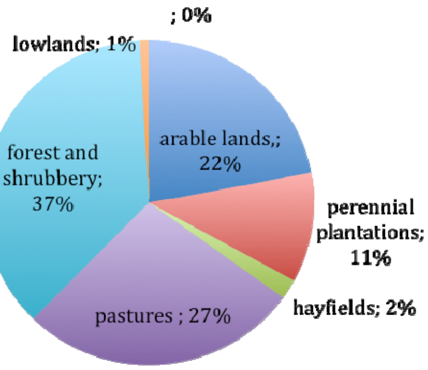


Chart 1. Land use distribution in Gori municipality (%)

Agricultural lands in ***Kareli municipality*** cover 36 407 ha, including 18 302 ha of arable lands, 4 678 ha of perennial plantations, 1 764 ha of hayfields and 11 762,5 ha of pastures. Forest area covers 26 746 ha, shrubbery- 1 223 ha.

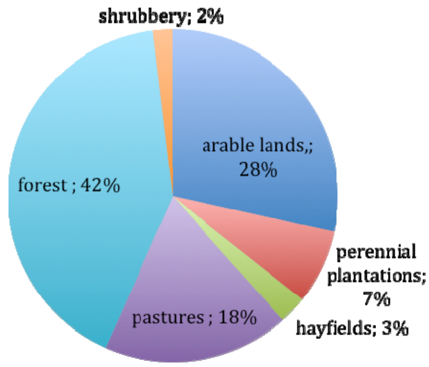


Chart 2. Land use distribution in Kareli municipality (%)

Population

Population of ***Gori municipality*** as of January1, 2010 was 144 919, including 34.3% of urban and 65.7% of rural residents. Women make up to 42,8% of total population. Population density is 62 people per square km. Rural population density is 41 people per square km. The municipality area includes one urban settlement-city of Gori and 103 villages, which are united into 20 territorial bodies (community).

Population of ***Kareli municipality*** as of January1, 2010 was 52 994, including 23.91 % of urban and 76.09% of rural residents. Women make up to 37.69%of total population. Population density is 48 people per square km. Rural population density is 36 people per square km. The municipality area includes one urban settlement –city of Kareli , 2 settlements- Agara (Kvena Tkoca) and Kornisi, 77 villages, which are united into 16 territorial bodies (community).

Economic indices

Gross domestic product of ***Gori municipality*** amounts to 0,167 millions of euro, share of agriculture makes 20%. The share of municipality total product in country's GDP is 1.68%, while municipality product per capita is 2 080 GEL. Sectoral structure of economics in Gori Municipality is as follows: agriculture (20%), households production (5%), industry (15%), construction (5%), transport and communication (12%), trade (12%), governance (17%), education (5%), healthcare (3%), other services (6%). Agriculture (20,2%) accounts for the largest share in municipality sectoral structure.

Gross domestic product of ***Kareli municipality*** amounts to 0,12 millions of euro, share of agriculture makes up 49%. The share of municipality total product in country's GDP is 1.35%, while municipality product per capita is 4 500 GEL. Sectoral structure of economics in Kareli Municipality is as follows : agriculture (49%), industry (49%), other services (2%).

Employment

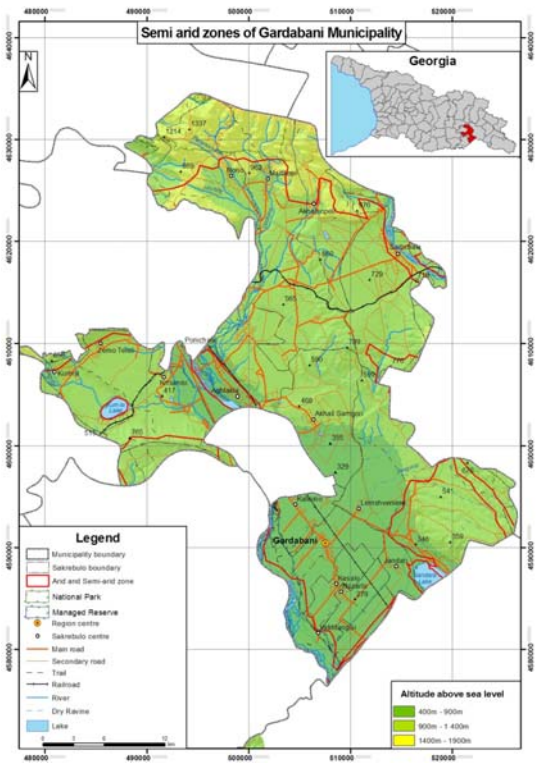
In both Gori and Kareli municipalities a large part of labour force is self-employed and is mainly engaged in agricultural activity. According to the official statistics the unemployment rate in both municipalities is 8.9%, however, the real figure is much higher. In the database of socially vulnerable families (created in March 12, 2005 by the governmental decree # 51) there are 22 407 families registered from Gori municipality (the total of 73 065 residents –the half of the total population); and 9120 families from Kareli municipality (the total of 30 080 residents – more than half of the population).

Infrastructure

Transcaucasia railway and international highway are located in both Gori and Kareli municipalities. From the roads of regional importance in Gori 115 kms (33%) are paved, while in Kareli-41 kms (23%) are paved. In Gori drinking water is provided to 75% of rural population, however water supply system is outdated and amortized and is in need of repair. In Kareli drinking water is provided only to 3% of rural population. Natural gas is supplied to 90% of Gori and 26% Kareli residents. In Gori municipality there are 65 public schools, 4 colleges and 3 universities. In Kareli municipality there are 35 public schools and 1 professional education center.

2.2. Gardabani Municipality

Gardabani municipality is situated in the east Georgia – on the territory of the historical-geographic Kvemo Kartli. The area comprises 1304 km^2, 872 km^2 from here is situated in semi-arid zone, which comprises 66,8 % of the total municipality area.



Map 2. Semi Arid Zones in Gardabani Municipality

Relief South and South-west areas of Gardanbani municipality is mountainous, the central part of Gardabani is locate on the right bank of Mtkvari River called Gardabani plain. South-East area of the municipality lies on the plateaus. Ialoni gorge (mount Ialoni 1881m.a.s.l), is the Northern area of Gardabani. The west border lies on the folded mountain system of Trialeti range The major packs of Gardabani are Sanishno (1499m a.s.l.) and Udzo (1419m a.s.l).

Climate Within the municipality air is dry sub-tropical. Average annual air temperature ranges from 13^{0}C (lowland) to 5-6^{0}C (mountain). In July from the temperature ranges from 25 to 10-11 ^{0}C, absolute maximum 40-41^{0}C (lowland), 30-32^{0}C (mountain), absolute minimum -25, -27^{0}C. Average annual precipitation level is from 441 mm (Kumisi) to 900-1000 mm (the Ialno Ridge), maximum in May, and minimum in January. It often hails. Snow cover in Kvemo Kartli plain is unstable.

Hydroligy The main river of Gardabani municipality is the river Mtkvari which flows on the 34 km length. Its tributaries are flooded during spring time and the low water level is observed in winter. Among the periodic rivers, main rivers are: the Orkhevi, Navtiskhevi, Khevdzmari rivers. On the right side of the river Mtkvari there is a Kumisi Lake and on the left side there is a Jandara Lake.

Soils In the Mtkvari River valley (Gardabani lowland) meadow grey-brownish soils are prevailed, with Lios silt-sands underlain beneath. These soils are characterized with a significant density, low water permeability, coarse structure and pH>7.

Grey-brownish (gypsum) soils are prevailed in semi-arid landscapes of Gardabani. Grey-brownish (gypsum) soils contain a big amount of gypsum and sulphur. Usually such soils are of heavy mechanical composition. Due to such mechanical composition the mentioned soils are characterized by high density, low permeability, and coarse structure and from the general agricultural point-of-view they are characterized with bad physical-mechanical properties.

Semi-arid Landscapes

According to the landscape map of the Caucasus (1979) and according to N. Beruchashvili's classification, there are 3 types of semi-arid landscapes in Gardabani municipality and these are:

- Foothill accumulative landscapes with semidesert, botriochloa and stipa steppes, "phrygana", partially "shiblijak" ;

- Foothill arid-denudational landscapes with botriochloa and stipa steppes, and "shiblijak" ;

- Low mountain arid-denudational landscapes with "shibliak", partially steppes and "phrygana" .

Land use

Agricultural lands in ***Gardabani municipality*** cover 58 154 ha, including 33 167 ha of arable lands, 4 050 ha of perennial plantations, 2 084 ha of hayfields, 18 845 ha of pastures. Forest area covers 23 369 ha, non-agricultural lands-29 513 ha.

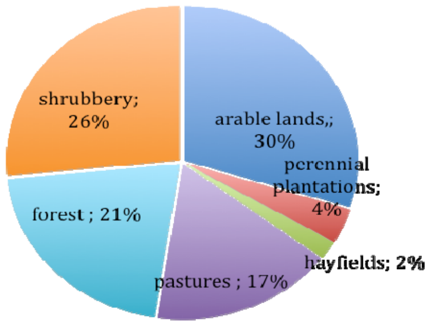


Chart 3. Land use distribution in Gardabani municipality (%)

Population

Population of ***Gardabani municipality*** as of January1, 2010 was 108 348, including 15 % of urban and 85 % of rural residents. Women make up to 65% of total population. Population density is 98 people per square km. Rural population density is 54 people per square km. The municipality area includes one urban settlement –city of Gardabani and 38 villages, which are united into 19 territorial bodies (community).

Economic indices

Gross domestic product of the whole municipality amounts to 0.81millions of euro, share of agriculture makes up 27%. The share of municipality total product in country's GDP is 8.2%, while municipality product per capita is 2 346 GEL.
Sectoral structure of economics in Gardabani Municipality is as follows : agriculture (24%), electricity generation (27%), construction (16%), transport (2%), trade (15%), healthcare (4%), reclamation industry (6%), other services

(4%). The largest share of municipality sectoral structure belongs to electricity generation (27%).

Emploiment

A large part of labor force is self-employed and is engaged in agriculture activity. According to official statistics the unemployment rate in the municipality is 9.4% however, in fact, it is much higher. In database of socially unprotected families from Gardabani municipality are registered 4 481 families (22 407 residents).

Infrastruqture

Municipality is crossed by 3 railways and numerous highways, oil and gas pipelines. . There are paved 19.2 km of roads of regional importance. Drinking water is provided to 75% of rural population, however water supply system is outdated and amortized and is in need of repair. Natural gas is supplied to 90% of residents. In Gardabani municipality there are 39 public schools and 2 vocational schools.

2.3. Sagarejo Municipality

Sagarejo Municipality is situated in the East Georgia - within the historical Outer Kakheti region. Its area comprises 1553 km^2, 825 km^2 from here located in semi-arid zone, which comprises 53,1 % of the total municipality area.

Mariamjvari Strict Nature Reserve (1040 ha)) and **Korughi Managed Nature Reserve** (1519,8 ha) are located in Sagarejo municipality.

Map 3. Semi Arid Zones of Sagarejo municipality

Relief

The **Gombori Ridge** is situated on the north part of the municipality. To the south part of the municipality the **Iori plateau** is expanded. the Sakaraulo Mountain (594 m) divides accumulation plains of Tsitsmatiani and Kachreti. There is located Udabno valley as well.

Climate

The mountainous part of Sagarejo forest meets the moderately humid climate zone and is characterized by dry and continental climate while the plain part of region is closer to the subtropical dry climate of southern Europe.

The annual temperature is 11-12^{0}C. Coldest month is Janury with avarage temperature -1,1 -0,1^{0}C. Avarage temperature of warmest month July is 22-23 0C. The air absolute maximum 38^{0}C has been recorded in the same month. The absolute minimum -24^{0}C is observed in January. Precipitation level comprises 400 - 700 mm per annum and the maximum falls in spring and in the beginning of summer. At the Gombori foothill and on the lower slopes the air is temperately humid with cold winter and long warm summer.

Hydrology

The river network of the municipality includes the **Iori River** and its tributaries from which permanent rivers are Vashliani and Gombori. Others are temporary rivers. Most of them have silting feature; floods are possible in spring and in the beginning of summer, which is related to heavy rain falls and melting of snow. There are many lakes on the Iori Plateau, all of them are salty containing a significant amount of Glauber salt. Some lakes become completely dried in summer time. There are salty springs represented here.

Soils

There are black and brown soils of spread on most of the area of the Iori Plateau, on the south part of the plateu cloddy and salty soils are spread and further below on the terraces lacustrine meadow and humid meadow soils are spread on comparatively small areas. Different type poorly developed soils are spread on the significant area of the territory, with rock exposures on the mountain slopes. Alluvium soils are spread across the Iori River. On the Gombori Ridge elevation zoning of soil surface is expressed: beginning from foothill forest, brown, typical and podsol forest uncultivated soils, finishing with uncultivated grassy and grass-covered-peaty mountain meadow soils. The soils are fertile in the municipality and give an abundant harvest under proper relief and irrigation conditions.

Semi-Arid Landscapes

The following semi-arid landscapes are spread on the territory of Sagarejo:
- Foothill arid-denudational landscapes with botriochloa and stipa steppes, and “shiblijak”;
- Low mountain arid-denudational landscapes with “shibliak”, partially steppes and “phrygana”.

Semi arid landscapes are very altered from the original face. Agricultural lands (fruit, corn, gardens, winter pastures) are mainly located in this landscapes.

Land use

Agricultural lands in Sagarejo Municipality covers 94 372.2 ha, including arable 29 575 ha, perennial plantations 6 425.7 ha, hayfields 1 397.5 ha, but pastures covers 56 974 ha. Forest area covers 42 065 ha, shrubbery – 3 745 ha.

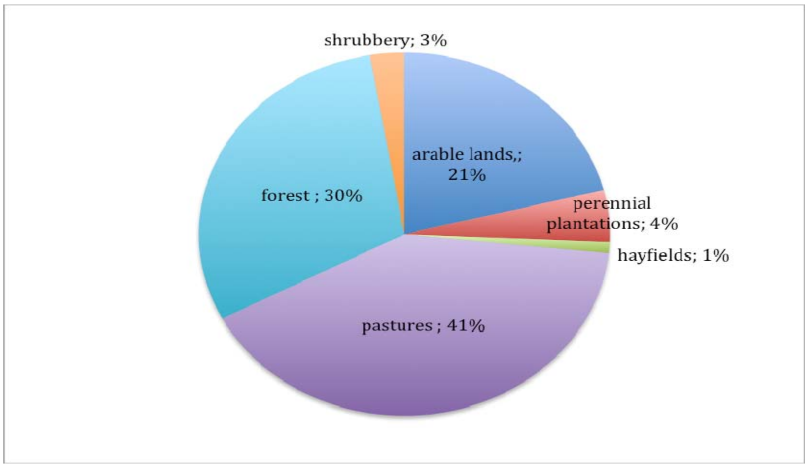


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Chart 4. Land use distribution in Sagarejo municipality (%)

Population The total number of the population in the Municipality is 63 765, of which working age population makes 65.6%; population below working age makes 19.6%; Population over working age makes 15%. The average age in the Municipality is 35.2 . Number of urban and rural populations are 12 856 and 51 190. Population density is 41.22 man per square km. 49.4% of the population are males and 50.6% are female. The Municipality includes one town - Sagarejo and 43 villages.

Economic Indices Gross domestic product of municipality consists of 0,1 million Euro, share of agriculture in GDP is 16%. Specific gravity of gross municipal production in country`s GDP is 1%. Gross municipal product per a person – 4 858 GEL.

Branch structure of economy of Sagarejo Municipality is represented as follows: agriculture (16%), construction (2%), transport, commerce, health, education (50%), industry (4%). The greatest share – 28% in branch structure of municipality is held by commerce.

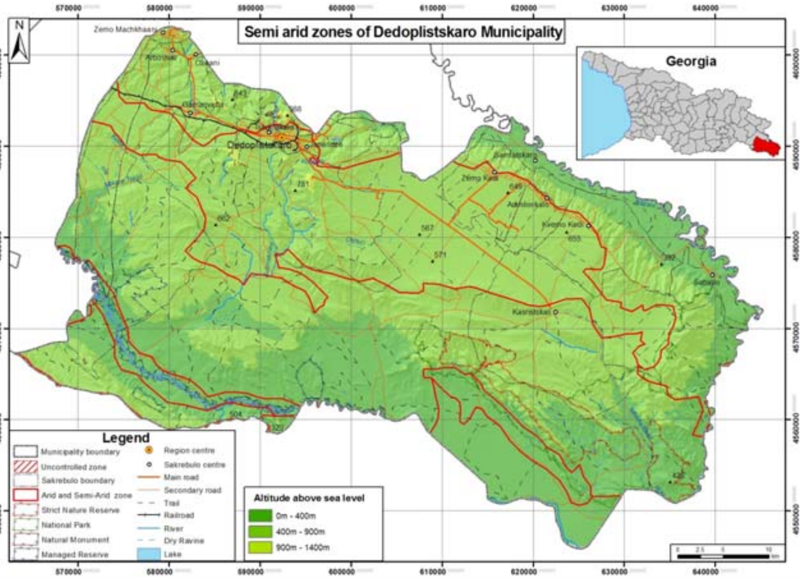
Employment The majority of Sagarejo population is self-employed - mostly involved in agricultural activities and consequently the major part of the income for the households come from selling agricultural products. 8% of the population is employed in state agencies. State allowances and pensions also make significant source of income

Under official statistics, level of unemployment in municipality is 8.9%. From Sagarejo Municipality 781 families (2 344 inhabitants) are registered in database of socially unprotected families created according to Regulation #51 of March 17, 2005 of Georgian Government.

Infrastructure International highway, internal central and local motorways cross the territory of the municipality. 70 km (37%) are asphalted from local roads; drinking water is supplied to 90% of village inhabitants. Natural gas is supplied to 45% of inhabitants. 26 public schools and 2 hospitals are in municipality.

2.4 Dedophlistskaro Municipality

Dedoplistskaro municipality is situated in the east Georgia – on the territory of the historical- geographic Kakheti. The area comprises 2 532 km2, occupies 22% of the territory of Kakheti region, 1965 km2 is situated in semi-arid zone, which comprises 77,6 % of the total municipality area.



Map 4. Semi-Arid Zones in Dedophlistskaro municipality

Vashlovani protected areas and Chachuna Managed Nature Reserve (5200ha) are located in Dedophlistkaro municipality.

Vashlovani Protected Areas consists of Vashlovani Strict Nature Reserve (10 143 ha), Vashlovani National Park (24 610 ha) and Natural Monuments as follows: “Eagle Gorge”, “Takhti-Tepa mud volcanoes”, “Juma Bay” and “Alazani Floodplains”, total area of which is about 24 924 ha. Vashlovani Protected Areas were opened in 2003.

Relief

Dedoplistskaro municipality is situated between the Alazani and Iori River Gorges on the elevated hillock the lowest altitude of which (90 m a.s.l) is located near the Mingechaur water reservoir, at the tributary of the Iori River.

The Nikorastsikhe Mountain is situated on the highest elevation (1001 m a.s.l), located to the south of Dedoplistskaro town. There are many flatlands on the territory – Didi and Patara Shiraki, Ole, Naomari, Kajiri, the Taribana, Iori and Chachuna steppes, the Eldari lowland, also hills – Amartuli, Demurdaghi, Gareja, the Kotsakhuri Height, Svindiskeli, Nazarlebi,

The north part of the region practically represents an extreme south section of the Gombori Ridge, gradually transforming into the Shiraki flatland. The north slope of this section of the ridge gradually descends towards the banks of the Alazani River.

Climate

Within the municipality climate is moderately humid and sub-tropical. Namely, in the lower part of the lowland the air is temperately warm with hot summer and higher up – the air transforms from temperately warm air to temperately humid air zone; Average annual temperature is 10^0C. Avarage monthly temperature in July is 22^0C, in January - 1.5-2.3 ^{0}C. Average annual precipitation level is from 250-300 mm (Eldari lowland) to 500-600 mm, maximum in May, and June.

Hidrology

Dedoplistskaro municipality is characterized with poor water reserves and it is mainly represented by a network of dry gorges and valleys. Most of rivers having short and periodic flows, most of which do not even reach the Iori and Alazani Rivers. The territory of the municipality is lined with following rivers: Velidjvari, Lekistskali, Uzundaraskhevi, Kushiskhevu, Ghoristskliskhevi, Kurumiskhevi, Pantishariskhevi and others. These rivers are mainly fed by atmospheric precipitations and in some places by the underground waters.

To the north-east of the municipality, near the Azerbaijani border flows the **Alazani River** and to the south-west part - the **Iori River**. For the irrigation systems of the Dedoplistskaro region the Alazani and Iori River flows have a decisive importance.

On the territory of Dedoplistskaro municipality there are several lakes and among them the Kochebi Lake and the Patara Lake. Salty lake Kochebi is situated on the altitude of 775 m a.s.l. To the north-east of the Kochebi Lake there is the Patara Lake and the banks of the lake in some places are protruded in and out.

In 1988 the Dali reservuar was constructed on river Iori with working capacity 140 mln m^3. The project considered irrigation of the agricultural lands caught between the borders of lower Iori gorge and among them the irrigarion of the area within the Azerbaijanian borders. Due to insufficient funding it was imposible to bring the project to the end, namely it was imposibble to construct the irrigation system depended on the mentioned water reservoir. So the existed water reservoir lost its main function.

Soils

The soils of Dedoplistskaro municipality are versatile. The black soils are most widely spread mainly on the plateaus, from thin to medium thick laying capacities. Grey-brownish and black cloddy soils are also distributed on the significant part of area. On the banks of the Iori River alluvial carbonate soils are dominated and humus-carbonate soils are also represented in small fragments here. We also meet different types of soils which are very washed and with a very small laying capacity, which are also spread on wider territories.

Semi-Arid Landscapes

The following semi-arid landscapes are spread on the territory of Dedoplistskaro:
- Plateaus mountain foot, hilly subtropical, semiarid steppe, Shibliak and semi-desert ;
- Plainand depression arid-denudational landscapes with halophit, partially dry steppes and botriochloa steppes;
- Lowland and foothill accumulative landscapes with artemisia, halophytic deserts and semi-deserts;
- Low mountain arid-denudational landscapes with "shibliak", partially botriochloa and stipa steppes and "phrygana";
- Low mountain arid-denudation landscape with arid light forests (broad-leaved and juniper) rarely with shibliak and phrygana;
- Lowland arid-denudation landscape, with badlands, mountain deserts, rarely with thin juniper and pine tree (the Eldari pine tree) forests.

Land use

Agricultural lands in ***Dedoflistskaro municipality*** cover 141 754 ha, including 50 514 ha of arable lands, 2 163 ha of perennial plantations, but pastures cover 86 037 ha. Forest area covers 20 381 ha, shrubbery 4 480 ha.

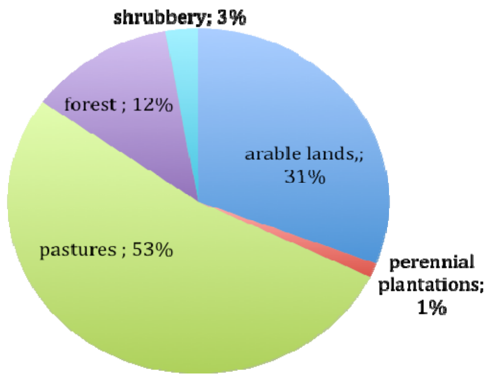


Chart 5. Land use distribution in Dedoflistskaro municipality (%)

Population The total number of the population in the Municipality is 30 240, of which working age Working age population makes 58% ; Population below working age makes 21%; Population over working age makes 21% . The average age in the Municipality is 38.8. The population density is 88 per/km^2. The Municipality includes one town – Dedophlistskaro and 13 villages.

Economic Indices Gross domestic product of municipality consists of 3.97 million Euro, share of agriculture in GDP is 70.5%. Specific gravity of gross municipal production in country`s domestic product is 3.1%. Gross municipal product per a person – 2 632 GEL. Branch structure of economy of Dedoplistskaro Municipality is represented as follows: agriculture (70%),, service (0,5%), industry (11,4%), culture-education (0,1%), transport (0,5%), commerce (15%), construction (0.8%). The greatest share – 70% in branch structure of municipality is held by agriculture.

Employment Major part of the population in Dedoplistskaro Municipality is self-employed - is mostly involved in agricultural activities and consequently the major part of the income for the households come from selling agricultural products. 25% of the population is employed in state agencies. State allowances and pensions also make significant source of income. From Dedoplistskaro Municipality 548 families (1 645 inhabitants) are registered in database of socially unprotected families created according to Regulation #51 of March 17, 2005 of Georgian Government.

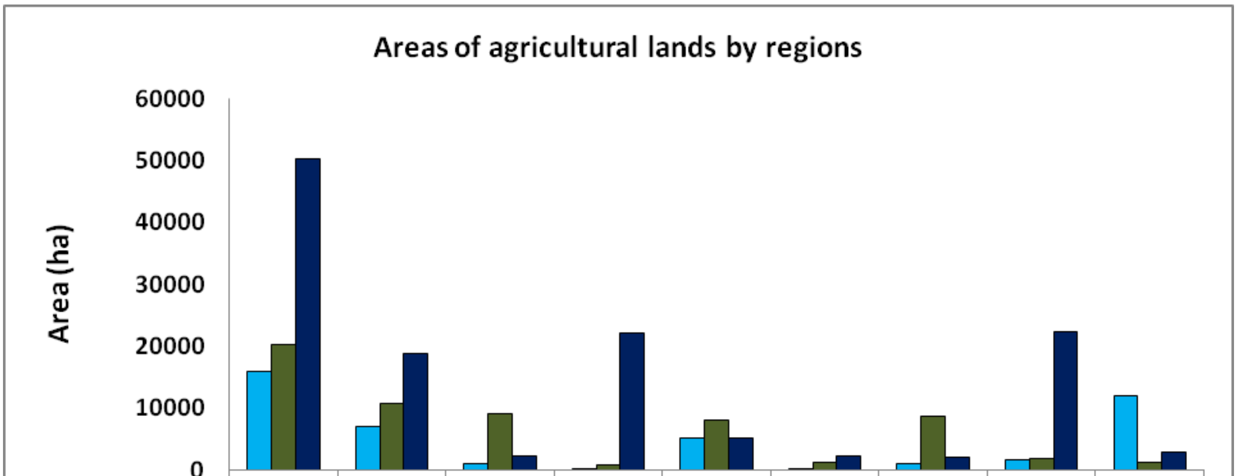
Infrastucture Main problem for population of Dedoplistskaro Municipality is badly organized roads, 90% of which requires full rehabilitation. Problem of water and gas supply has not been settled yet for great part of population. 94 km are asphalted from local roads; drinking water is supplied to 67% of village inhabitants. Natural gas is supplied to 40% of inhabitants.

15 public schools are in municipality.

3. Agricultural sector development in the selected semi-arid areas

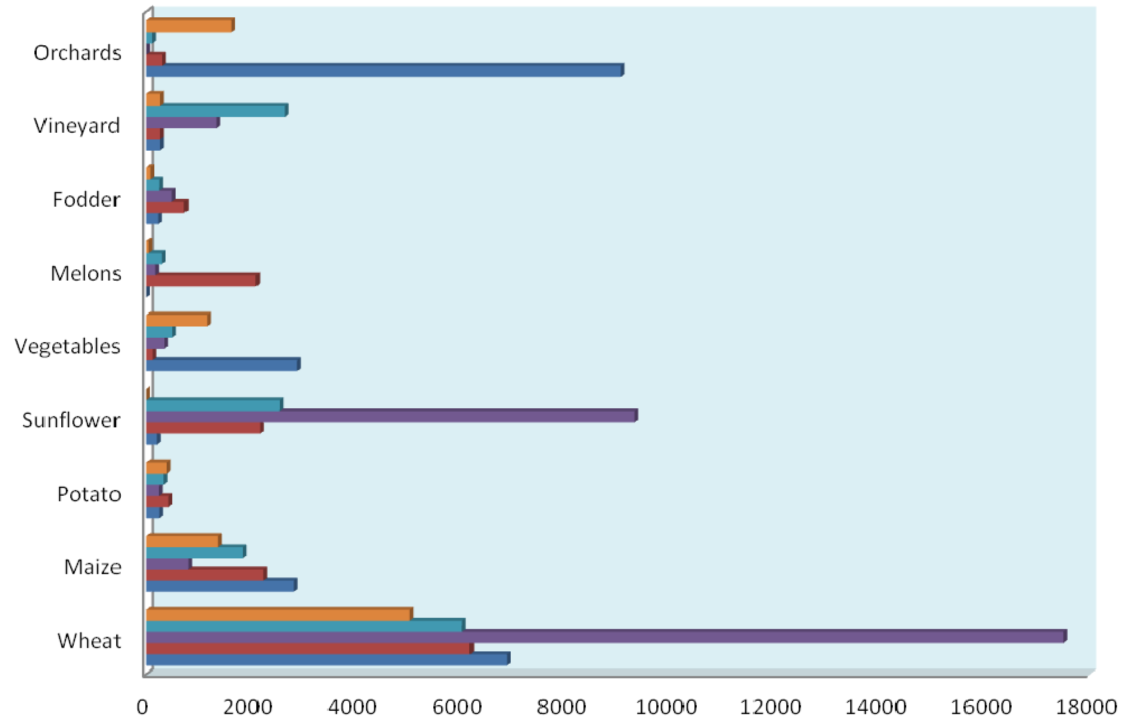
About 18-20% of agricultural lands of Georgia are located in dry subtropical climate zone, where the major horticultural activities are corn-breeding, grape-breeding, and vegetable-breeding. The largest areas are covered by pastures and extremely small areas are covered by mowing lands. Non-irrigated lands are cultivated by wheat, barley, oat and rye from the cereal crops and rarely by grapes. The population of the semi-arid area also grows walnuts, seed-bearing and stone fruit trees, vegetables, legumes and melons, but only on irrigated lands. On the figures 6 and 7 are shown the structure of agricultural areas by regions and municipalities.

Figure 6. Structure of the agricultural lands by regions



	Wheat (ha)	Maize (ha)	Potato(ha)	Sunflow er (ha)	Vegeta bles (ha)	Mealon s(ha)	Fodder (ha)	Vineyar ds (ha)	Orchard s (ha)
Shida Kartli	15995	6973	983	208	5118	63	1028	1622	11894
Kvemo Kartli	20296	10827	9193	822	8045	1195	8617	1757	1281
Kakheti	50192	18720	2249	22088	5161	2175	2145	22227	2860

Figure 7. Structure of the agricultural lands by municipalities



	Wheat	Maize	Potato	Sunflower	Vegetables	Melons	Fodder	Vineyard	Orchards
Kareli	5018	1370	398	0	1160	45	82	267	1627
Sagarejo	6029	1851	338	2544	504	303	253	2643	115
Dedophlistskaro	17492	796	247	9309	351	176	496	1339	1
Gardabani	6173	2228	431	2166	123	2094	730	268	309
Gori	6882	2816	253	207	2880	0	233	267	9044

3.1. Kareli and Gori Municipalities

Since the old days, Shida Kartli has been known as the region of horticulture (cultures growing in subtropical arid climate) and viniculture (grapes for sparkling wine and table wine). “Geographical description of Georgia” by Vakhtang the 6th is the best literary evidence of existence of horticulture and viniculture in this region since ancient times. The source describes the cultures that were spread at that time in different valleys in Shida Kartli and represents the region as land with richest and oldest horticulture and viniculture.

The agriculture of Shida Kartli has suffered the significant changes started from the 50s of the XX century - in the region the new irrigation system has been created and the old system has been reconstructed. Because of appearance of the new irrigation system the areas of irrigated lands exceeded 100 thousand hectares in the region. The areas of annual and perennial crops have increased. The area of fruit crops increased to 40 thousand hectares in 80-ies of the past century and exceeded with the great advantage to such lands in other regions of Georgia. The area of fruit tree crops of Shida kartli created 35% of Georgia in that period. In Shida Kartli region was also cultivated several fodder and technical crops: Sugar beet (*Beta vulgaris*) which was used for local production of sugar by the factory in Agara (Shida kartli) but the yield of it wasn’t the satisfactory for the total production. In the region was cultivated other crops of beet too (B. vulgaris var. *lutea* D.C.; var. *rosea* L.; var. *rubra* (L.) Moq.) that were used as fodders in most cases. For the animal feeding was also cultivated colocynth (*Citrullus colocynthis* Pang.), Jerusalem artichoke (*Helianthus tuberosus* L.) and Lupine (*Lupinus polyphyllus* Lindl.), which are no longer cultivated in modern period.

At present agricultural lands in ***Gori municipality*** cover 61 902 ha, including 22 293 ha of arable lands, 11 000 ha of perennial plantations, 1 988 ha of hayfields, but pastures cover 27 621 ha. State Forest Fund's land covers 44 939 ha, including 35 311 ha of forests; 1 902 ha of shrubbery, 852 ha of fields. In 212 were cultivated up to 16 000 ha of arable land. 2850 ha of wheat, 1787 ha of barley , 4000 ha of corn, 1050 ha of beans, 55 ha of potato, 510 ha of onion and 650 ha of onion and others were planted.

There isn't any large agro industrial establishment in the municipality so farms are small and privately- owned. In 2010 at the area of Gori municipality 24 farms and unions were mainly engaged in fruit growing, livestock farming. 2 of them are certified commercial organic farms.

Main branches of agriculture are: fruit growing, vegetable growing – cucurbitaceous, cereals and grape are grown as well. Main products are: wheat flour, preserved food, apple concentrate, alcoholic beverages, spirit, fruit and vegetables.

In Gori municipality there are operating 2 agro-centers which give consultations to farmers and supply them with farming machines and pesticides.

By 1990, the orchards occupied 18.000 ha and annually yielded 140-150 thousand tons of fruit with region's more than 50% of incomes falling to horticulture. Massive uprooting of gardens that followed land reform in the country has resulted in reduction of the total area of gardens to 11.000 ha. The situation was also conditioned by other factors, such as destruction of the melioration system, suspension of operation of the plants protection and agrochemical services, loss of the traditional market, stoppage of fruit processing enterprises. Sale of high-quality fruit still remains problematic in domestic market conditions.

Area of lands under grain crops has decreased in recent years just like land fertility. No phosphate or potash fertilizers have been imported in the region since 1990s. At present, the municipality annually consumes up to 3000 tons of mineral fertilizers.

The Gori district has always been famous for its unique vine varieties (Chinuri, Goruli Mtsvane and Tavkveri). Before 1990s, the total area of vineyards was 900 ha and annual yield was 4000 tons of grapes. At present the area of vineyards has decreased to 200 ha.

Before 1990s, collective farms and individual farmers kept 20-22 thousand heads of cattle. Now the cattle population, owned by private farmers, amounts to 30.000 heads, including 19.000 cows.

Agricultural lands in ***Kareli municipality*** cover only 36 407 ha, including 18 302 ha of arable lands, 4 678 ha of perennial plantations, 1 764 ha of hayfields and 11 762,5 ha of pastures (It should be noted that according to statistical data of 2005 perennial plantations in Kareli municipality covered 10 215 ha of lands). In 212 plowed and planted were 13 326 ha of lands, including 5568,5 ha of cereals and 7757,5 ha of vegetables.

Main products produced in municipality are: apple concentrate, inert materials, wheat and bread, building materials, cereals, fruit, vegetables milk and milk products, meat.

In municipality there are 400 farms, 16 of them are engaged in different farmers unions.

In Kareli municipality there are operating 4 agro-centers, which give consultations to farmers and supply them with farming machines and pesticides.

Currently all orchards and 87% (15.529 ha) of arable lands are owned privately, 12.852 ha of agricultural lands, including 2.273 ha of arable lands, 987 ha of grasslands and 9.593 ha of grazing lands are owned by the state.

Deficiencies in the supply of irrigation water are named by the local farmers as the basic problem in Kareli and Gori municipalities. After the cancellation of irrigation systems about 30% of the agricultural lands were undergoing to degradation.

Almost all lands under perennial cultures in Gori Municipality (10-11 thousand ha) and 7000 ha or arable lands are irrigated, while 15.000 ha of arable lands are not. Despite considerable efforts taken for rehabilitation of the irrigation channels, a large part of them is still out of operation.

Irrigation systems are also noteworthy, namely the Tiriponi-Saltvili system, which is fed by the rivers Didi and Patara Liakhvi and the Doe-Grakali Channel, which starts from the river Mtkvari, also the Skra-Kareki channel is worth mentioning, which starts from Kvemo Kvedureti. All these channels were built in 1950-65 and therefore they are in need of rehabilitation. Main irrigation channels, which originate from Tskhinvali, during the years, were blocked because of the conflict in the region and due to this the amelioration system is completely undermined.

Currently the mentioned channels do not function. For example, the agricultural-economical lands in Zeltubani and Tsitgelubani had been irrigated from the Nadarbazevi Lake. The irrigation was quite costly, because the electric pumps were used to fill the Nadarbazevi Lake from the Tiriponi and Saltvisi water channel in order to mix the salty lake water with the waters provided form the channels and to use it for the irrigation purposes. Due to the fact, that the Nadabazevi Lake cannot be filled with the river water, the lake is gradually becoming salty and hence it cannot be used for the irrigation purposes any more. Hereby it shoud be pointed out, that in the depth of 5-6 m from the ground surface, there is a ground water with a significant debit observed on this territory, which could be used for the irrigation purposes.

Following melioration activities are considered in the economical development plan of Gori Municipalities: rehabilitation of the Nikozi Irrigation channel from the Saltvisi channel, construction of village Kelktseuli irrigation channel, construction of the irrigation channel in village Skra, rehabilitation of the Kitsnisi-Dzevera channel, arrangement of the irrigation channel in village Karbi, cleaning of the irrigation channel in village Tkviavi, rehabilitation of the irrigation channel in village Kvemo Akhalsopeli, rehabilitation of the irrigation channel in village Sveneti.

In Kareli Municipality, 7820 ha of arable lands are irrigated with help of irrigation channels and 1100 ha are irrigated with water from the rivers Dzama, Prone, Ptsiula, Gvanani, Teliana, Artsvula, Kintsvura and others, while 8882,15 ha are not irrigated. The main irrigation channels are: Tashiskari Channel (irrigates 5000 ha), Kartli Channel - (600 ha), Zeda Rus Arkhi Channel (300 ha), Tsiskvili Channel (300 ha), Leteti Channel (60 ha), Davitis Rus Arkhi (60 ha). A majority of the channels need rehabilitation.

During the past 20 years, desertification process has increased in Shida Kartli, where wind erosion has become more intensive under the influence of temperature rise resulting from destruction of wind belts and precipitation deficit.

According to the Ministry of Agriculture, 8677 Ha of land suffers from wind and water erosion in Kareli Municipality, and 14 157 Ha of land in Gori Municipality. 450 Ha of soil is salted in Kareli and 233 Ha – in Gori.

3.2. Gardabani Municipality

In Kvemo Kartli crop production, animal husbandry and poultry farming make up almost equal shares in agriculture. So-called “suburban farming”, widely spread in the region, is focused on supplying perishable goods, early fruit and vegetables to Tbilisi.

During the last 50 years, main changes in crop production have affected the share of perennial plants and arable lands in the agricultural sector, while the area of grazing lands has increased at their expense. The significant increase in the area of grazing lands was also caused by the decrease in feed crops production, although Kvemo Kartli currently produces more feed crops than other regions of Georgia with alfalva (*Medicago sativa* L.) prevailing among these cultures.

Land farming is mainly spread on irrigated lands (Samgori Irrigation System). Unirrigated lands are mostly located in the areas adjacent to Ialguja. In the recent ten years, only a small part of these lands was cultivated and for the time being the lands are being used for grazing purposes.

In Gardabani municipality there are 1000 farms, 750 of them are commercial.

1 agro-center is operating in Gardabani municipality, which gives consultations to farmers and supplies them with farming machines and pesticides.

As of 2012 Agricultural lands in ***Gardabani municipality*** cover 58 154 ha, including 33 167 ha of arable lands, 4 050 ha of perennial plantations, 2 084 ha of hayfields, 18 845 ha of pastures.

Share of agriculture in the whole sectoral structure of municipality's products amounts to 24,3 %. Main products are: vegetables, cereals, livestock farming and beekeeping.

Vegetable growing used to be the main agricultural sector in the region with total area of lands under vegetables making up 5.000 ha and annual production amounting to 70.000 tons (14-18 t/ha). At present vegetable growing is practiced only by middle-sized farms. There are almost no big farms producing any concrete sort of vegetables in the municipality. The farmers grow tomatoes, eggplants, pepper and onion and sell them spontaneously, mainly at the local market. Grain crops (corn and wheat) are also produced by medium-sized farmers, most of whom buy seeds with only few producing them.

Grassland mainly spread on non-irrigated areas, and are weedy and low-yielding.

The lands has been irrigated since 1950. Main irrigation channels of Zemo and Kvemo Samgori, Gardabani, Teleti, Ponichala and Teleti irrigation channels and their branches are located in Gardabani Municipality. Local population also used for irrigation water from the rivers Mtkvari and Lochini.

Currently the irrigation systems are completely damaged. Some farmers started to use drip irrigation systems but only on small territories.

On the Gardabani lowland mainly chloride salty soils are spread. Composition of chloride salt negatively influences agricultural features of soils and hinders development of the agriculture.

One of the main natural factors for promoting of desertification in Gardabani Municipality is strong winds. Comparing with the period before and after 1980, velocity of strong wind is increased almost five times. Accordingly, 576 ha land is eroded by wind erosion.

3. 3. Sagarejo and Dedophlistskaro municipalities

Kakheti is one of the major agricultural regions of Georgia. The region is on the first place in the country in production of grape and vine. Kakheti is also famous as the oldest and the top producer of cereals. In the parts of the region which are under moderate humid climatic zone is also developed vegetable-breeding, breeding of melon, watermelon and pumpkins and fruit-breeding. Grape-breeding is common in dry areas as well as in irrigated lands. The most common horticultural activity in non-irrigated and dry lands located in Dedophlistskaro and in south part of Sagarejo is corn-breeding and oil-crop breeding.

In the municipalities of Sagarejo and Dedophlistskaro is still cultivated the oldest varieties of wheat: 'Shavpkha, 'Dolis Puri', 'Khulgo' and 'Tavtukhi' and several varieties of barley. In the beginning of the present decade in these municipalities were also intensively cultivated rye, oat and millet the areas of which are decreased for today. During the last century lowland areas and foothills Shiraki and Gareji plains was intensively cultivated by cereal crop varieties such are: wheat - 'Rbili Khorbali' (*Triticum vulgare*), 'Magari Khorbali' (*T. durum, T. turgidum, T. polonicum, T. compactum*); common millet (*Panicum miliaceum*), foxtail millet (*Setaria moharium*) and sorghum (*Sorghum cernuum*) which are no longer cultivated.

Agricultural lands in ***Sagarejo municipality*** cover 94 372.2 ha, including 29 575 ha of arable, 6 425.7 ha of perennial plantations, 1 397.5 ha of hayfields, but pastures covers 56 974 ha. 48 475,8 ha of lands are privately owned, 45 896,4 ha of lands belong to the state. In 212 were 8930 ha of lands (30% of arable lands) plowed and planted, including 7830ha of cereals and 1100ha of vegetables. Arable lands are mainly used for cultivating autumn corps: wheat and barely; and spring corps: corn, sunflower, vegetables and cucurbitaceous.

Share of agriculture in the whole sectoral structure of municipality products amounts to 16%. Main products are: wine-growing, cereals, vegetable frowning and livestock farming.

In the municipality there are 100 farms. There aren't any large farms, farmer's associations, however there are 4 certified organic farms in the municipality.

In Sagarejo municipality there are operating 4 agro-centers, which give consultations to farmers and supplies them with farming machines and pesticides.

The area of lands under crop and the volume of production have been decreasing in Sagarejo for years. As of 2012, 70% of croplands are uncultivated. The area of vineyards is also shrinking. Vineyards are thinning out and their crop yield is dropping. Vineyards are being replaced with melon plantations.

Agricultural production costs exceed the sale price 3-4 times or even more. This is mainly due to the increase in fuel price, obsolete equipment, expensive fertilizers and chemicals.

Natural climatic conditions have changed significantly. Incessant rains in spring and high temperatures in summer 2010 strongly affected winter and spring crops. Farmers had to works and treat vineyards additionally, which resulted in cost increase.

Grazing lands are concentrated on the Iori plateau. Most of them are weedy, non-irrigated and depleted due to neglect and overgrazing.

In the past, up to 90.000 ha of agricultural lands along the Iori River used to be irrigated with Iori water. There are several channels connected to the Iori. The main of them is currently operating Samgori channel. Irrigation water deficit in the arid areas is due to the fact that a majority of arable lands are located at a considerable height from the Iori basin level. Before 1990s, the lands located on the plateau also used to be irrigated through the channels that pumped water from the Iori with help of electric pumps. The channels do not work today.

According to the Ministry of Agriculture data, 213939 Ha lands suffers from wind and water erosion in Sagarejo Municipality, and about 35 Ha is salted.

Agricultural lands in ***Dedoflistskaro municipality*** cover 141 754 ha, including 50 514 ha of arable lands, 2 163 ha of perennial plantations, but pastures cover 86 037 ha.

Only half of arable lands was plowed and planted 2012.127 708 ha of lands are privately owned, 14 237 ha of lands belong to the state.

Major crops for the region are: cereals, sunflower and vine. Crop capacity of the region is significantly higher than average value of Kakheti region.

There are 300 farms in the municipality, 3 cooperatives and 3 certified organic farms.

In Dedoplistskaro climate change impact on agriculture mainly shows itself in intensified land degradation and desertification. The region suffers from frequent and long droughts and strong winds, which greatly contribute to desertification. According to the Ministry of Agriculture, 164.488 ha of lands are subject to wind and water erosion and 828 ha are subject to salinization. The strong winds and sparse woods contribute to erosion of the surface humus soil and consequently to its depletion. Comparative analysis of studies, conducted in 1983 and 2006, shows that during 23 years humus content in the 10-cm surface layer of black soil in Shiraki district decreased from 7.5-9.2% to 2.8-3.2%, i.e. 2.8 times.

According to the data of Ministry of Agriculture, 164 488 Ha suffer from wind and water erosion, and 828 Ha is salted.

Land degradation in Dedoplistskaro district is going most intensively in winter pastures that hold 52% of the district’s area. The pastures are mostly accumulated along the Iori shores and in Taribani. Intensive degradation processes, causes by climate aridization, overgrazing and neglect, are observed in 80% of winter pastures in Dedoplistskaro district.

Until 1990s, farmers used to move cattle from Eastern Georgia to Caspian coastal regions for winter, which allowed keeping the Dedoplistskaro grasslands in satisfactory condition. In early 1990s this process ceased causing an increase in grazing pressure on grasslands in Dedoplistskaro.

More than 50.000 heads of sheep are wintering here at present. The amount exceeds the grazing pressure norm 2-3 times. Southern slopes and bents are affected by erosion most of all. Overgrazing prevents grass regeneration and bare land, subject to erosion and drying under the influence of solar radiation, is washed down into ravines by precipitation and scattered by the wind.

The irrigation systems of Dedoplistskaro greatly depend on the Alazani and Iori rivers. Most of the systems fail to meet modern technical requirements and need reconstruction and upgrading.

4. The current status of floristic complexes and crop varieties in the semi-arid ecosystems of Shida Kartli, Kvemo Kartli and Kakheti and the change tendencies

4.1 Semiarid vegetation complexes of the target regions

During the field works the inventory of the natural vegetation of the following areas have been created: Gori – surrounding areas of Kvernaki range, Gardabani – areas of Iaghluja rnge; Dedophlistskaro and Sagarejo – areas of Iori plateau. The data of field survey are shown in the Table 1 (sections [a, b, c, d]). The field data validation has been performed according to Lachasgvili et al, (2007); Akhalkatsi (2009), Lachashvili & Khachidze (2010); Kvachakidze (2010).

Semi-desert and desert vegetation

Dominants of the semiarid and arid floral complexes are wormwood (*Artemisia lerchianae*), bluestem (*Bothriochloa ischaemum*), prickly thistle (*Salsola ericodes*), and broadleaf milkweed (*S. dendroides*). They form the floral formations on the different landscapes mainly on the gray-brow, salinized and in some cases black soils. The most common formations found during the expeditions are:

- Ecosystem created by wormwood, bulbous bluegrass (*Poa bulbosa* var. *vivipara*) and ephemeras (Artemisieto pooso-ephemerosum) on gray-brown soils in the South-Eastern areas of Kvernaki range; the western plains on Iaghluja range; the Southern parts of Taribana plains.
- Ecosystems created by wormwood, prickly thistle and ephemeras (Artemisieto-Salsolo dendroides-ephemerosum). On the salinized soils to the South-East areas of Taribana plain.
- Ecosystems created by wormwood, bluestem, prickly thistle and ephemeras (Artemisieto-bothriochlooso- ephemerosum). On the gray-brown soils in the South-East areas of Iori plateau; the western part of Kvernaki range and the South west slopes of the Iaghluja range.
- Ecosystems created by milkweed (*Salsola nudosae*) and wormwood (Salsoletum nudulosum-artemisietum lerchianae) South-East areas of Iori plateau, eroded slops on the clay-sodic soils.
- On the extremely salinized soils in the Iori plateau ecosystems are created by Gamanthus pilosus (Gamanthae pilosus)
- On the salinized (sodic-black and sodic-brown soils) of Alazani plains exist the ecosystems created by quack grass (Elitrigieta, *E. repens*) in composition of this plant community also participates *Aeluropus littoralis* and *Cynodon dactilon*.

The most rare and sensitive habitat from semi desert and desert habitats in Kvernaki range is Nitrarietum created by Nitre bush (*Nitraria schoberi* L.) In Georgia Nitrarietum appear only in Meskheti, Shida Kartli, and Iori Plateau in Kakheti.

Friganoid type of vegetation has fragmented distribution and is represented on the Kvernaki range and in the South-Eastern parts of Iori plateau. Formations are created by reaumuria (Reaumuria alternifoliae), pea shrub (*Caragana grandiflora*)

In the survey areas has been also found tragacantic formations composed by tragacant [Astracantha microcephala (Astragalus microcephalus), *A. caucasicus*], prickly thrift (*Acantholimon fominii*).

In Kvernaki range and Iori plateau still appears the most sensitive habitat type of foothill deserts developed on badland clay soils. These habitats are distributed on the extremely inclined slopes of the Eastern part of

Kvernaki near to Shio-Mghvime monastery. The habitats are created by Reaumuria (*Reaumuria alternifolia* (Labill.) Britten) and milkweed (*Salsola nodulosa* (Moq.) Iljin). These habitats are in extremely hard ecological conditions what is caused by: high temperature, absence of the water in soil and extremely inclined substrate. The climate change can be considered as a main threat for these habitats that can lead to complete desertification of the areas inhabited by this species. There is no direct anthropogenic impact on these habitats because of their inaccessible location.

Semi-desert and desert vegetation complexes are typical winter pastures, which have been used extensively irrationally over the decades. This ecosystem is passed through by Baku–Tbilisi -Supsa and South Caucasus pipelines. Moreover, semi desert vegetation complexes are located in surroundings of urban areas that can be defined as the main reasons of their unfavorable ecological condition. In semiarid ecosystem the structure of vegetation is violated and the amount of biomass is critically decreased. The main threat for this habitat is the anthropogenic impact on the background of climate change (Abdaladze, 2007).

Steppe vegetation

The majority of the steppes in the target regions have secondary origin. These steppes appeared mainly in the result of the deforestation of foothill and dry open woodland forests. The major formations of steppe vegetation complexes are created by the two formations 1) bluestem steppes (Bothriochloeta - *B. ishaemum*) and 2) father grass steppes (Stipeta - *Stipa lessingiana, S. capillata, S. tirsa*). The most common formations found during the expeditions are:

- Glycyrrhizieto-Bothriochloëta – Ecosystem created by bluestem (B. *ishaemum*) and licorice (*Glycyrrhiza glabra*). This formation has been found in Iori plateau and on Iagluja range on the gray-brown soils.
- Festuceta-Bothriochloëta - Ecosystem created by bluestem (B. *ishaemum*) and Volga fescue [*Festuca sulcata* (= *F. valesiaca* var *sulcata*)]. This type of steppe is distributed in Iaghluja Mountains (Gardabani), Shiraki and Gareji plateau (Sagarejo) and Eldari plain (Dedophlistskaro) on the forest brown and gray-brown soils.
- *Stipeto-Bothriochloëta* - Ecosystem created by bluestem (B. *ishaemum*) and father grasses (*Stipa lessingiana, S. capillata*). This formation is developed mainly on the forest brown or black soils and is widely distributed in all of the target regions.

The steppes are covering smaller areas in Sida Kartli – Kvernaki range than in the other regions that might be the reason of droughts in summer as well as in the cold period typical in Kvernaki range.

Shibliak type scrub vegetation

Shibliak type vegetation has fragmented distribution area in Iaghluja, Iori plateau and Kvernaki range. Mostly this hemi-xerophyl formation occurs on deforested areas of dry open woodlands or foothill forests on the forest brown soils and is dominated by buckthorn (*Paliurus spina-christi*) and oriental hornbeam (*C. orientalis*). In composition of shibliaks also participate: smoke tree (*Cotinus coggygria*), common spiraea (*Spiraea hypericifolia*), wild cornel (*Cornus mas*), silver thorn tree (*Crataegus orientalis*), common hazel (*Corylus avellana*), scarlet firethorn (*Pyracantha coccinea*), barberry (*Berberis vulgaris*), alder dogwood *(Rhamnus palasii*) pomegranate (*Punica granatum*), willow-leafed pear (*Pyrus salicifolia*), atraphaxis (*Atraphaxis spinosa*), ephedra (*Ephedra procera*), dog rose (*Rosa canina*) and dewberry (*Rubus caesius*).

Dry open woodlands

From the target areas this type of forests is only distributed in the Iori plateau. Open woodlands are developed on the brown soils and mainly are dominated by pistachio (Pistacieta, *P. muticae*) and juniper species (Junipereta, *J. foetidissima, J. polycarpos,* J. rufescens) smaller areas are covered by formations of Caucasian hackberry (Celtisetum, *Celtis caucasica*), Georgian maple (Aceretum, *A. ibericum*) and willow-leaf pear (Pyretum, *Pyrus salicifolia*), in composition of open woodlands also participate: oleaster (*Elaeagnus angustifolia*), smoke tree (*Cotinus coggygria*), wild cherry [*Cerasus incana* (=*Prunus incana*)], alder dogwood *(Rhamnus palasii*), spiraea species (*Spiraea hypericifolia, S. crenata*) and endemic pear species (*Pyrus demetrii, P. georgica, P. sachokiana, P. eldarica*).

Table 1. Inventory data of the semiarid complexes of target regions

a) The list of Semi-desert and desert vegetation

Adonis aestivalis, Aellenia glauca, Aizoon hispanicum, Allium atroviolaceum, Alopecurus myosuroides, Alyssum desertorum, Anabasis aphylla, Artemisia fragrans, Astragalus brachyceras, Bothriochloa ischaemum, Bromus japonicus, Calendula persica, Caragana grandiflora, Colpodium humile, Eremopyrum orientale, Festuca sulcata,Gagea* spp., *Gamanthus pilosus, Helianthemum salicifolium, Iridodychtium reticulatum, Iris iberica, Juno caucasica, Kalidium caspicum, Koelpinia linearis, Lappula patula, Lepidium vesicarium, Limonium meyeri, Medicago minima, Petrosimonia brachiata, Poa bulbosa, Queria hispanica, Rostraria glabriflora, Salsola dendroides, Salsola ericoides, S. glauca, Spergularia diandra, Stipa szovitsiana, Stizolophus coronopifolius, Suaeda microphylla, Tetradiclis tenella, Torularia contortuplicata, Trachynia distachya, Tulipa biebersteinii, T. eichleri, Velezia rigida.

b) The list of steppe vegetation

Bromus japonicus, Carex bordzilowskii, Dactylis glomerata, Festuca sulcata, Glycyrrhiza glabra, Medicago caerulea, Phleum phleoides, Stipa capillata, Trifolium arvense, Trisetum pratense, Stipa lessingiana, Botriochloa ischaemum, Stipa capillata, Festuca sulcata, Stipa pulcherrima, Koeleria macrantha, Phleum phleoides, Cleistogenes bulgarica, Medicago coerulea, Astragalus brachycarpus, Inula germanica, Stachys iberica, Galium verum, Thalictrum minus, Leontodon asperrimus, Filipendula vulgaris, Thymus tiflisiensis, Potentilla recta, Picris strigosa, Veronica multifida, Pimpinella aromatica, Bilacunaria microcarpa, Tragopogon pusillus, Seseli grandivittatum, Campanula hohenackeri, Cephalaria media, Crucianella angustifolia, Xeranthemum squarrosum, Trigonella spicata, Bromus japonicus, Linus nodiflorum.

c) The list of shibliak hemi-xerophyl vegetation

Tanacetum argyrophyllum, Ephedra procera, Cytisus caucasicus, Caragana grandiflora, Dianthus calocephalus, Hedysarum turkewiczii, Onobrychis meskhetica, Teucrium polium, Thymus sosnowskyi, Stachys atherocalyx, S. iberica, Festuca valesiaca, Campanula hohenackeri, C. raddeana, C. alliariifolia, Artemisia sosnowskyi, Stipa capillata, S. pulcherrima, Koeleria cristata, Elytrigia elongatiformis, E. trychophora, E. caespitosa, Agropyron repens* var. *subulatus, Valerianella plagiostephana.

d) The list of dry open woodland vegetation

Pistacia mutica, Juniperus polycarpos, J. foetidisima, J. rufescens, J. oblonga, Celtis australis, C. caucasica, C. glabrata, Pyrus salicifolia, P. ketzkhovelii, P. demetrii, P. takhtadziani, P. georgica, P. fedorovii, P. oxyprion, P. sakhokiana, P. salicifolia* var. *angustifolia. Acer ibericum, Cynosurus cristatus,, Amygdalus georgica,, Atraphaxis spinosa, Atraphaxis spinosa, Berberis vulgaris, Bothriochloa ischaemum, Campanula hohenackeri, Caraganagrandiflora, Prunus incana, Centaurea ovina, Colutea orientalis, Cotinus coggygria, Elaeagnus angustifolia, Ephedra procera, Festuca sulcata, Jasminum fruticans, Lonicera iberica, Paliurus spina-christi, Prunus microcarpa, Punica granatum, Quercus iberica, Reaumuria alternifolia, Rhamnus pallasii, Rhus coriaria, Rosa canina, Silene cyri, Spiraea crenata, Stachys fruticulosa, Tamarix ramosissima, Teucreum polium, Ulmus carpinifolia.

The list of local endemic plants of the target regions are shown in the table 2. The most of these species are inhabitants of the semiarid floral complexes and suffer high anthropogenic pressure such are: irrational use of pasture lands (overgrazing), pollution of the environment, building the pipelines and roads, irrational use of pesticides, plant collection and deforestation. IUCN threat criteria have not yet been assessed for the most of these species but tacking into account the high anthropogenic pressure in their habitats, the listed species must already be considered as vulnerable. The top five species in the table 2 are already in Georgian red list (1982, 2006) with defined status.

Table 2 Georgian and small local endemic species of target regions

Endemic *	Species	Distribution
○	*Acer ibericum* M. Bieb. (NT)	Kakheti, Kvemo Kartli
○	*Berberis iberica* Stev. & Fisch. ex DC. (VU)	Shida Kartli, Kakheti
○	*Paeonia carthalinica* Ketzch. (VU)	Shida Kartli, Kvemo Kartli, Meskheti
□	*Paeonia mlokosewitschii* Lomakin (VU)	Shida Kartli, Kvemo Kartli, Meskheti
○	*Pyrus sachokiana* Kuth. (EN)	Shida Kartli, Kvemo Kartli, Meskheti
○	*Salvia garedji* Troitzky (VU)	Kakheti
□	*Amygdalus georgica* Desf.	Shida Kartli, Kakheti
○	*Aster ibericus* Steven	Shida Kartli, Kvemo Kartli, Meskheti
□	*Astragalus atenicus* Ivan.	Shida Kartli
□	*Astragalus kadshorensis* Bunge	Kakheti
○	*Astragalus kemulariae* Grossh.	Shida Kartli, Kvemo Kartli, Meskheti
□	*Astragalus raddeanus* Regel.	Kakheti
□	*Campanula armazica* Kharadze	Shida Kartli
□	*Campanula kachetica* Kantsch.	Kakheti
○	*Cerastium sosnowskyi* Schischk.	Kvemo Kartli, Shida Kartli, Meskheti
□	*Corylus kachetica* Kem.-Nath.	Kakheti
□	*Fritillaria lagodechiana* Charkev.	Kakheti
□	*Galanthus kemulariae* Kuthatheladze	Kakheti
□	*Galanthus ketzkhovelii* Kem.-Nath.	Kvemo Kartli, Kakheti
□	*Galanthus lagodechianus* Kem.-Nath.	Kakheti
□	*Galatella eldarica* Kem.-Nath.	Kakheti
□	*Galium praemontanum* Mardal.	Kakheti
□	*Gentiana lagodechiana* (Kusn.) Grossh.	Kakheti
○	*Helianthemum georgicum* Juz. & Pozd.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Heracleum wilhelmsii* Fisch. & Ave-Lall.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Iris carthaliniae* Fomin	Kvemo Kartli, Kakheti
○	*Iris iberica* Hoffm.	Shida Kartli, Kvemo Kartli, Kakheti
○	*Nepeta betonicifolia* C. A. Mey. subsp. *strictifolia* (Pojark.) Metits.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Nepeta iberica* Pojark.	Shida Kartli, Kvemo Kartli, Meskheti
□	*Onobrychis kachetica* Boiss.	Kakheti
○	*Onobrychis meschetica* Grossh.	Shida Kartli, Kvemo Kartli, Meskheti
□	*Paeonia lagodechiana* Kem.-Nath.	Kakheti
□	*Paeonia majko* Ketzch.	Kartli
○	*Paeonia steveniana* Kem.-Nath.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Podospermum idae* Sosn.	Shida Kartli, Kvemo Kartli, Meskheti
□	*Psephellus kacheticus* Boiss.	Kakheti
○	*Pulsatilla georgica* Rupr.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Reaumuria kuznetzovii* Sosn. & Manden.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Salvia compar* Trautv. ex Grossh.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Thymus coriifolius* Ronn.	Shida Kartli, Kvemo Kartli, Meskheti
□	*Torularia eldarica* Grossh.	Kakheti

○	*Tragopogon serotinus* Sosn.	Shida Kartli, Kvemo Kartli, Meskheti
○	*Tripleurospermum rupestre* (Somm. & Levier) Pobed.	Shida Kartli, Kvemo Kartli, Meskheti

*** ◘ Endemic species with small local distribution; ○ species endemic to Georgia**

In the target regions exists many Caucasian endemic plant species from which the species listed in table 3 are included in the “Red list of Georgia” (2006) and have defined IUCN status.

Table 3. Georgian red list species occurring in the target areas

IUCN status	Species
Near Threatened (NT)	*Celtis caucasica* Willd.
Vulnerable (VU)	*Celtis glabrata* Steven ex Planch.
Vulnerable (VU)	*Cerasus microcarpa* (C.A. Mey.) Boiss.
Endangered (EN)	*Ewersmannia subspinosa* (Fisch. ex DC.) B. Fedtsch.
Near Threatened (NT)	*Juglans regia* L.
Endangered (EN)	*Nitraria schoberi* L.
Critically Endangered (CR)	*Populus euphratica* Olivier
Vulnerable (VU)	*Pterocarya fraxinifolia* (Poir.) Spach
Vulnerable (VU)	*Quercus pedunculiflora* K. Koch (syn. *Q. longipes Steven*)
Vulnerable (VU)	*Ulmus minor* Mill.

Priority species

East Georgia is rich in rare and endemic plants. The larger number of endemic species appears on the high elevations in subalpine, alpine and subnival belts than on the lowlands of the East Georgia. As it is shown in tables 2 and 3, some of rare and endemic species that appears in target regions are already categorized according IUCN categories and criteria (The red list of Georgia, 2006). From the target regions Kakheti is much richer in endemic and rare species than the other regions selected. Species listed in tables 3 and 4 are distributed mainly on the lowland and dry areas of the target regions. Besides, there are more of such species in target dry lands which are thought to be under the influence of several threats. According to several authors (Lachashvili et al., 2010; Akhalkatsi et al., 2005) Following plants distributed in semiarid complexes of Georgia can also be considered as vulnerable: *Bongardia chrisogonum, Chrysopogon gryllus, Globularia trichostantha, Hedera pastuchovii, Hyppophae rhamnoiddes, Juniperus foetidissima, Pistacia mutica, Platycladus orientalis, Punica granatum, Tulipa biebersteiniana, T. eichleri, Ulmus elliptica, U. suberosa, Vitis silvestris.* These species were included in old Georgian red list (1982). According to Lachashvili et al., (2010) only in the areas of Iori plateau and Alazani basin within the Kaketi region there are 26 species in total which must be included in Georgian red list.

The most sensitive ecosystems of local semiarid and arid flora and indicator species

It is difficult to draw precise conclusions regarding climate change impact on local floristic complexes even with rather diverse field material at hand. There are no accurate comparative descriptions necessary to identify changes in plant cover, plant community distribution or ratio.

The most sensitive ecosystems of local semiarid and arid flora of target dry lands are:

- Steppe vegetation complexes dominated by father-grass species (*Stipa* spp.); bluestem (*Bothriochloa ischaemum*) fescue (*Festuca* spp.) licorice (*Glycyrrhiza* spp.) with geophytes and ephemeral plant species developed on the brown and black soils of deforested lowland and foothill areas.

- Plant communities formed by Nitraria (*Nitraria schoberi*) and as well Reaumuria (*Reaumuria alternifolia)* and milkweed (*Salsola nudosae*) developed on the clay soils of foothills and extremely inclined dry slopes.

By analyze of the existing data, it has been determined that the area of cultivated lands have been extremely decreased on the expense of pasture land increase in the target regions during last three decades. However steppe vegetation which creates the high value of the pasture lands is extremely degraded in the target dry regions during last 60-70 years. Degradation is caused by desertification of lowland and foothill areas of arid territories in project target regions amplified by strong influence of extensive grazing in former times.

According the information received from the scientists specialized on semiarid and arid flora of Georgia, it can be concluded that land cover in the semiarid parts of target regions have decreased for 10-12% on overage from the middle period of past century. This change and is mainly caused by erosion processes on the foothill areas or low mountain slopes. Alongside with climatic factors (unequal distribution of precipitation, change in temperature fluctuation limits, abrasion) this is also due to man's impact (forest felling and irregular grazing).

Observations of the existing studies (Ketskhoveli, 1960; Kikodze, 2005; Lachashvili, 2007; Lachashvili and Chkhaidze 2010) allow concluding that steppe vegetation degradation process has intensified in the target areas during the last 50 years. Most of the steppes in the target area are Andropogon and Andropogon-Stipa steppes. The degradation shows in limited seed turnover of heavy feeders (mainly grain and legumes), replacement of steppe formations with semi-desert shrubs, grasses and weeds. Based on visual and floristic inventory results, degradation is rather intensive and overgrazing is believed to be the main cause of this process (Kikodze, 2005).

The inventory of vegetations conducted within the project identified a few wild flora representatives, the decline or appearance of which are proving that a level of dryness on that territory is increasing, including feather grass species (*Stipa capillata, S. lessingiana*), Nitre bush (Nitraria schoberi L.), Carex and *Salvia*. Using those plant species to observe the affects of the climate changes are to be applied for checking the biodiversity.

The most widely-spread weeds in the steppe are the drought-resistant varieties: *Achillea micrantha, Silybum marianum, Hordeum leporinum, Cousinia orientalis, Centaurea ovina, Salvia* spp. *Chenopodium* spp., and others. The increase in *Salvia* population can be the best indicator of degradation of the steppe vegetation. It is noteworthy that an increase in population of the rare variety of Salvia - *Salvia garedji* – can be observed in Kakheti steppes. Until recently the variety has been considered vulnerable, but climate aridization can cause further increase in its population alongside with the population of other weeds. *Salvia garedji* can be used as an indicator in Kakheti. *Salvia viridis* is widely spread in all the there target areas. The variety can also be used as one of the indicators.

Stipa is relatively moisture loving plant (it can be considered as an agro-biodiversity representative as a common feed source for the cattle) and finds its home more in the sub-humid areas, where it is quite a dominant in nature. It cannot resist to a harsh dryness but easily self-revitalizes under the sub-humid conditions (according to our definition as the steppes). Less presence of this plant in the semi-arid territories of Gori district and especially in Kvernaki maintain range, where animal grazing is almost excluded, once again proves the fact that level of dryness is increased there that is being justified by both the climatic parameters and the semi-aridity index. Artemisia and other plants are replacing Stipa because they are more adapting to semi-desert conditions better. Due to a lack of information about decreased areas where stipa as the plant is growing, it is hard to bring the solid arguments for which an intense monitoring would have be required on fragmentation and less dissemination of this plant that would have brought the real and interesting results on proving the affects of the climate change in the region.

Nitratia easily adaptable to mineralization/acidity and quite a resistant to sever climatic conditions. The plant is mainly growing on the distant places from population and cattle more on hill sides therefore anthropogenic influence on it is less likely. Nitratia is less competitive in the semi-dry areas, but to the harsher climatic conditions this plant is resistant, it even represents a cohabitate. The replacement of plans typical for semi-deserts (floral communities constituted by bluegrass, feather-grass, Salsola ericoides, Salsola dendroides Pall and wormwood,) with Nitratia points at increasing dryness and should be also used as an indicator. It should be noted that the increasing habitats of semi-desert plant complexes and the shrinking habitats of steppe plants point at intensification of climate aridization process. The eventual critical outcome of the process is creation of extremely exhausted badlands that lack grass cover or have critically low floral diversity. Badlands are widely spread up to the middle of the south-east part of the Kvernaki range. Nitratia can be used as the indicator here.

Carex could be used for monitoring the aridity increase and land degradation in the region. A presence of Carex on some deforested areas means that the soil still has some moisture in it and decrease of the plant population is a predicting sign that the soil moisture will be reduced more. In the Ateni ravine between Zemo Ateni village and Ateni village, this plant Carex can be used as an indicator.

Monitoring of the selected plant indicators in the semi-arid and arid areas and dynamics of plant complexes spread in these areas will help to assess intensification of the aridizarion process in the project areas.

Invasive and adventive plants

According the literature data (Kikodze, 2010) the number of introduced plant species in Georgia has extremely increased during the last two centuries, that is reasoned by increase of trade volume, development of tourism and degradation of natural habitats in the country. For today 380 species of introduced plants are identified in Georgia. The most of them are adventive and invasive species. In the dry lands of Georgia introduced plants with several origins can be found. The most common weeds of Georgia are received from Asia, America and Mediterranean. These plants are well adapted to dry climate and create potential risk for local natural and cultivated flora.

The most common invasive species listed below have high importance in agriculture as they were often used as a natural fodder plants as well as for medicinal purposes. Such plants are: common agrimony (*Agrimonia eupatoria*), yarrow (*Achillea millefolium*), Couch grass (*Agropyron repens*), red bryony (*Bryonia dioica*), shepherd's-purse (*Capsella bursa-pastoris*), chickory (*Cichorium intybus*), Celandine (*Chelidonium majus*), cuscuta (*Cuscuta europaea*), black henbane (*Hyoscyamus niger*), deadnettle (*Lamium album*), common mallow (*Malva sylvestris*), field mint (*Mentha arvensis*), common plantain (*Plantago major*), common chickweed (*Stellaria media*), dandelion (*Taraxacum officinale*), coltsfoot (*Tussilago farfara*), nettle (*Urtica dioica*) etc. These species can be found near to the settlements in dry lands as well as in whole of the country.

The most common adventive and invasive plant species of the target areas of Shida Kartli, Kvemo Kartli and Kakheti are:
Amaranthus albus L., *A. blitoides* S. Wast., *A. hybridus* L., Avena *sativa* L.*, Conyza canadensis* (L.) Creng., *Centaurea diffusa* Lam., *Echium biebersteinii* Lacaita, *Erigeron crispus* Pourr., *Euphorbia lathyris* L., *E. nutans* Lag. *Fagopyrum esculentum* Moench*, Gnaphalium affine* D. Don., *G. luteo-album* L., *Paspalum thunbergii* Kunth ex Steud., *P. paspaloides* (Michx.) Scribn. *Hibiscus trionum* L., *Medicago orbicularis* (L.) Bartalini, *Polygonum aviculare* L., *Solanum rostratum* Dun. *Xanthium spinosum* L. *X. stramarium* L.

The listed species below are widespread weed plants of the field crops, cornfields and other rural areas in Shida Kartli:
Cuscuta epithymum L.*, C. approximata* Bab., *C. cesatiana* Bertol., *Axyris amaranthoides* L., *Ambrosia artemisiifolia* L. *Paspalum distichum* (Michx.) Scribn., *Sorghum halepense* (L.) Pers., *Cephalaria syriaca* subsp. *transcaucasica* (Bobrov) Galushko, *Cyclachaena xanthifolia* (Nutt.) Fresen., *Panicum capillare* L., *Sophora alopecuroides* L., *Convolvulus arvensis* L., *Lolium perenne* L., *Avena fatua* L., *Setaria viridis* (L.) P. Beauv, *Polygonum convolvulus* L., *Vaccaria hispanica* (Mill.) Rauschert, *Cyperus rotundus* L., *Dipsacus laciniatus* L. *Phragmites australis* (Cav.) Trin. ex Steud., *Typha latifolia* L.

Extreme growth of the number of weed plants for any ecological reason is not observed in the regions, however it can be concluded that the areas of the weeds has been increased in 50 year period as some of the lands cultivated in former times are left as a pastures in resent period in all of the target regions.

The most widespread invasive tree plants in in target regions are ailanthus (*Ailanthus altissima* (Mill.) Swingle) and Black Locust (*Robinia pseudoacacia* L.). This species where often used by local people of Georgia to create living fences in their gardens. From gardens these tree weeds have been spread in the forested areas and recently are becoming dangerous for forest complexes.

4.2. Crop Wild Relatives

The term "crop wild relatives" (CWR) have two common interpretations. A working definition of a CWR was provided by Maxted et al. (2006): A crop wild relative is a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop. More commonly CWR is defined as wild species from the same genus of the cultivated plant that is in direct relationship to this crop. The last definition of CWR will be used as a major term in the report.

According to Akhalkatsi et al. (2012), in Georgia occurs 479 species from 76 genera of 20 plant families that are in direct relationship to the crops which where cultivated in the territory of the country from the ancient period.

List of priority crop wild relatives of cultivated plants in selected areas is presented in Table 4. The methodology of prioritizing crop wild relatives is given in Annex 1.

Table 4. Summarized data presenting the total score of the crop wild relative species of the selected regions

Crop	CWR Species	Threat (IUCN)	Rarity	Endemicity	GP/TG	Total
Triticum	*1. Aegilops cylindrica*		2		6	8
	2. A. tauschii		7		6	13
	3. A. triuncialis		7		4	11
Avena	*4. Avena barbata*	2	7		6	15
Hordeum	*5. Hordeum bulbosum*		2		6	8
	6.Hordeum spontaneum	2	7		10	19
Secale	*7. Secale anatolicum*	2	7		6	15
Lathyrus	*8. Lathyrus tuberosus*		2		4	6
Vicia	*9. Vicia iberica*		2	4	4	8
Linum	*10. Linum humile*	2	10		10	22
Allium	*11. Alliumkarsianum*		7		2	8
Asparagus	*12. Asparagus caspius*	2	4	5	6	17
Brassica	*13. Brassica elongata*		2		2	4
Coriandrum	*14. Coriandrum sativum*		4		10	14
Lepidium	*15. Lepidium perfoliatum*		7		2	9
Satureja	*16. Satureja laxiflora*		4		10	14
	17. Satureja spicigera		2		6	8
Ribes	*18.Ribes alpinum*		4		6	10
	19.R. biebersteinii		4		6	10
Rubus	*20Rubus cartalinicus*	2	4	10	4	20
	21 R. charadzeae	2	4	10	4	20
	22 R. cyri	2	4	10	4	20
	23 R. georgicus	2	4	10	4	20

	24 R. kachethicus	2	4	10	4	20
	25 R. ketzkhovelii	2	4	10	4	20
	26 R. caucasicus	2	2	5	4	15
	27 R. idaeus				10	10
Cerasus	*28.Cerasus avium*		2		10	12
	29.Cerasus microcarpa	2	6		4	12
Amygdalus	*30 Amygdalus georgica*	2	10	6	4	22
Berberis	*31 Berberis iberica*	2	10	6	4	22
Cornus	*32.Cornus mas*				10	10
Corylus	*33.Corylus avellana*		2		10	12
	34.Corylus kachetica	2	10	10	6	22
Malus	*35.Malus orientalis*				10	10
Mespilus	*36.Mespilus germanica*				10	10
Prunus	*37. Prunus cerasifera*				10	10
	38. Prunus spinosa		2		10	12
Pyrus	*39. Pyrus caucasica*		2	5	10	17
	41 P. demetrii		4	10	2	16
	42. P. georgica		4	5	2	11
	43. P. salicifolia				2	2
Malus	*35.Malus orientalis*				10	10
Mespilus	*36.Mespilus germanica*				10	10
Prunus	*37. Prunus cerasifera*				10	10
	38. Prunus spinosa		2		10	12
Morus	*44. Morus alba*				10	10
	45. Morus nigra				10	10
Punica	*46. Punica granatum*		4		10	14
Castanea	*47. Castanea sativa*				10	10
Vitis	*48. Vitis vinifera* ssp. *sylvestris*	4	10		10	24
Medicago	*49. Medicago sativa*		4		10	14
Onobrychis	*50.Onobrychistranscaucasica*		2		10	12

As it is shown in the list the most vulnerable crop wild relative species are contained in following crop groups: ***Hordeum, Linum, Amygdalus, Berberis, Corylus, Pyrus*** and ***Vitis***. These groups with indicted high scores of the species can be considered as priority groups of the crop wild relatives for all target regions.

4.3. Current conditions and trends of agrobiodiversity in selected semi-arid regions

Based on literature date (Khomizurashvili, 1931, 1941, 1969; Tsulukidze, 1940, Menabde, 1948, Ketskhoveli, 1957, Ramishvili, 1986) major grape, cereal, legume, vegetable, melon, watermelon, pumpkin, fruit, nut and berry crops that where cultivated in target regions since the 50s of the past century have been identified. In the table 5 is shown explained by how many varieties was the specific crop presented in all target regions and what number of it exists now.

The analysis of statistical date shows a dramatic decrease in areas under crop in the study areas and throughout Georgia as compared to the middle of the 20th century. The areas under crop have decreased by 60% on average and even by 80% as far as certain cultures are concerned. Some cultures (millet, grass pea, lens, lentil, etc.) have been removed from production owing to socioeconomic changes. Besides, during the past three decades, lots of annual and perennial cultures have been imported in Georgia without any control or study, contributing to the genetic erosion that started in Georgia in the soviet times.

The semi-arid areas of the selected region currently have rahther low diversity of crops. The econmic and ecolological developments of the last 50 years have greatly contributed to genetic erosion in the country, and particularly in the semi-arid areas.

Table 5. Statistical review of crop varieties (1940-2010)

Crops and varieties	Total number	Removed	Existing
Grapes			
Grape	188	98	90
Cereals			
Oat	1	1	0
Barley	18	11	7
Common millet	1	1	0
Foxtail millet	1	1	0
Rye	1	1	1
Wheat	60	45	15
Maize	21	6	15
Legumes			
Lentils	1	1	0
Horse beans	1	1	0
Lablab	1	1	0
Chickpea	1	1	0
Bean	47	0	47
Soya	1	0	1
Grass peavine	1	1	0
Chilipuca	1	1	0
Pea	1	1	0
Narbonne vetch	1	1	0
Cow Pea	1	1	0
Vegetables			
Tomato	14	9	6
Eggplant	3	1	2
Pepper	4	4	4
Cabbage	14	9	5
Savoy Cabbage	2	2	1
Brussels Sprouts	2	2	1
Cauliflower	3	3	1
Broccoli	1	1	1
Kohlrabi	1	1	0
Collard	1	1	0
Cucumber	8	4	4
Onion	6	2	4
Garlic (Rocambole)	1	0	1
Leek	2	1	1
Chard	1	1	0
Sugar beet White	1	0	1

Sugar beet Yellow	1	1	0
Sugar beet Rose	1	1	0
Sugar beet Red	4	2	2
Carrot	4	3	1
Chinese Radish	1	0	1
Radish	1	0	1
Potato	6	2	4
Sweet-potato	4	4	0
Parsley	2	2	2
Celery	2	1	1
Spinach	4	2	2
Chervil	1	1	0
Garden Cress	1	0	1
Lettuce	1	0	1
Dill	1	0	1
Cilantro	1	0	1
Basil	1	0	1
Summer Savory	1	0	1
Sorrel	1	0	1
Tarragon	1	0	1
Rape	1	0	1
Parsnip	1	0	1
Melons			
Asparagus	1	0	1
Watermelon	12	4	8
Muskmelon	12	3	9
Pumpkin	7	0	7
Marrow, Acorn Squash	1	0	1
Cocozelle	1	0	1
Pattypan Squash	1	0	1
Butternut Pumpkin	1	0	1
Fruits			
Apple	59	29	30
Pear	44	10	34
Peach	48	21	27
Quince	11	4	7
Apricot	14	4	10
Cherry	27	8	19
Plum	41	18	23
Fig	25	7	18
Persimmon	11	3	8
Pomegranate	21	10	11
Medlar	1	0	1
Blackthorn	1	0	1
Hawthorn	1	0	1

Cornel	1	0	1
Russian-olive	1	0	1
Berries (annex 1, G)			
Barberry	1	0	1
Strawberry	1	0	1
Musk Strawberry	1	0	1
European Strawberry	1	0	1
Sea-Buckthorn	1	0	1
Mulberry	1	0	1
Black Mulberry	1	0	1
Red Currant	1	0	1
Black Currant	1	0	1
Raspberry	1	0	1
Dewberry	1	0	1
Blackberry	1	0	1
Caucasian Whortleberry	1	0	1
Cramp bark	1	0	1
Nuts (annex 1, H)			
Almond	11	3	8
Georgian Nut	1	0	1
Nut	11	4	7
Walnut	5	0	5

In cereal and legume crops not only varieties but the crops are also removed from production.

This is a long-lasting process, but during the past 50 years, farmers in the target areas continued to grow some crops - numerous local wheat species and landraces (local cultivars), such as millet, lentil, broad bean, Setaria italica, rye, lathyrus, Envum Ervilia, and chick-pea. At present the cultures are critically endangered in the selected region.

This fact is mainly reasoned by economic factors. Beans from legume crops and wheat from cereals are the most valuable in economical point of view in Georgia, the other cereals and legume crops were mainly used as a fodder plants and soon after the end of former socialistic period production of them had stopped or extremely decreased in the country. There is not good market for the fodder plants inside the country as the hay, moved in the most parts of Georgia have very high quality. The same can be concluded in case of the other crops – introduced high-quality crop varieties have removed many traditional varieties and landraces since the 50s of the past century.

In modern times mainly varieties of spring cereal crops, vegetable crops and early maturing fruit crops are introducing in the country. Most of them are unrecorded. In Eastern Georgia local farmers use numerous synonymic varieties of modern or new species. Some species are known under different names in different regions of Georgia. This problem first of all concerns the annual plants. The farmers, who tried to cultivate old traditional varieties of wheat or barley, apparently used mixed seeds. Some local farmers believed they sowed Shavpekha, Dolis Puri, Eksmtskriva Keri and other traditional varieties, but samples from their fields did not coincide morphologically with the mentioned species (Menabde, 1948).

During the past decade, spring wheat was the most frequently imported of grain crops. Besides the economic factors this fact can be concerned to climate change. According the collected information in local people of Sagarejo and Dedophlistskaro municipalities, in the dry lands of Iori plateau about four German, France and American varieties of the spring wheat have been tested during the last three years. As the locals were admitting, all of these new varieties are useless because of the intensification of droughts in the spring time, during their vegetation period.

During the expeditions in the project target regions of Georgia local farmers were asked several questions about what problems do they face during their horticultural activity. What crops and varieties of traditionally cultivated or introduced plants are they preferred in former times and in recent period and what kind of supply methods they use for propagation and care of the crop plants.

It should be noted that local farmers have ambition to cultivate oldest traditional crops and varieties but the economic importance of them are very low and because of this reason the old crops have very small distribution and use. Locals know quite well modern and the oldest crops. However there are some varieties and breeds introduced in period of the collapse of former Soviet Union which are mistakenly named as old crops. This period is thought to be the hardest by the means of genetic erosion in Georgia. Crop varieties introduced in that time are not registered and there is no description of them in horticultural literature.

In the municipalities of all of three target regions diversity of grape varieties and landraces are higher than in case of the oldest traditional crops: fruits, nuts, grains and especially legume crops and varieties which are replaced by other modern and economically valuable crops.

To mitigate the genetic erosion, it is necessary to popularize local draught-enduring and frost-resistant species in the target areas. The Meskheti-Javakheti region, bordering on the target areas, is particularly rich in such species. Table 6 below shows a short list of local and introduced more or less drought-enduring species that used to be cultivated in the target areas in the middle of the last century.

Table 6. Drought-enduring cultures and varieties

Grain crops	*Legumes*	*Vegetables*	*Grapes*	*Fruit*	*Nut plants*
Wheat	**Grass pea**	**Tomato**	“Rkatsiteli”	**Apple**	**Almond**
“Zanduri”	**Lentil**	**Anion**	“Sachino” (“Chinchura”)	“Nabada”	**Hazelnut**
“Asli”	**Soya bean**	**Garlic**	“Kharistvala”	“Turashauli”	
“Dika”	**Garbanzo**		“Saperavi”	“Mamuli”	
“Shavtkha”	**Pea**		“Lomiauri”	“Kirimula”	
“Doli”	**Kidney bean**		“Grubela”	“Kekhura”	
Most of local winter barley species	**Austrian winter pea**		“Shavkapito”	“Reneti”	
Most of local oats species	**Field bean**		“Izabela” (“Adesa”)	“Rozmarini”	
Most of millet species	**Lentil**		“Mahmudi”	**Pear**	
Most of rye species			“Taipi”	“Panta Mskhali”	
Corn			“Khalili”	“Tapla Mskhali”	

"Kviteli Simindi"	"Khechechuri"
"Mtis Kviteli"	"Kakhuri Gulabi"
"Chokela"	"Samariobo"
"Ajameturi"	"Milakhuri"
Most of sunflower species	"Beg Armudi"
	"Ber Boski" (Alexander's Pear)
	"Kipera"
	Alycha
	Pomegranate
	Oleaster
	Hawthorn
	Barberry

5. Vulnerability Assessment of Selected Semi-arid Areas to Climate Change

5.1 General climatic characteristics of semi-arid areas of Georgia

Four meteorological stations located on semi-arid territories: Gori, Sagarejo, Dedoflistskaro and Gardabani have been evaluated initially within the project. Those semi-arid territories have been selected in accordance with an aridity index calculated by main climatic parameters on the basis of norms existed before 1960 as well as based on Map of Natural Landscapes of the Caucasus Region (by Prof. N Beruchashvili, An Ecoregional Consrevation Plan for the Caucasus, WWF, May, 2006).

The meteorological stations mainly were characterized by 4 periods: from their opening until 1960 (the basic norm), between 1956-1980 (I period), between 1981-2005 (II period) and future 2020-2050s. Fixed norms for the various climatic parameters of the basic period is taken from a climatic reference book in which there are norms calculated for the meteorological stations before 1960 (mainly 30-years averages called hereafter a "basic norm", Annex 2). I and II periods are evaluated by the data obtained through the real observations, when the future evaluation is based on a regional model (PRECIS) used in the Second National Report of Georgia prepared to the UNFCCC (United Nations Framework Convention on Climate Change).

The field visits and interviews with local people have revealed that in these territories described above the aridity is very local phenomena and those meteorological stations are not always able to adequately demonstrate this local affect which is rather caused by the annual harsh winds than by a shortage of the annual precipitation level. In fact, those stations are not the agro-meteorological stations (most of agro-meteorological stations don't function any more), which are on the same altitude and closer vicinity to the agricultural plots and they are measuring all climatic parameters on a lower level i.e. the measuring devices are at the same lower height as the agricultural crops. Out of the studied stations, namely Sagarejo and Dedoflistskaro are on a higher altitude, therefore on the basis of some consultations with the agricultural experts it was decided to consider other stations located in the same districts (one in each district) as Udabno and Eldari which were not evaluated before because by that time they were already closed (not functioning) - therefore there are no current data that could have been retrieved - but they are located on a more lower altitude therefore would be able to describe the local climate in the district better than the others.

Evaluation of four meteorological stations functioning on the semi-arid territories in Georgia have shown a general trend that the climate on those territories is more tend to warming on the expenses of the Fall and minimum temperatures (absolute minimums or mean of absolute minimums), when the spring is getting cooler and with excessive precipitations in some places.

A meteorological station in Gori was used for characterizing climatic parameters of **Kareli and Gori districts,** which is located on 588 m. altitude above sea level and in accordance to the basic climatic norms (1925-1960), the absolute maximum was +40^{0}C and absolute minimum was -28^{0}C, which are lowered now and the lowest temperatures detected during I and II periods equal to -26^{0}C and -22^{0}C. The basic period value of the absolute maximum was not repeated in the following years. As for the average of mean annual temperature for the same basic period it equaled to 10.9^{0}C with the coldest January month average of mean monthly temperature -1.2^{0}C which in the II period turned positive figure (0.05^{0}C) and showing an increasing tendency. August was considered as the hottest month in Gori region, with the average of monthly temperature of 22.3^{0}C. For this period the district had a mild precipitation level with maximum of 760 mm and minimum 330mm. The average norm of the annual precipitations in the basic period equaled to 498mm and slightly is increasing in the following periods. The winds are the main contributor to the aridity of the district. The average of mean annual speed of the wind was 4.1 m/sec. but those speeds are lowered and the maximum speeds are increasing.

A meteorological station Sagarejo located on 802 m altitude above sea level was used for characterizing **Sagarejo** district climatic parameters. In accordance to the data of 1916-1960, the average of mean annual temperature was 11^{0}C. Similar to Gori district, the coldest month in this time period was January with the average mean temperature -0.1^{0}C and absolute minimum -24^{0}C. In the following periods the average temperature of the coldest month increased and equaled to +1.10C but the lowest was -17.80C. The average monthly indicator of the hottest month as August was 22.0^{0}C. In the same month there was the absolute maximum observed in this period that equaled to 38^{0}C. In 1981-2005 there was 1 degree higher maximum indicator as 39.2^{0}C. In the basic period the maximum of precipitations was 126mm (June) and minimum 28mm (January), but the average precipitations in the same period equaled to 779 mm that was increased in the following periods to 779 mm. Among the meteorological stations located on the semi-arid regions, Sagarejo is the one with the highest precipitation level. The average of mean annual speed of the wind was 2.2 m/sec. but those speeds are slightly decreased by now.

Udabno territory was described according to the data provided by the meteorological station Udabno which is located on 745 m. altitude above sea level. During the basic period 1951-60 this area's average annual temperature was 10.4^{0}C which is slightly increased in the following period. The coldest month is January with the average temperature that was -1.1^{0}C. Similar to other districts, the coldest month is getting warmer and in I period the temperature reached 0.4^{0}C and then lowered to 0^{0}C. The hottest months are July-August with the average monthly indicator equals to 22.2^{0}C. In the period, the absolute maximum temperature was 38^{0}C which never happened again. In the basic period, the lowest absolute maximum was -25^{0}C. But in following two periods, the lowest temperature was -18.2^{0}C. The annual average precipitation level in the Udabno's territory in the basic period, equaled to 434mm which was increased later and reached 460mm. In the basic period was characterized by very harsh wind with the average speed of 3.9 m/sec. North-west and east winds were more common and constituting 60%. In the following period, especially in the second period, the average annual wind speed is significantly decreasing to 2.3 m/sec.

A meteorological station Dedoflistskaro located on 800 m. altitude above sea level was used for characterizing **Dedoflistskaro** district climatic parameters. In accordance to the observations of 1951-1960, the average annual temperature was 10.1^0C that is increased by 0.9^0C in 1981-2005. Similar to other districts, the coldest month during the basic period was January with the average temperature of -1.2^0C. But in the following periods the average temperature of the coldest month was increased and reached $+0.4^0$C in II period. The highest indicator of the temperature indicated in the reference book was $+35^0$C but the latest data is giving 39.5^0C. The lowest as -26^0C is never happened again and the absolute minimum during 1981-2005 equaled to -16.2^0C. Due to the obvious continental climate, the annual amplitude (annually averaged daily amplitude) is the greatest throughout Georgia and equaled to 25^0C approximately before 1960. In I period that we studied, there was the higher amplitude detected once, but in II period, by 10 times higher and reached even 30^0C. The annual precipitation level in the district varies from 300 (east lower land) to 600 mm (relatively on the higher terrain and slopes of hills). The average annual speed of the wind equals to 2.1 m/sec. but those speeds are decreased by now and the maximum speeds increased. The time period between February - April is characterized with more severe wind.

The climatic description of the territory of **Eldari** valley was made in accordance with Eldari meteorological (since 1967 it was a check point until 1986) station which is located on 500 m. altitude. On the basis of the data before 1960, the average annual temperature was 11.6^0C, the coldest month is January. Its average indicator was 0.5^0C but in the following period it became 0.4^0C. The hottest months of the basic period were July-August with its average indicator that equaled to 23.9, 23.8^0C respectively. The absolute maximum equaled to 39^0C which never happened again but the absolute minimum was -26^0C that never lowered than -23.5^oC in the following months. In the basic period the precipitations equaled to 470mm that never changed in the following periods. The average annual speed of winds was 2.3 m/sec that was lowered slightly to 2m/sec. The west and north-west winds are mostly common to this area and constituting 46%.

Gardabani district was described according to the data provided by the meteorological station Gardabani which is located on 300 m. altitude above sea level. During the basic period (1936-1960) the multi-year data of the station was indicating that this area's average annual mean temperature was 12.9^0C with $+41^o$C absolute maximum and -25^0C absolute minimum. Similar to other districts, the coldest month in the basic period was January with the average temperature of 0.3^0C. However this indicator in the following period was decreased and became a negative figure, but after this in the II period it moved to a positive one that equaled to 0.2^0C, however the lowest temperature in this period was as low as -20.0^0C. In the basic period, this district was quite a dry where the total of the annual precipitations equaled to 402mm. Temperatures in I and II periods is showing the tendency of increasing 0.6^0C and the precipitation level even lowering than before that equaled to 383mm in II period. The region becomes even drier. The winds are highly contributing to the aridity of the region. The average annual speed of the wind was 2.1 m/sec, but those are decreased now as well as the maximum speed of winds.

The detailed information about the climate parameters about the current and future (2020-2050) changes in these districts are presented in separate report placed on the web-site of RECC (www.rec-caucasus.org).

All above mentioned information and attachments to this document are proving a tendency of the overall warming background in those semi-arid areas. Actually, the average temperature of the coldest month - January, at all stations in II period is a positive figure, the average speed winds are lowered everywhere mostly in Gori, but the maximum winds are increased and still increasing at most stations especially in Kakheti region.

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The analysis of the average annual climatic parameters of the above discussed meteorological stations shows that the highest annual **temperature** is characteristic to the Gardabani and Eldari (annex 3) stations. It will remain the same in the future. The changes happened between I and II periods, the biggest increase is at Eldari station and the second biggest is at Dedoflistskaro. Despite the fact, that the Gardabani temperature is less changed than it did at any other stations (except Gori), its average annual temperature still remains too high until 2050. The absolute maximums don't differ much between those stations but Gardabani always was and would remain the number one, but with the absolute minimum the Gori will stay as station having the lowest absolute minimum.

Among the stations discussed, the Gardabani is the driest, then Udabno and finally Eldari, but the **most precipitations** are is Sagarejo – this trend would remain as same in the future (Annex 4). In the future until 2050, the precipitations are increasing everywhere but slightly. The smallest increase will be in Gori and Gardabani which could not even cover an error of the model and therefore we should think, that decreasing is more likely that increasing. Between I and II periods of spring season there are a slight increase in precipitations observed in all stations and mostly in Dedoflistskaro. Exceptions are Gori and Sagarejo only.

As it was mentioned above, the aridity in Georgia is still having very local affect, the constant winds are considered to be the main reasons for. Out of the stations described, first Udabno and then Gori stations are characteristic to the highest average annual wind frequency in the basic and I periods. The mean value winds are the highest during the spring and summer times first only in Gori and then in Udabno. In II period the mean speed of winds are decreased everywhere but not in Gardabani station where a slight increase is even observed. In the future mean speed of wind is decreased everywhere but remain constant only in Gardabani. As for the high speed winds (so called blows) the highest speed is more characteristic to Udabno (40 m/sec) for all seasons. The Sagarejo station is on the second place and then comes Gori. Almost in every station, those winds were the highest in speed only during the spring time and gradually were increased in the following period. Those are not contributing much to the aridity of the area, but too dangerous to the agriculture sector, because the high speed winds when there are no wind-breakers, are taking the upper humus layer of the soil off as a result of which the crop yield drops significantly (annex 5).

Semi-arid territories usually are having a characteristic of severe droughts. The **droughts** have been evaluated by SPI method (standardized precipitation index, annex 7) and results are included in the annex 6. Two types of severe and extremely severe droughts will be evaluated in the regions for I and II periods. The overall picture have shown that the most frequent severe droughts - especially of a 12 month-duration, took place in I period in Dedophlistskaro district included Eldari too. Those 12-month duration droughts are the hydrological droughts, but 3-month-duration droughts are mainly related to the soil moisture and affecting the agriculture sector mainly. Those types of droughts are mainly taking places in Sagarejo, Dedoflistskaro and Eldari. Gardabani has them less frequently. Though, they will be increasing in the future especially in Sagarejo and Dedoflistskaro. Regarding the extremely severe droughts there is almost none, or only a few in Gardabani and Gori. They are more characteristic to Udabno, Sagarejo and Dedoflistskaro districts where the tendency of increasing the frequency of such droughts is observed. The hydrological droughts (12-month-duration) are significantly decreased In the II period especially in Dedoflistskaro, however the increase of those type of droughts in the future is still expected.

Analyzing all six meteorological stations located in the closest vicinity to the semi-arid territories (none of which is located right on such territory itself, except of Eldari station) has shown, that the main problem of the agriculture sector in Kakheti region is basically related to the agricultural droughts, but in Shida Kartli and Kvemo Kartli regions, those are mainly related to high speed annual winds and high temperature. In both cases, those two components are having the major influence on development of the semi-aridity of the areas including the vegetation. This is also proved by the index of dryness, which is to be calculated for those stations (Annex 9).

There are the extreme weather indexes evaluted for those stations along with the mentioned parameters such as: SU25 (a number of days when day-night maximum is Tmax>25°C), tropical nights – TR20 (a number of days when day-night minimum is Tmin>20°C), frosty nights – FD(0) (a number of day-nights when minimum is Tmin<0°C), frosty days – ID (0) (a number of days-nights when maximum is Tmax<0°C) (Annex 3).

Per **hot days (SU25) and tropical nights (TR20) indexes**, Gardabani and Eldari are sharing the first and the second places, but a number of hot days are decreasing in Eldari in the II period but a number of tropical nights are increasing in both districts. Udabno, where a number of hot days are increasing significantly, is gradually taking the fist place per hot day index, while Gardabani takes only the second place after Udabno. Regarding the tropical nights this trend is repeated and Udabno is on a first and Gardabani moves to a second place. Thus, Udabno is becoming the hottest spot in the future among other semi-arid territories throughout Georgia and if we consider an increase of frequency of droughts and the average annual winds, it will more become like a situation in Gardabani (Annex 3).

The analysis conducted per frosty nights (FDO) and frosty days (IDO) indexes from a warming stand point show that Gardabani, Eldari and Udabno are significantly warming per a day index, but Dedoflistskaro and Udabno per the frosty night's index. The Kakheti region is more characterized by severe frosty nights especially Dedoflistskaro district in the winter time. However, this index extremely drops in the future, indicating that there would be better conditions for the winter wheat from the freezing stand point. Though, the day frost index is going to be increased significantly in Dedoflistskaro and Eldari. Therefore, final affects of those indexes on the agriculture is very hard to evaluate (Annex 3).

5.2 . Assessment of agro-climatic parameters and aridity indexes

Some other parameters important for agriculture sector have been also evaluated such as: **sum of active temperatures** (when it exceeds 10^0C) and **vegetation periods** (Annex 8). It is actually obvious from the attachment that the active temperatures sums are increasing in almost all periods which proves the ongoing warming process thus creating a better condition for vegetation especially for a grapevine when a sugar content of grapes are mainly dependent on the totals of active temperatures (sugar content of grapes is formed when active temperatures sum exceeds 20^0C). The sums of active temperatures when the temperature exceeds 10^0C can be compared to three past periods: basic, first and second. Analyses show that this sums of active temperatures is mainly increased in Eldari, Dedoflistskaro and Udabno. The least is detected (no changes) in Gori station. The vegetation period varies for the different crops, it depends on what temperature it starts vegetation. Almost no changes in vegetation period is observed in Gori district. For the grapevine favourite conditions are being created in Sagarejo district where the sum of active temperatures more than 20^0C has been increasing and vegetation period is being prolonged mainly in fall season.

Except those parameters those four stations (Eldari, Udabno, Gardabani and Gori[2]) were evaluated against the aridity index trends. FAO (Food and Agriculture Organization) model CropWat was used for this evaluation. The UNEP's definition of different types of aridity of territories are included in a table below.

Clasification of territories	Aridity Index	Amount of territories existing globally (%)
Hiper-arid	AI<0.05	7.5
Arid	0.05 <AI < 0.20	12.1
Semi-arid	0.20 < AI < 0.50	17.7
Dry subhumid	0.50 < AI < 0.65	9.9

As it has been pointed out above, in order to identify to what category the territory belongs to (considering its climatic dryness), the aridity index (AI) developed by UNEP was used. It is calculated by a potential evapo-transpiration and the average annual precipitation to be characteristic to the relevant territory. The formula is as follows (UNEP 1992).

$$AI_U = \frac{P}{PET}$$

where,

PET - is a potential evapo-transpiration

P - is the average annual precipitation

Those two figures should be expressed in the same unit (mm).

[2] Sagarejo and Dedoflistskaro were excluded due to their high altitude location from the sea level, thus could not describe the agricultural territories well enough.

Potential evapo-transpiration of the given area has been calculated by CropWat (FAO) model using the above UNEP formula in order to assess water deficit of concrete plants considering their specific features. The methods and calculation parameters are given in detail in Paragraph 4. Aridity indexes for the mentioned stations are given in the table below, while data used for their calculation are presented in Annex 9.

Meteostation	Time period	AI
Gori	1980-2005	0.470
Gori	2021-2050	0.392
Gardabani	1980-2005	0.365
Gardabani	2021-2050	0.365
Udabno	1963-1992	0.501
Udabno	2021-2050	0.474
Eldari	1951-1965	0.484
Eladari	2021-2050	0.498

It becomes clear that the most arid station throughout Georgia is Gardabani which would remain so in the future. Gori is on the second place and would become more arid in the future but would remain as second. As for the Udabno, it was more dry and sub-humid before 1992 but would be more semi-arid in the future on the expenses of the mean annual winds as it was mentioned above. This index is characteristic to the territory and not to the vegetations.

4. Assessement of water deicit of some agricultural cultures in semi-arid areas

While selecting the pilot territories, the trends in water shortage for some agricultural crops, as most relevant ones for the districts, were also applied. Cabbage was selected as the leading agricultural crop in Shida Kartli (Gori), tomatoes in Kvemo Kartli (Gardabani), pastures and winter wheat in Kakheti region (Sagarejo, Udabno, Dedoflistskaro, Eldari). For increasing the validity of the argument, the evaluation have bee conducted over the same crops (cabbage, tomatoes, wheat) in all four districts and some comparative analysis was developed, however the pastures were evaluated for the Eldari and Udabno territories only. Water shortages over the agricultural crops are included in annexes 10 and 11. The latter also includes a daily water demand per each crop and the shortage for a year round.

The start of the vegetation periods for the agricultural crops the shortage of water (used in the model) to be evaluted for, are included in the following table:

Type of crops	Beginning of Vegetation
Cabbadge	07.06 (planting)
Tomato	25.04 (planting)
Wheat	05.10 (Gori) 11.10 (Udabno)
Pastures	01.05

The results are shown in attachments IX and X. On the basis of those results we can come to a conclusion that out of all those crops that have been analyzed above, the pastures have the biggest demand on water in Udabno and Eldari that is more increasing in the future. Besides, the water is even getting less in there during the winter time. The next crop in that regard is winter wheat and tomatoes respectively. If we observe the water demand of agricultural crops in various districts we will see (in case of cabbage and tomatoes) that both crops are in need of water now in Gardabani and then in Gori-Kareli. Cabbages (leading crop in Gori district) might have problems in Gori and this district may require more water resources in a short run, but the water shortage will anyway be higher in Gardabani. At present, the winter wheat requires more water in Gardabani and then in Gori. But the future pictures are to be changed and the highest water demand will be in Gori for the wheat crop. In eldari water is running out in pastures but the water demand is higher in Udabno.

The finally we conclude that in Gardabani (approximately 75%) and in Gori-Kareli (approximately 65%) all those three agricultural crops will have more water shortage than in other districts. But in the future the water demand by some of those crops will be decreased in Gardabani though the shortage will be still very high. In addition to the information was given above about selecting the pilot territories, some extra efforts will be required to envisage: an amount of irrigation water, conditions of an irrigation system and conditions of wind-breaks because the aridity of this region is not caused by a lack of precipitation but by the average annual high speed winds, especially in Gori and Kareli.

5.4 Indicators of climate change impact on biodiversity and agrobiodiversity in the selected semi-arid areas

According to the analysis of the climatic parameters, through envisaging the aridity index, the territory covered by the Gardabani meteorological station, among those finally studied stations (Eldari, Udabno, Gardabani, Gori), is the hottest and driest and this condition would remain the same in the future. The Gori meteorological station is on the second place and according to some other parameters (water demand by agricultural crops, the average annual winds) its conditions would become more severe. General picture shows that Eldari and Udabno are in the better conditions, but according to some parameters (severe droughts, extreme and mean temperatures) Eldari is the hottest and vulnerable territory following Gardabani. However, by the high winds frequency - Gori is on the first and Udabno is on the second place. According to the aridity index, Udabno before 1992 was more dry and sub-humid (after 1992 there are not data) and would become as semi-dry as other territories in the future.

Gardabani, Gori-Kareli and Eldari proved to be the most vulnerable semi-arid districts by their climatic parameters and index of dryness (as confirmed by Dedoflistskaro data in the Second National Report).

Interviews with representatives of local authorities and population of the **Kareli Municipality** show a decrease in production in horiculture and vegetable-growing that used to be the leading agricultural sectors in the past, including the production of the main local cultures like apple, particularly its traditional varieties, pear, and peach. It is noteworthy that pests have become more active lately. Tomato yield has decreased drastically for tomatoes do not manage to ripen due to the early onset of cold weather in autumn. Causes of this event need to be studied more thoroughly, since warming in the semi-arid areas occurs at the expense of autumn. However, this concerns the Gori meteorological station in the last place. The Kareli Municipality can be characterized better using observations of the Skra meteostation, which, according to the reference book of 1960, showed even more semi-aridity (0.365 in the IV-X months) than the Gori station (0.392 in IV-X months), however the station was not analyzed in detail within the framework of this project. With agricultural droughts occurring more frequently lately, vegetable crops (cabbage, potato) have been almost completely destroyed even when watering was applied. Cabbage is the main agricultural culture in the Kareli Municipality. Yield of once widely spread cabbage varieties (Kharisgula, Amagari) has dropped significantly, leading to their replacement with hybrid species that are less vulnerable to environmental conditions but also are less tasty.

One of the major problems of the Kareli Municipality is the destruction of wind belts that used to protect all gardens. The dramatic decrease in fruit and wheat production started after the wind belt cutting. Wheat yield has dropped from 3-3.5 to 1.5-2 tons per hectare. Cultivation of several apple varieties ("Banani", "Kekhura" and "Iveria") has become problematic due to diseases.

A major problem in the **Gardabani District,** just like in Dedoflistskaro, is land degradation, caused by destruction of wind belts. This has had a major impact on agricultural lands in the village of Gamarjveba and in Martkopi, where agricultural crops have dropped significantly and vines have withered. Farmers gradually abandoned the main agricultural sector, vegetable-growing, and shifted to cattle breeding.

Vegetable yield has decreased considerably in the villages of Kesalo, Nazarlo and Vakhtangisi, where they traditionally used to take rich crops of different vegetables (egg-plant, tomato, greens, anions, garlic). Now they mainly use agricultural lands as grasslands or sow oats, that has a very low yield. In fact, a large part of lands in the municipality has been transformed into low-quality grasslands. Salinization of soil has been observed in the Jandara environs.

Another major problem is destruction of the irrigation systems, particularly in the villages of Lemshveniera, Akhali Samgori and Gamarjveba, where they used to grow grain-crops (wheat, barley). At present the croplands have been turned into low-quality grasslands and the local population is engaged in cattle breeding.

Wind belts have been cut on the area of 365 ha across the municipality, strongly affecting the excellent croplands. The humus layer is subject to strong wind erosion. It has been almost completely destroyed on the area of 2000 ha in the vicinity of Martkopi, the area that used to boast high yields of fruit and vegetables. Currently, the lands are not cultivated and are exhausted and abandoned.

In the Sagarejo Municipality the negative impact of climate change has mostly told on spring grain-crops. Harsh cold winds in spring wheat sprouting period destroy almost halve of the crops. Fertile layer of soil has been significantly reduced due to the cutting of wind belts, while the destroyed irrigation systems have caused a large part of croplands to be transformed into low-grade grasslands.

The Dedoflistskaro District has been covered in detail in the Second National Report, prepared for the international climate change conference. The major problem of this region is land degradation, caused by man's impact and intensified by climate change. It has contributed to the signs of land desertification, mainly in the grasslands. Land degradation in the district is the most intensive in winter grasslands that make up 52% of the district's agricultural lands. Until 1990s the lands used to be periodically fertilized and separate sites were treated with gypsum. Sheep herds were traditionally driven to Dagestan, to the winter pastured on the Caspian Sea shore. At present, almost 50.000 heads of sheep spend winter in this area, which leads to two-three-fold overgrazing with the norm being 3-4 heads of sheep per hectare. Overgrazing leads to destruction of the grass cover. Bare land is exposed to the impact of solar radiation, harsh winds and precipitation, which is the precondition for desertification. Southern slopes of hills are most vulnerable to this process. Overgrazing and land degradation are typical for 80% of grasslands in Dedoflistskaro.

Water deficit assessment for the Eldari grasslands (based on meteorological data of the Dedoflistskaro and Eldari meteorological stations), conducted within the framework of the Second National Report and the current project, shows that if in 1951-1965, water deficit in local grasslands reached 50% of the demand, in 1961-1975 it reached 55%. By 2050 the deficit will decrease to the initial 48%, but by 2100 it will reach 58%. This allows concluding that grasslands in this region experience annual natural increase in water deficit that will reach 50-60% in the future, and that alongside with other measures, aimed at land reclamation, the grasslands require continuous irrigation, which is not happening today and, alongside with overgrazing, is contributing to degradation processes.

Interviews with population of the three regions point at a significant decrease in yield of fruit, namely cornel, apricot, plum, cherry, hazelnut, walnut, and winter grain-crops. According to people's observations, this was caused by the early onset of warm weather in spring followed by frosts. The phenomenon was confirmed by data of the Gori meteorological station, according to which frosts occur on April 17 (1961-2010) instead of April 11 (1957-1980). However, early warming and vegetation occur most frequently in Eldari (8-10 days) and Sagarejo (6 days).

According to information, provided by residents of selected semi-arid areas of Georgia, soil depletion process is extremely intensive. In view of annually increasing harm from pests and fungal diseases, local farmers have to use more pesticides than two or three decades ago.

Due to the lack of adequate irrigation in all these areas, lands that used to be cultivated in past years are not cultivated anymore.

6. Vulnerability Indices of selected areas

6.1 Calculating Vulnerability Indices

In accordance with widely accepted approach on vulnerability we have chosen to use the three major vulnerability components:

1. Adaptive capacity of communities to climate change
2. Exposure of communities to climate–hazards
3. Sensitivity of communities to climate–hazard exposures

Each of these three vulnerability components is further divided on sub-components:

ADAPTIVE CAPACITY	Component
Social capital	Sub-component
Human capital	Sub-component
Financial capital	Sub-component
Physical capital	Sub-component
EXPOSURE	Component
Climate hazards	Sub-component
SENSITIVITY	Component
Ecosystems	Sub-component
Communities	Sub-component
Agriculture	Sub-component

For each vulnerability sub-components, a set of vulnerability indicators has been assigned. These indicators are listed in Table 7. (Determining of vulnerability coefficients for indicators is presented in Annex 13, description of indicators is given in chapter 6.2)

The indicators are different and based not only on information related to agriculture, but also on analysis of environmental changes in the selected municipalities. The applied method includes simultaneous analysis of change of climatic parameters in the target areas, covering the period of 50 years, crop production biodiversity indicators and socioeconomic indicators.

Values and coefficients of vulnerability indicators for Georgia ispresented in table 8.

Table 7: Values and coefficients of vulnerability indicators for Georgia

Vulnerability category		Type of category	Values derived from the figures provided by Natinal experts					Vulnerability Coeficient				
			Gori	Kareli	Sagarejo	Dedofliswyaro	Gardabani	Gori	Kareli	Sagarejo	Dedofliswyaro	Gardabani
ADAPTIVE CAPACITY		Component										
Social Capital		**Sub-component**										
	Farm Organisations	Indicator	8.33	4.00	0.10	1.00	0.40	0.012	0.025	1.000	0.100	0.250
	Female work	Indicator	28.89	60.00	11.48	71.43	70.00	0.40	0.19	1.00	0.16	0.16
Human capital		**Sub-component**										
	Education	Indicator	91.00	86.00	91.00	86.00	71.00	0.78	0.83	0.78	0.83	1.00
	Agricultural education	Indicator	18.00	8.00	4.00	6.00	25.00	0.22	0.50	1.00	0.67	0.16
Financial capital		**Sub-component**										
	Livestock units per capita	Indicator	0.24	0.45	0.65	0.63	0.56	1.00	0.53	0.37	0.38	0.42
	Avarage Salary	Indicator	190.48	142.86	190.48	119.05	95.24	0.50	0.67	0.50	0.80	1.00
Physical capital		**Sub-component**										
	Infrastructure	Indicator	237,728	128,701	184,021	109,874	620,621	0.38	0.21	0.30	0.18	1.00
	Access to market	Indicator	2,614	3,761	11,563	3,840	4,008	0.23	0.33	1.00	0.33	0.35
EXPOSURE		Component										
Climate hazards		**Sub-component**										
	Temperature increase	Indicator	0.05	0.05	-0.10	0.60	-0.06	0.21	0.21	0.01	1.00	0.06
	Ratio of rauny days to dray days	Indicator	-0.10	-0.10	-0.10	-0.01	-0.10	1.00	1.00	1.00	0.10	1.00
	Droughts increase	Indicator	8.00	8.00	0.10	-5.00	14.00	0.68	0.68	0.27	0.01	1.00

SENSITIVITY		Component											
Ecosystems		**Sub-component**											
	Plant cover	Indicator	52.30	36.94	79.17	76.47	73.73	0.71	1.00	0.47	0.48	0.50
	Land use	Indicator	79.38	93.66	57.06	21.36	28.28	0.27	0.23	0.37	1.00	0.76
	No. of varietes	Indicator	144	144	262	262	151	1.00	1.00	0.55	0.55	0.95
Communities		**Sub-component**											
	Women	Indicator	42.78	37.69	53.63	49.60	64.74	0.66	0.58	0.83	0.77	1.00
	Children	Indicator	3.22	0.96	5.68	3.16	1.67	0.57	0.17	1.00	0.56	0.29
	Below poverty	Indicator	15.46	17.21	3.92	5.44	21.00	0.74	0.82	0.19	0.26	1.00
	Population growth	Indicator	0.96	1.07	0.96	1.00	0.98	0.89	1.00	0.89	0.93	0.91
Agriculture		**Sub-component**											
	small-scale farming	Indicator	91.67	91.67	100.00	99.00	25.00	0.92	0.92	1.00	0.99	0.25
	rural population	Indicator	65.70	76.09	85.68	68.78	85.01	0.77	0.89	1.00	0.80	0.99
	Land degradation	Indicator	100.00	100.00	100.00	100.00	100.00	1.00	1.00	1.00	1.00	1.00
	Production	Indicator	86.57	48.77	46.35	27.25	70.10	0.31	0.56	0.59	1.00	0.39
	Crop Diversification	Indicator	32.44	43.56	10.21	2.05	23.04	0.06	0.05	0.20	1.00	0.09
	Irrigation	Indicator	29.08	31.24	9.77	0.43	24.20	0.01	0.01	0.04	1.00	0.02
	Agric. workers	Indicator	74.10	45.03	66.60	67.00	90.00	0.82	0.50	0.74	0.74	1.00
	Livestock density/ha	Indicator	0.73	1.13	0.73	0.18	0.79	0.65	1.00	0.65	0.16	0.70

The next step was to assign relative importance – a weight factor to each indicator and sub-components. weights were identified by national experts.

The vulnerability index of an indicator is calculated by multiplying its weight factors by its coefficient (calculated in the previous step). Table 8 shows weight factors, coefficients and indices (indexes) for vulnerability sub-components and indicators for the five proposed pilot regions in Georgia.

Table 8: Vulnerability indices for vulnerability indicators and sub-components for Georgia

		Gori		**Kareli**		**Sagarejo**		**Dedoplistskaro**		**Gardabani**	
	Weight	Coefficient	Index	Coefficient	Index	Coefficient	Index	Coefficient	Index	Coefficient	Index
ADAPTIVE CAPACITY											
Social Capital											
Farm Organisations	0.80	0.01	0.01	0.10	0.00	1.00	0.80	0.01	0.01	0.25	0.20
Female work	0.20	0.40	0.08	0.16	0.01	1.00	0.20	0.40	0.08	0.16	0.03
Subtotal	1.00		0.09		0.01		1.00		0.09		0.23
Total social capital	0.25		0.02		0.00		0.25		0.02		0.06
Human capital											
Education	0.40	0.78	0.31	0.83	0.33	0.78	0.31	0.83	0.33	1.00	0.40
Agricultural education	0.60	0.22	0.13	0.50	0.30	1.00	0.60	0.67	0.40	0.16	0.10
Subtotal	1.00		0.45		0.63		0.91		0.73		0.50
Total human capital	0.40		0.11		0.16		0.23		0.18		0.12

Financial capital											
Livestock units per capita	0.10	1.00	0.10	0.53	0.05	0.37	0.04	0.38	0.04	0.42	0.04
Avarage Salary	0.90	0.50	0.45	0.67	0.60	0.50	0.45	0.80	0.72	1.00	0.90
Subtotal	1.00		0.55		0.65		0.49		0.76		0.94
Total financial capital	0.25		0.14		0.16		0.12		0.19		0.24
Physical capital											
Infrastructure	0.65	0.38	0.25	0.21	0.13	0.30	0.19	0.18	0.12	1.00	0.65
Access to market	0.35	0.23	0.08	0.33	0.11	1.00	0.35	0.33	0.12	0.35	0.12
Subtotal	1.00		0.33		0.25		0.54		0.23		0.77
Total physical capital	0.25		0.08		0.06		0.14		0.06		0.19
ADAPTIVE CAPACITY			**0.35**		**0.39**		**0.74**		**0.45**		**0.61**
EXPOSURE											
Climate hazards											
Temperature increase	0.30	0.21	0.06	0.21	0,06	0,01	0.00	1.00	0.30	0.06	0.02
Ratio of rauny days to dray days	0,30	1.00	0.30	1.00	0.30	1.00	0.30	0.10	0.03	1.00	0.30
Droughts increase	0.40	0.68	0.27	0.68	0.27	0.27	0.11	0.01	0.00	1.00	0.40
Total exposure	1.00		0.64		0.64		0.41		0.33		0.72
EXPOSURE			0.64		0.64		0.41		0.33	0.72	0.72
SENSITIVITY											

Ecosystems											
Plant cover	0.30	0.71	0.21	1.00	0.30	0.47	0.14	0.48	0.14	0.50	0.15
Land use	0.50	0.27	0.13	0.23	0.11	0.37	0.19	1.00	0.50	0.76	0.38
No. of varietes	0.20	1.00	0.20	1.00	0.20	0.55	0.11	0.55	0.11	0.95	0.19
Subtotal	1.00		0.55		0.61		0.44		0.75		0.72
Total ecosystems	0.33		0.18		0.20		0.14		0.25		0.24
Communities											
Women	0.15	0.66	0.10	0.58	0.09	0.83	0.12	0.77	0.11	1.00	0.15
Children	0.15	0.57	0.08	0.17	0.03	1.00	0.15	0.56	0.08	0.29	0.04
Below poverty	0.40	0.74	0.29	0.82	0.33	0.19	0.07	0.26	0.10	1.00	0.40
Population growth	0.30	0.89	0.27	1.00	0.30	0.89	0.27	0.93	0.28	0.91	0.27
Subtotal	1.00		0.75		0.74		0.62		0.58		0.87
Total communities	0.33		0.25		0.24		0.20		0.19		0.29
Agriculture											
small-scale farming	0.10	0.92	0.09	0.92	0.09	1.00	0.10	0.99	0.10	0.25	0.03
rural population	0.05	0.77	0.04	0.89	0.04	1.00	0.05	0.80	0.04	0.99	0.05
Land degradation	0.15	1.00	0.15	1.00	0.15	1.00	0.15	1.00	0.15	1.00	0.15
Production	0.10	0.31	0.03	0.56	0.06	0.59	0.06	1.00	0.10	0.39	0.04
Crop Diversification	0.15	0.06	0.01	0.05	0.01	0.20	0.03	1.00	0.15	0.09	0.01
Irrigation	0.15	0.01	0.00	0.01	0.00	0.04	0.01	1.00	0.15	0.02	0.00
Agric. workers	0.05	0.82	0.04	0.50	0.03	0.74	0.04	0.74	0.04	1.00	0.05

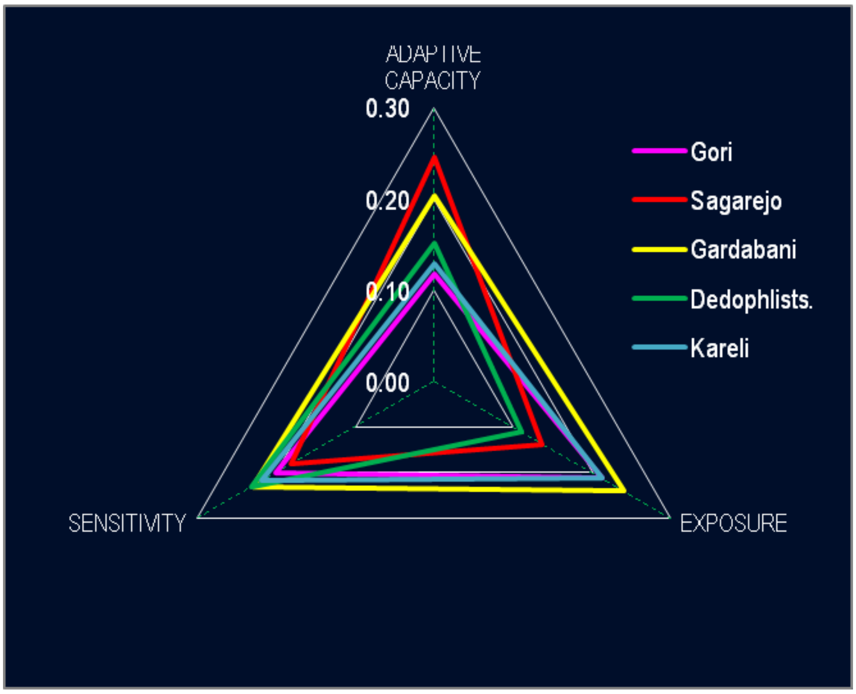
Livestock density/ha	0.25	0.65	0.16	1.00	0.25	0.65	0.16	0.16	0.04	0.70	0.18
Subtotal	1.00		0.53		0.63		0.60		0.77		0.51
Total Agriculture	1.00			0.53			0.63		0.25		0.17
SENSITIVITY	**0.33**			**0.17**			**0.21**		**0.69**		**0.69**

The overall vulnerability index is made by multiplying vulnerability component indices with their assigned weight factors. The three components are assigned an equal weighting (0.33 each), as shown in Table 9.

	Gori			**Kareli**			**Sagarejo**			**Dedopliskaro**			**Gardabani**		
Vulnerability Component	Vulnerability Index	Weight	Weighted index	Vulnerability Index	Weight	Weighted index	Vulnerability Index	Weight	Weighted index	Vulnerability Index	Weight	Weighted index	Vulnerability Index	Weight	S Weighted index
ADAPTIVE CAPACITY	0.35	0.33	0.12	0.39	0.33	0.13	0.74	0.33	0.25	0.45	0.33	0.15	0.61	0.33	0.20
EXPOSURE	0.64	0.33	0.21	0.64	0.33	0.21	0.41	0.33	0.14	0.33	0.33	0.11	0.72	0.33	0.24
SENSITIVITY	0.60	0.33	0.20	0.65	0.33	0.22	0.54	0.33	0.18	0.69	0.33	0.23	0.69	0.33	0.23
VULNERABILITY INDEX			**0.53**			**0.56**			**0.56**			**0.49**			**0.67**
MOST VULNERABLE			4			2/3			2/3			5			1

Table 9: Component and the overall vulnerability indices for the five proposed pilot regions in Georgia.

The vulnerability indices of the three vulnerability components can be presented graphically for each region:



The proposed pilot regions are ranked according to their overall vulnerability indices. The region with the highest overall vulnerability index is the most vulnerable from the climate change point of view. The least vulnerable region is the one with the lowest overall vulnerability index.

In case of Georgia, with the overall vulnerability index of 0.67 Gardabani is the most vulnerable region (Table 3). Kareli and Sagarejo have both 0.56 points and share second and third place in terms of most vulnerable regions. They are followed by Gori which has 0.53 points. With a vulnerability index of 0.49, Dedophlistskaro seems to be the least vulnerable of all five regions considered.

6.2. Calculation of Indicator Values

6.2.1 Adaptive capacity of communities to climate change

Social capital

Social capital is determined suing two indicators: farm organisations and female work participation.

Farm Organizations — **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.

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. 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 Agriculture education — (= secondary agricultural school or university) Region with the lowest formal agricultural education is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

Financial capital

Financial capital is assessed by livestock and average salary:

Livestocks 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.

Avarage salary

Average salary: regions with higher average salary are assumed to be wealthier and therefore better able to prepare for and respond to adversity. Consequently, the highest vulnerability coefficient of 1.00 to the region with the lowest average salary.

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 km2) 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.

6.2.2 Adaptive capacity of communities to climate change

Systems' exposure to variable/changing climate is defined by the change of temperature, rainfall and occurrence of droughts.

Changes in Infrastructure

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:

		Meteo data available	
Meteostation	Municipality	1st period	2nd Period
Eldari	Dedophlistskaro	1950 -1968	1969-1986
Udabno	Sagarejo	1955-1973	1974-1992
Gardabani	Gardabani	1957-1981	1982-2006
Gori	Gori	1957-1981	1982-2006
Gori	Kareli	1957-1981	1982-2006

Region with the highest change in temperature is considered to be most vulnerable and is assigned factor 1.00.

Ratio od dry to rainy days durin vegetation

Ratio of dry to rainy days 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

Is calculated as 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.

6.2.3 Sensitiviti to climate – hazard exposures

Ecosystems sensitivity to climate-hazard exposure

Plant Cover

Plant cover value is calculated as the percentage of permanent grassland (= meadows and pastures) in the total agricultural area. 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 varietes

Region with the lowest number of local varieties is considered to be most vulnerable and is assigned factor 1.00.

Local community sensitivity to climate-hazard exposure

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. Region with the highest percentage of women in the total population 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 household

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, except for Gardabani where five family members are taken as an average). This is further divided by the number of total inhabitants and multiplied by hundred. Region with the highest value is considered to be most vulnerable and is assigned factor 1.00.

Population growth

Population growth is a stress on the resources. A rapid expansion in population indicates the rising pressure on natural resources and a high vulnerability. The data on the population growth was measured as the ratio of population in 2001 vs. the population in 2011. Region with the highest percentage of growth is considered to be most vulnerable and is assigned vulnerability coefficient 1.00.

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

Region with the highest percentage of rural population in the total population 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.

Agriculture 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[3]. 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. 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,

3 Statistik und Berichte des Bundesministerium für Ernährung, Landwirtschaft
http://www.bmelv-statistik.de/de/statistisches-jahrbuch/kap-c-landwirtschaft/

	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 coefficient 1.00.

Annexes

Annex 1. The methodology of prioritizing crop wild relatives

The methodology of prioritizing crop wild relatives is defined by Maxted et al. (2006). In Georgia this method has been used in the research: "Conservation and sustainable use of crop wild relatives in Samtskhe-Javakheti" (Akhalkatsi 2009). According to the method the relationship between crop and its wild relative is defined in terms of the CWR belonging to gene pools 1 or 2, or taxon groups 1 to 4 of the crop. Under gene pool is considered definitions of gene pool concept by Harlan and de Wet (1971). This concept defines Gen Pools as following:

- Primary Gene Pool (GP-1) within which GP-1A are the cultivated forms and GP-1B are the wild or weedy forms of the crop;
- Secondary Gene Pool (GP-2) which includes the coenospecies (less closely related species) from which gene transfer to the crop is possible but difficult using conventional breeding techniques;
- Tertiary Gene Pool (GP-3) which includes the species from which gene transfer to the crop is impossible, or if possible requires sophisticated techniques, such as embryo rescue, somatic fusion or genetic engineering.
-

The taxon group concept is used to establish the degree of CWR relatedness of a taxon. Application of the taxon group concept assumes that taxonomic distance is positively related to genetic distance. CWR rank of taxon groups according to PGR Forum (2005) is defined as follows:

Taxon Group 1a – crop

Taxon Group 1b – same species as crop

Taxon Group 2 – same series or section as crop

Taxon Group 3 – same subgenus as crop

Taxon Group 4 – same genus

Taxon Group 5 – same tribe but different genus to crop

Thus, combined use of the gene pool and taxon group concept proposed above provide the best pragmatic means available to determine whether a species is a CWR and how closely related a CWR is to its crop.

To evaluate the value of a concrete CWR species it is necessary to understand the role of CWR in origin and development of high economic values of a crop. However, application of this broad definition results in the possible inclusion of a wide range of species that may be either closely or more remotely related to the crop itself. Therefore there is a need to estimate the degree of CWR relatedness to enable limited conservation resources to be focused on priority species, those most closely related to the crop.

Two levels are determined to prioritize CWR species, which are mainly important as agronomically valuable species. These levels are:

Level 1 - prioritization would be based on economic value of related '*native'* crop in Georgia and on this basis the top 25 crop genera would be selected for further prioritization.

Level 2 - prioritization would be based on relative threat, rarity, endemicity and genetic relationship with the crop (based on gene pools GP1b+2). The goal of prioritization would be a list of the top 30 priority CWR species in Georgia.

The scoring system developed by N. Maxted (2008) (Tab. 5) was used to evaluate key species of field survey.

Scoring system to evaluate priority CWR species by N. Maxted (2008)

N	Legends	Status	Score
1	Threat (IUCN)	Critically endangered	10
		Endangered	7
		Vulnerable	4
		Near threatened	2
		Least concern	0
2	Rarity	Present in 1 10x10km grid square	10
		Present in 2-5 10x10km grid square	7
		Present in 6-20 10x10km grid square	4
		Present in 21-50 10x10km grid square	2
		Present in >50 10x10km grid square	0
3	Endemicity	Only in Georgia	10
		Only in Caucasus	5
		Only in South-east Europe	2
		Throughout Europe	0
4	GP1+2	Gene pool 1b / Taxon group 1b	10
		Gene pool 2 / Taxon group 2	6
		Taxon group 3	4
		Taxon group 4	2
		Gene pool 3 / Taxon group 5	0

Annex 2. Reference Book Data

Meteo station	Average annual temperatures	Average temperature of the coldst month	Average temperature of the hottest month	Average annual precipitation	Abs. min. temperature	Abs. max. temperature	Minimum precipitation	Maximum precipitation	Average annual winds (m/sec)	Total active temperatures (above 10 0C)
Gori	10.9	-1.2	22.3	498	-28 (I)	40(VIII)	31	69	4.1	3516
Gardabani	12.9	0.3	25.3	402	-25 (I)	41(VII-VIII)	14	66	2.1	4160
Sagarejo	11.0	-0.1	22.0	768	-24 (I)	38(VIII)	28	123	2.2	3423
Dedoflistskaro	10.1	-1.5	21.7	704	-26 (I)	35(VII-VIII)	27	109	1.8	3234
Eldari	11.6	-0.5	23.9	470	-26 (I)	39(VII-VIII)	16	82	2.9	3754
Udabno	10.4	-1.1	22.2	434	-25 (I)	38(VIII)	15	70	3.9	3314

Annex 3. Current and Future Temperatures in Selcetd Semi-arid Areas

Average Annual Temperature in arid regions

Meteorological-station	Average Temperatures (^{0}C)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	0.9	9.7	21.2	11.7	**10.9**
-1.1*	1974-1992	0.8	10.0	21.7	12.2	**11.2**
22.2**	**Difference**	**-0.1**	**0.3**	**0.5**	**0.4**	**0.3**
10.4***	**2020-2050**	3.7	10.9	23.4	15.5	**12.8**
Sagarejo	1956-1980	1.5	10.2	20.9	11.8	**11.1**
-0.1*	1981-2005	1.7	10.5	21.3	12.1	**11.5**
22.0**	**Difference**	**0.2**	**0.2**	**0.4**	**0.3**	**0.3**
11.0***	**2020-2050**	4.9	12.0	23.6	14.4	**13.8**
Dedoflistskaro	1956-1980	0.6	9.7	20.7	11.2	**10.6**
-1.5*	1981-2005	0.9	9.8	21.5	11.9	**11.0**
21.7**	**Difference**	**0.3**	**0.1**	**0.8**	**0.7**	**0.4**
10.1***	**2020-2050**	3.9	11.5	23.8	13.8	**13.3**
Eldari	1950-1968	1.7	11.0	23.1	12.6	**12.0**
-0.5*	1969-1986	1.4	11.7	23.8	13.8	**12.7**
23.9**	**Difference**	**-0.2**	**0.7**	**0.7**	**1.1**	**0.6**
11.6***	**2020-2050**	4.5	12.5	25.3	16.5	**14.1**
Gardabani	1956-1980	2.5	12.7	24.0	13.9	**13.3**
0.3*	1981-2005	2.9	12.6	24.2	14.3	**13.5**
25.3**	**Difference**	**0.5**	**-0.1**	**0.2**	**0.3**	**0.2**
12.9***	**2020-2050**	6.2	13.7	26.7	17.3	**15.4**

Gori	1956-1980	0.7	10.5	20.9	11.7	**11.0**
-1.2*	1981-2005	0.7	10.5	21.0	11.8	**11.0**
22.3**	**Difference**	**0**	**0**	**0.1**	**0.1**	**0.05**
10.9***	**2020-2050**	**3.4**	**9.8**	**24.1**	**17.0**	**13.6**

*Average of the coldest month average temperature before 1960 (reference book data)

** Average of the hottest month average temperature before 1960 (reference book data)

***Average of the annual average temperature before 1960 (reference book data)

By analyzing all above indicated temperatures it becomes obvious that by average of the annual temperature among those meteorological stations, the hottest station is Gardabani and then Eldari. The hottest summer is characteristic to Gradabani and then to Eldari. The same picture was before 1960 by the available data (reference book data). The biggest increase between I and II period is shown in Eldari and then in Gori. But the hottest station still remains to be Gardabani and Eldari in the future. The overall warming is obvious in East part of Georgia. An indicator of an average temperature of the coldest months in winter is changed from negative to positive figure for all considering meteorological stations.

Extreme temperatures (absolute max. and absolute min.) in semi-arid regions

Meteorological-station	Extreme Temperatures (^0C)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	-18.2		37.5		
+38	1974-1992	-13.1		36.9		
-25	**Difference**	**5.1**		**-0.6**		
Sagarejo	1956-1980	-17.8		37.5		
+38	1981-2005	-14.4		39.2		
-24	**Difference**	**3.4**		**1.7**		
Dedoflistskaro	1956-1980	-21.4		36.5		
+35	1981-2005	-16.2		39.5		
-26	**Difference**	**5.2**		**3.0**		
Eldari	1950-1968	-19.0		38.9		
+39	1969-1986	-23.5		38.1		
-26	**Difference**	**-4.5**		**-0.8**		
Gardabani	1956-1980	-20.1		39.6		
+41	1981-2005	-12.9		41.0		
-25	**Difference**	**7.2**		**1.4**		
Gori	1956-1980	-26.10		39.7		
+40	1981-2005	-22.20		38.0		
-28	**Difference**	**3.90**		**-1.7**		

Absolute maximum in the first period was the highest in Gardabani and Gori, but in the second period there is an increase in Gardabani and decrease in Gori. However there is an overall increase in all meteorological stations and almost a unified absolute maximum is detected, but it still remains to be the highest in Gardabani.

The absolute minimum is decreased everywhere (warming) except Eldari where, in the second period this minimum starts increasing. Absolute minimum is warming as most in Gardabani.

Extreme Temperatures

SU(25)- Number of days in a period when day-night maximum equals Tmax>25°C

(number of hot days SU25)

Meteorological-station	Number of days of the extreme temperature (25^0C)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	0.0	6.5	64.6	11.4	**82.53**
	1974-1992	0.0	4.2	65.5	12.8	**82.47**
	Difference	**0.0**	**-2.4**	**0.8**	**1.5**	**-0.05**
	2020-2050	0.2	34.5	87.3	39.7	**161.7**
Sagarejo	1956-1980	0.0	2.0	48.3	36.4	**86.7**
	1981-2005	0.0	2.6	49.5	37.2	**89.2**
	Difference	**0**	**0.6**	**1.2**	**0.8**	**2.5**
	2020-2050	0.0	8.6	64.3	13.9	**86.7**
Dedoflistskaro	1956-1980	0.0	4.6	60.5	8.8	**73.8**
	1981-2005	0.0	5.3	69.6	14.0	**88.0**
	Difference	**0**	**0.7**	**9.1**	**5.2**	**14.2**
	2020-2050	0.0	6.7	72.9	11.3	**90.9**
Eldari	1950-1968	0.0	12.4	75.1	18.1	**106.5**
	1969-1986	0.0	6.3	74.4	15.3	**96.9**
	Difference	**0.0**	**-6.2**	**-0.7**	**-2.7**	**-9.6**
	2020-2050	0.0	14.3	83.7	15.9	**119.3**
Gardabani	1956-1980	0.0	19.1	83.4	22.5	**125.1**
	1981-2005	0.0	16.3	83.3	25.5	**125.1**
	Difference	**0.0**	**-2.8**	**-0.1**	**2.9**	**0.0**
	2020-2050	0.1	16.7	79.2	28.6	**124.5**
Gori	1956-1980	0.0	5.0	58.4	22.9	**86.2**
	1981-2005	0.0	4.3	59.6	26.1	**90.0**
	Difference	**0.0**	**-0.6**	**1.3**	**3.2**	**3.8**
	2020-2050	**0.0**	**12.9**	**72.4**	**17.9**	**103.1**

MTR (20)- Number of days in a period when day-night minimum Tmin>20°C (tropical nights TR20)

Meteorological-station	Number of nights with extreme temperature (20^0C)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	0.0	0.0	6.7	0.1	**6.7**
	1974-1992	0.0	0.1	11.5	0.3	**11.8**
	Difference	0.0	0.1	4.8	0.2	**5.1**
	2020-2050	0.0	5.7	81.6	14.9	**102.2**
Sagarejo	1956-1980	0.0	0.0	3.2	1.8	**5.0**
	1981-2005	0.0	0.0	3.2	2.8	**6.0**
	Difference	0.0	0.0	0.0	1..0	**1.0**
	2020-2050	0.0	0.0	6.7	0.0	**6.8**
Dedoflistskaro	1956-1980	0.0	0.0	3.4	0.0	**3.4**
	1981-2005	0.0	0.0	4.6	0.1	**3.7**
	Difference	0.0	0.0	1.2	0.1	**0.3**

	2020-2050	0.0	0.0	11.1	0.0	**11.1**
Eldari	1950-1968	0.0	0.1	13.2	0.4	**13.6**
	1969-1986	0.0	0.0	24.2	0.9	**25.2**
	Difference	0.0	-0.1	11.0	0.6	**11.6**
	2020-2050	0.0	1.3	44.7	6.4	**52.5**
Gardabani	1956-1980	0.0	0.0	28.2	1.4	**29.6**
	1981-2005	0.0	0.0	33.2	1.5	**34.7**
	Difference	0.0	0.0	5.0	0.1	**5.1**
	2020-2050	0.0	4.6	57.1	10.0	**71.7**
Gori	1956-1980	0.0	0.0	2.9	4.1	**7.0**
	1981-2005	0.0	0.0	2.6	2.2	**4.9**
	Difference	0.0	0.0	-0.3	-1.9	**-2.1**
	2020-2050	**0.0**	**0.1**	**9.7**	**0.6**	**10.4**

FD(0) Average numbers of frosty nights (day-night minimum Tmin<0°C)

Meteorological-station	Number of days with extreme temperature (250C)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	65.1	17.6	0.0	6.9	**89.8**
	1974-1992	65.3	12.6	0.0	5.1	**82.2**
	Difference	0.2	-4.9	0.0	-1.8	**-7.6**
	2020-2050	57.9	6.3	0.0	6.9	**71.1**
Sagarejo	1956-1980	53.5	36.3	0.1	2.0	**91.3**
	1981-2005	56.8	36.2	0.2	2.2	**94.1**
	Difference	3.3	-0.1	0.1	0.2	**2.8**
	2020-2050	56.4	14.0	0.0	7.7	**77.7**
Dedoflistskaro	1956-1980	11.3	1.1	0.0	0.2	**12.4**
	1981-2005	10.7	0.9	0.0	0.3	**12.4**
	Difference	-0.6	-0.2	0.0	0.1	**0.0**
	2020-2050	46.7	10.4	0.0	3.9	**61.0**
Eldari	1950-1968	65.4	15.4	0.0	8.6	**90.4**
	1969-1986	61.4	10.9	0.0	4.5	**76.4**
	Difference	-4.0	-4.5	0.0	-4.1	**-13.9**
	2020-2050	45.0	7.4	0.0	3.9	**56.3**
Gardabani	1956-1980	55.4	7.6	0.0	5.7	**68.8**
	1981-2005	49.7	5.8	0.0	4.1	**60.0**
	Difference	-5.7	-1.8	0.00	-1.6	**-8.8**
	2020-2050	32.6	3.9	0.0	1.3	**42.1**
Gori	1956-1980	60.9	26.9	0.0	5.7	**93.4**
	1981-2005	62.5	25.5	0.0	6.3	**94.4**
	Difference	1.6	-1.4	0.04	0.7	**1.1**
	2020-2050	**22.9**	**3.2**	**0.0**	**3.0**	**29.1**

ID (0) Average number of frosty days (day-night maximum Tmax<0°C)

Meteorological-station	Number of days with extreme temperature (250C)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	11.9	1.3	0.0	0.3	**13.0**
	1974-1992	13.4	1.3	0.0	0.0	**14.9**
	Difference	**1.5**	**0.0**	**0.0**	**-0.3**	**1.9**
	2020-2050	1.4	0.0	0.0	0.0	**1.4**
Sagarejo	1956-1980	5.7	2.9	0.0	0.0	**8.4**
	1981-2005	4.7	2.4	0.0	0.0	**6.9**
	Difference	**-1**	**0.5**	**0.0**	**0.0**	**1.5**
	2020-2050	7.2	0.7	0.0	0.3	**8.1**
Dedoflistskaro	1956-1980	26.4	1.8	0.0	0.9	**29.1**
	1981-2005	25.5	2.4	0.0	0.9	**29.1**
	Difference	**-0.9**	**0.6**	**0.0**	**0.0**	**0.0**
	2020-2050	4.4	0.6	0.0	0.0	**5.0**
Eldari	1950-1968	5.5	0.3	0.0	0.4	**6.1**
	1969-1986	12.8	1.3	0.0	0.0	**14.2**
	Difference	**7.3**	**1.0**	**0.0**	**-0.4**	**8.0**
	2020-2050	2.5	0.0	0.0	0.0	**2.5**
Gardabani	1956-1980	4.3	0.0	0.0	0.0	**4.2**
	1981-2005	1.9	0.0	0.0	0.0	**1.9**
	Difference	**-2.4**	**0.0**	**0.0**	**0.0**	**-2.3**
	2020-2050	2.5	0.0	0.0	0.0	**2.4**
Gori	1956-1980	7.2	1.6	0.0	0.0	**9.1**
	1981-2005	6.0	0.5	0.0	0.0	**6.5**
	Difference	**-1.2**	**-1.1**	**0.0**	**0.0**	**-2.6**
	2020-2050	**3.1**	**0.1**	**0.0**	**0.6**	**2.8**

Annex 4. Precipitations and semi-aridity indexes

Meteorological-station	Total precipitations (mm)	Winter	Spring	Summer	Fall	Annual	Threshold of dryness (mm)
Udabno	1955-1973	55.3	154.3	160.2	94.3	461.9	**348**
	1974-1992	63.0	155.0	136.8	100.4	460.9	**362**
0.358*	**Difference**	7.7	0.7	-23.4	6.2	-1.0	
434**	**2020-2050**	74.5	145.5	149.7	111.6	481.1	
Sagarejo	1938-1960	104.2	255.3	241.8	177.1	779.9	**362**
	1961-1992	107.5	250.6	243.9	179.4	775.1	**370**
0.688*	**Difference**	3.2	-4.7	2.1	2.3	-4.8	
768**	**2020-2050**	105.1	246.6	298.6	175.7	824.8	**410**
Dedoflistskaro	1956-1980	78.0	188.7	194.5	128.4	589.4	**372**
	1981-2005	76.2	214.7	186.1	142.1	624.6	**362**
0.587*	**Difference**	-1.8	26.0	-8.4	13.7	35.2	
704**	**2020-2050**	96.9	186.8	211.3	129.4	624.4	**406**
Eldari	1950-1968	60.0	142.6	141.7	115.0	471.0	
	1969-1986	61.0	152.4	143.1	112.8	470.1	
0.412*	**Difference**	1.0	9.8	1.4	-2.2	-0.9	
470**	**2020-2050**	80.3	150.7	172.1	132.5	534.9	
Gardabani	1956-1980	57.0	127.8	136.3	79.3	400.9	**406**
	1981-2005	57.6	135.8	112.1	85.6	383.0	**410**
0.300*	**Difference**	0.6	8.0	-24.3	6.3	-17.9	
402**	**2020-2050**	88.0	136.7	102.7	90.2	417.9	**442**
Gori	1956-1980	98.6	149.1	138.8	130.4	514.6	**359.2**
	1981-2005	102.9	140.5	149.6	111.7	505.8	**360.0**
0.392*	**Difference**	4.3	-8.6	10.7	-18.6	-8.8	
498**	**2020-2050**	**103.2**	**136.7**	**151.5**	**116.9**	**509.8**	**400**

* Climate aridity index calculated by reference data (G.Gogichaishvili)

** Total of annual precipitations from a climate reference book (1967)

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Annex 5. Winds

Avarage speed of winds

Meteorological-station	Average speed of winds (m/sc)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1973	3.8	4.0	3.5	3.3	**3.7**
	1974-1992	2.9	2.5	1.7	2.2	**2.3**
	Difference	-0.9	-1.5	-1.8	-1.1	**-1.4**
	2020-2050	3.1	3.0	2.4	2.7	**2.8**
Sagarejo	1938-1960	2.5	2.4	2.0	2.1	**2.1**
	1961-1992	1.9	1.8	1.6	1.8	**1.8**
	Difference	-0.6	-0.6	-0.3	-0.3	**-0.3**
	2020-2050	2.1	1.8	1.6	1.7	**1.8**
Dedoflistskaro	1956-1980	1.7	2.1	1.7	1.6	**1.8**
	1981-2005	1.6	1.5	1.1	1.2	**1.3**
	Difference	-0.1	-0.6	-0.6	-0.4	**-0.5**
	2020-2050	1.8	1.9	1.5	1.5	**1.7**
Eldari	1950-1986	2.2	2.3	2.0	1.9	**2.0**
	1986-2006	m.a.	m.a.	m.a.	m.a.	**m.a.**
	Difference	m.a.	m.a.	m.a.	m.a.	**m.a.**
	2020-2050	1.9	2.1	1.7	1.7	**1.9**
Gardabani	1956-1980	1.6	2.5	2.7	1.6	**1.6**
	1981-2005	1.3	2.0	1.9	1.1	**1.55**
	Difference	0.3	0.5	0.8	0.4	**0.05**
	2020-2050	1.6	2.4	1.9	1.7	**1.9**
Gori	1956-1980	2.8	4.2	3.8	3.1	**3.5**
	1981-2005	1.2	1.6	1.5	1.2	**1.4**
	Difference	-1.6	-2.6	-2.4	-1.9	**-2.1**
	2020-2050	**0.8**	**1.2**	**1.1**	**0.9**	**1**

High Speed Winds

Meteorological-station	High speed winds (m/sc)	Winter	Spring	Summer	Fall	Annual
Udabno	1955-1970	m.a.	m.a.	m.a.	m.a.	m.a.
	1970-1992	40	40	34	40	40
	Difference	m.a.	m.a.	m.a.	m.a.	m.a.
Sagarejo	1956-1992	31	29	30	26	31
	1993-2005	m.a.	m.a.	m.a.	m.a.	m.a.
	Difference	m.a.	m.a.	m.a.	m.a.	m.a.
Dedoflistskaro	1956-1980	35	34	24	35	35
	1981-2005	40	40	25	40	40
	Difference	**5**	**6**	**1**	**5**	**5**
Eldari	1955-1973	m.a.	m.a.	m.a.	m.a.	m.a.
	1974-1992	m.a.	m.a.	m.a.	m.a.	m.a.
	Difference	m.a.	m.a.	m.a.	m.a.	m.a.
Gardabani	1956-1980	21.0	32.0	28.0	32.0	32.0
	1981-2005	24.0	24.0	22.0	24.0	24.0
	Difference	**3.0**	**-8.0**	**-6.0**	**-8.0**	**-8.0**
Gori	1956-1980	30.0	30.0	25.0	25.0	30.0
	1981-2005	35.0	35.0	30.0	30.0	35.0
	Difference	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**

Annex 6. Severe Droughts estimated by SPI method

Meteorological-station	Severe droughts (SPI<-1.5)	For 1 month	For 3 months	For 6 months	For 9 months	For 12 months
Udabno	1955-1973	5	6	5	9	**9**
	1974-1992	2	9	9	7	**2**
	Difference	**-3**	**3**	**4**	**-2**	**-7**
	2020-2050	10	18	15	19	**23**
Sagarejo	1956-1980	27	23	18	15	**19**
	1981-2005	10	13	13	11	**12**
	Difference	**-17**	**-10**	**-5**	**-4**	**-7**
	2020-2050	28	28	30	23	**22**
Dedoflistskaro	1956-1980	17	23	23	27	**30**
	1981-2005	20	18	17	10	**11**
	Difference	**3**	**-5**	**-6**	**-17**	**-19**
	2020-2050	23	28	30	28	**27**
Eldari	1955-1973	13	23	12	13	**18**
	1974-1992	8	6	8	6	**5**
	Difference	**-5**	**-17**	**-4**	**-7**	**-13**
	2020-2050	11	11	12	17	**15**
Gardabani	1956-1980	13	4	2	1	**0**
	1981-2005	15	10	6	7	**6**
	Difference	2	3	4	6	**6**
	2020-2050	14	17	12	15	**21**
Gori	1956-1980	19	13	11	13	**14**
	1981-2005	23	17	15	17	**10**
	Difference	**4**	**4**	**4**	**4**	**-4**
	2020-2050	**18**	**12**	**13**	**4**	**7**

Extreme droughts estimated by SPI method

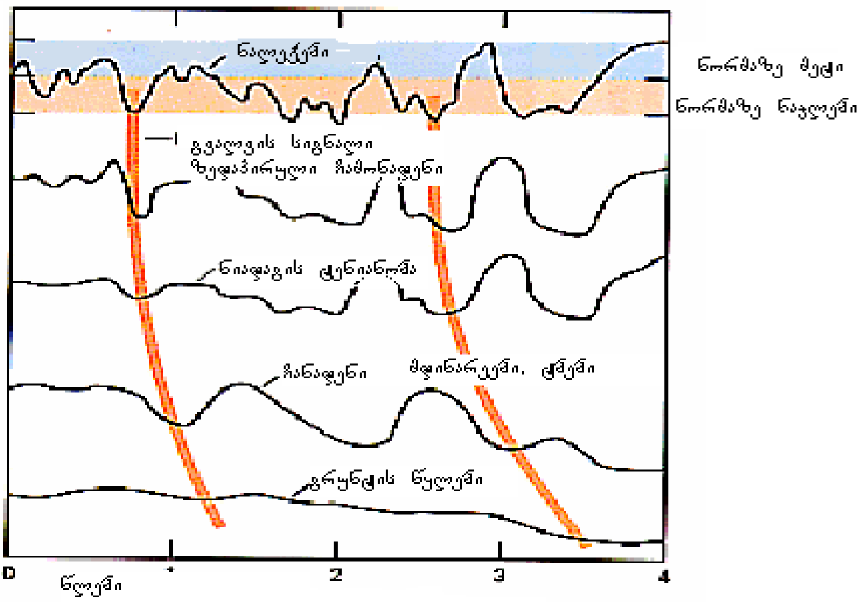
Meteorological-station	Extreme drought (SPI<-2.0)	For 1 month	For 3 months	For 6 months	For 9 months	For 12 months
Udabno	1955-1973	9	9	10	3	8
	1974-1992	16	15	6	4	4
	Difference	**7**	**6**	**-4**	**1**	**-4**
	2020-2050	11	6	9	5	4
Sagarejo	1956-1980	13	10	11	5	4
	1981-2005	4	6	4	3	2
	Difference	**-9**	**-4**	**-7**	**-2**	**-2**
	2020-2050	9	12	8	7	6
Dedoflistskaro	1956-1980	7	8	12	15	15
	1981-2005	13	8	8	4	1
	Difference	**6**	**0**	**-4**	**-11**	**-14**
	2020-2050	7	10	8	9	8
Eldari	1955-1973	4	3	11	9	9
	1974-1992	2	5	0	1	3
	Difference	**-2**	**2**	**-11**	**-8**	**-6**
	2020-2050	7	10	10	4	6
Gardabani	1956-1980	2	1	0	0	0
	1981-2005	6	1	1	0	0
	Difference	4	0	1	0	0

	2020-2050	8	3	7	3	3
Gori	1956-1980	8	5	4	3	3
	1981-2005	3	4	9	9	6
	Difference	**-5**	**-1**	**5**	**6**	**3**
	2020-2050	6	10	10	11	8

Annex 7. Drought Estimation Index (SPI)

A drought is a condition of the ecosystem that is lack in moisture caused by dire shortage in precipitations for a certain period of time. Any difficulties occurring while identification and classification of droughts are mainly related to a determination of a time period during of which the drought outcomes are accumulated as well as to a determination how a shortage of precipitations and applicable water resources have a mutual influence on the results. Applicable water resources include: soil moisture, ground waters, snow covers, wash off waters and remained water in reservoirs. The drought is connected to an increasing demand on water to be exceeding all available water supplies created by one or more abovementioned applicable water resources. A time period before any type of precipitation turns into any applicable water resources greatly differs from one another. Water application has its own timing. Therefore any result caused by the water shortage is a complex function of the ater resource and its application. Time period is very significant during which precipitation deficit is accumulated that differentiates a different types of droughts therefore.

Drawing 1 shows the different categories of droughts caused by a shortage in precipitations: first of all, 1-3 months from a beginning of a drought are severely affecting the agriculture sector that is so much dependant on a presence of a moisture content in soil, but those other sectors which are more dependant on surface (resources and lakes) and ground waters are to be affected later (approximately after 6-9 months) being caused by a precipitate deficit.



Drawing.1. Influence of precipitation deficiency over different types of water resources

Precipitation standardized index is a deviation of precipitations from an average from a selected time period and divided by an average quarterly deviation (σ) where an average and average quarterly deviation is determined for a period between 1955-2006 years and various time clusters (i=1, 3, 6, 9, 12 month)

$$SPI = \frac{x_i - \bar{x}_i}{\sigma}$$

Time clusters selected by us (i=1, 3, 6, 9, 12 month) is characteristic to the influence of precipitation deficit over all five types of applicable water resources. Precipitation standardized index is proportional to a precipitation deficit which makes it possible to determine a probability of drought frequency, a percentage share of average and total precipitation deficit.

For a time period of *i* (a time cluster) if a meaning of SPI falls under 0 and is getting lower than -1 – than comes the drought. So, the drought starts from its first negative meaning and ends when its positive meaning comes. According to SPI meaning, categories of the drought intensity can be determined which are indicated in the table.

	Categories of the drought intensity
-0.99>SPI>0.99	Closer to normal
-1.00> SPI>-1.49	Moderate
-1.50>SPI>-1.99	Severe
-2.00> SPI	Extremely severe

Annex 8. Totals of active temperatures and vegetation periods

Meteorological-stations	Total active temperature (more than 10 ºC) before 1960	Total active temperature (more than 5 ºC) in I and II periods	Total active temperatures (more than 10 ºC) in I and II periods	Total active temperatures (more than 20 ºC) in I and II periods	Start of vegetation period (more than 5 ºC) in I and II periods	Start of vegetation period (more than 10 ºC) in I and II periods	Start of vegetation period (more than 20ºC) in I and II periods	End of vegetation period (more than 5 ºC) in I and II periods	End of vegetation period (more than 10ºC) in I and II periods	End of vegetation period (more than 20 ºC) in I and II periods
Udabno (1955-1973) (1974-1992)	3314	3876 3990	3458 3555	1549 1754	23.03 19.03	16.04 13.04	25.06 21.06	27.11 25.11	25.10 24.10	01.09 05.09
Sagarejo 1956-1980 1981-2005	3423	3926 4012	3459 3605	1501 1667	17.03 16.03	14.04 08.04	25.06 20.06	28.11 29.11	25.10 27.10	31.08 02.09
Dedoflistskaro 1956-1980 1981-2005	3234	3778 3896	3350 3490	1461 1610	21.03 20.03	15.04 15.04	26.06 24.06	21.11 22.11	21.10 25.10	30.08 02.09
Eldari (1950-1968) (1969-1986)	3745	4243 4522	3839 4100	2262 2372	19.03 09.03	11.04 02.04	06.06 06.06	25.11 03.12	26.10 31.10	09.09 12.09
Gardab 1956-1980 1981-2005	4160	4703 4730	4237 4346	2515 2667	02.03 02.03	01.04 01.04	02.06 31.05	05.12 04.12	01.11 05.11	14.09 18.09
Two 1956-1980 1981-2005	3516	3881 3924	3488 3533	1639 1742	17.03 17.03	12.04 12.04	27.06 25.06	20.11 20.11	24.10 25.10	10.09 11.09

Annex 9. Calculation of aridity index for semi-arid areas

Gori 1980-2005	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	34.0	0.2	4.9	-3.6	79.8	3.2	2.4	206.8	3.4	0.8	23.87
February	31.5	0.8	6.0	-3.4	76.2	4	3.0	258.5	4.2	1.2	33.32
March	31.4	5.1	11.2	0.4	70.3	4.9	3.7	316.7	5.1	2.2	66.96
April	49.6	11.0	17.8	5.1	68.7	5.1	3.8	329.6	6.5	3.5	104.1
May	59.3	15.1	21.5	9.5	70.7	4.6	3.4	297.3	7.6	4.2	130.2
June	61.8	18.9	25.4	13.3	70.4	4.3	3.2	277.9	9.3	5.1	152.7
July	45.3	22.1	28.3	16.7	68.9	4.6	3.4	297.3	9.6	5.6	174.22
August	41.7	22.1	28.5	16.4	69.0	4.3	3.2	277.9	9.5	5.2	160.89
September	28.2	17.8	24.2	11.9	71.0	4.2	3.1	271.4	8.0	3.8	112.8
October	41.4	12.0	18.3	6.6	76.1	3.5	2.6	226.2	6.3	2.2	66.65
November	46.9	5.6	11.1	1.4	80.8	3.4	2.5	219.7	4.3	1.1	32.7
December	35.6	1.2	5.9	-2.6	82.4	2.9	2.2	187.4	3.4	0.7	20.15
	506.6										1078.56
Aridity Index	**0.470**										

Gori 2021-2050	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	33.1	1.0	6.8	-1.5	78.3	3.8	2.9	247.0	3.4	1.22	37.82
February	30.3	1.7	8.6	-0.5	76.0	4.0	3.0	257.6	4.2	1.63	45.64
March	29.3	4.4	13.2	2.6	69.0	3.9	2.9	251.0	5.1	2.8	86.8
April	43.6	10.3	19.8	7.7	65.1	3.9	2.9	250.4	6.5	4.57	137.1
May	63.1	14.9	23.1	11.6	68.3	3.9	3.0	255.3	7.6	5.12	158.72
June	52.8	20.2	27.7	15.9	66.7	3.8	2.9	247.1	9.3	5.89	176.7
July	49.3	24.1	29.6	19.1	68.6	3.9	2.9	253.6	9.6	6.06	187.86
August	49.1	25.7	29.4	18.8	69.2	3.8	2.9	247.0	9.5	5.65	175.15
September	31.2	22.1	25.6	14.4	69.9	3.9	2.9	251.2	8.0	4.33	129.9
October	35.5	16.5	18.9	8.0	74.7	3.8	2.8	245.8	6.3	2.54	78.74
November	50.7	10.0	13.0	3.3	75.6	3.8	2.9	246.3	4.3	1.59	47.7
December	41.7	4.7	8.3	0.1	78.3	3.9	2.9	251.1	3.4	1.21	37.51
	509.8										1299.64
Aridity Index	0.392										

Gardabani 1980-2005	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	17.0	2.3	7.3	-1.0	77	1.5	1.1	96.9	4.7	0.7	20.15
February	21.8	3.0	8.3	2.9	72	2.2	1.6	142.2	5.1	1.2	32.76
March	34.7	7.1	12.8	8.0	69	2.5	1.9	161.6	6.2	2.1	63.55
April	46.7	12.9	19.2	12.3	65	2.7	2.0	174.5	7.2	3.4	100.5
May	56.4	17.2	23.3	16.8	65	2.4	1.8	155.1	8.3	4.3	133.3
June	49.7	22.1	28.6	20.6	61	2.6	1.9	168.0	9.6	5.5	165
July	38.0	25.6	31.8	19.6	55	3.1	2.3	200.3	10.1	6.3	194.37
August	27.7	24.9	31.4	15.5	56	2.4	1.8	155.1	9.3	5.2	161.82
September	21.8	20.6	27.0	9.8	63	2.1	1.6	135.7	7.7	3.6	108
October	38.6	14.3	20.3	4.1	72	1.8	1.3	116.3	6.1	2.0	62.31
November	24.5	7.9	13.1	-0.1	79	1	0.7	64.6	4.7	0.8	24
December	17.5	3.4	8.4	-1.5	80	1	0.7	64.6	3.8	0.5	14.88
	394.2										1080.64
Aridity Index	0.365										

Gardabani 2021-2050	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	25.8	4.1	10.6	2.7	71.4	2.1	1.6	134.6	4.7	0.95	29.45
February	40.7	5.3	11.0	6.0	70.3	2.2	1.6	140.8	5.1	1.33	37.24
March	36.6	9.1	14.7	9.9	65.8	2.1	1.6	138.0	6.2	2.19	67.89
April	37.2	14.7	20.8	13.7	61.5	2.2	1.6	139.0	7.2	3.45	103.5
May	63.8	18.1	25.2	17.3	63.4	2.1	1.6	137.3	8.3	4.45	137.95
June	32.9	23.8	31.4	22.4	59.9	2.1	1.6	137.7	9.6	5.68	170.4
July	37.8	27.5	34.2	21.5	56.7	2.2	1.6	139.8	10.1	6.04	187.24
August	31.9	26.8	33.1	17.9	61.8	2.1	1.6	135.8	9.3	5.14	159.34
September	35.7	23.8	30.1	12.9	63.9	2.1	1.6	137.0	7.7	3.88	116.4
October	31.1	16.5	21.4	6.1	73.2	2.1	1.6	135.6	6.1	2.16	66.96
November	23.8	11.8	16.5	3.1	73.8	2.1	1.6	137.5	4.7	1.33	39.9
December	20.6	6.7	12.4	1.3	73.2	2.1	1.6	138.8	3.8	0.96	29.76
	417.9										1146.03
Aridity Index	0.365										

Udabno 1963-1992	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	19.6	-0.2	4.2	-3.5	77.8	3.2	2.4	205.5	4.1	0.8	23.87
February	25.5	0.4	5.0	-3.0	79.2	2.9	2.2	189.5	4.5	1.0	27.72
March	35.5	4.2	9.3	0.5	77.9	3.1	2.3	202.5	5.2	1.6	50.53
April	52.2	10.5	16.2	5.9	72.6	2.9	2.2	189.2	6.0	2.8	83.1
May	72.4	15.2	20.7	10.4	72.3	2.6	2.0	169.5	7.3	3.7	114.39
June	70.0	19.3	24.9	14.2	68.8	2.6	1.9	165.3	9.3	4.7	141.3
July	41.2	22.9	28.4	17.7	63.5	2.0	1.5	130.9	9.5	5.0	156.24
August	35.2	22.2	27.6	17.1	65.3	2.0	1.5	129.9	9.2	4.5	137.95
September	38.0	18.1	23.7	13.3	71.0	2.6	1.9	165.0	7.2	3.2	95.7
October	35.5	11.8	17.1	7.8	77.9	2.3	1.7	150.3	5.7	1.7	53.94
November	26.2	6.6	11.5	3.2	80.1	2.6	1.9	165.4	4.3	1.0	29.7
December	17.8	2.1	6.5	-1.1	79.1	2.8	2.1	182.4	3.7	0.7	22.01
	468.9										936.45
Aridity Index	0.501										

Udabno 2021-2050	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	19.1	2.4	6.9	-1.6	74.4	3.2	2.4	205.0	4.1	0.95	29.45
February	36.4	3.0	7.6	-0.5	77.1	3.1	2.3	197.3	4.5	1.16	32.48
March	32.0	6.2	11.2	2.3	76.5	3.3	2.4	210.1	5.2	1.79	55.49
April	42.2	11.8	17.7	7.6	69.9	3.0	2.3	195.7	6.0	3	90
May	73.9	15.5	21.3	11.1	71.7	2.7	2.1	177.5	7.3	3.79	117.49
June	60.6	21.0	26.5	16.2	67.8	2.8	2.1	178.1	9.3	4.99	149.7
July	47.0	24.8	30.0	20.0	63.3	2.2	1.6	142.4	9.5	5.32	164.92
August	40.8	24.5	29.6	19.6	68.2	2.2	1.6	140.6	9.2	4.68	145.08
September	39.5	21.4	26.8	17.1	70.9	2.8	2.1	181.4	7.2	3.56	106.8
October	43.6	14.2	18.8	10.3	78.0	2.5	1.9	160.8	5.7	1.87	57.97
November	28.2	10.0	14.8	6.7	76.7	2.7	2.0	175.4	4.3	1.22	36.6
December	17.7	5.6	9.9	1.7	75.1	3.1	2.3	199.1	3.7	0.96	29.76
	481.1										1015.74
Aridity Index	0.474										

Eldari 2021- 2050-1965	Precipitation (mm)	Temp	Tmax	Tmin	Relative humidity	Wind speed (m/s) at 10m	Wind speed (m/s) at 2m	Wind speed (km/day) at 2m	Daily sunshine (hrs)	Daily PET (mm)	Monthly PET (mm)
January	15.2	0.9	6.3	-3.5	74.9	2.3	1.7	149.9	3.9	0.8	25.42
February	22.2	2.0	7.7	-2.5	74.6	2.2	1.7	143.0	4.2	1.1	31.36
March	36.3	4.7	10.3	0.4	74.0	2.4	1.8	152.5	4.7	1.7	51.77
April	47.4	10.9	16.6	5.6	70.4	2.2	1.6	140.4	6.0	2.7	81.6
May	62.1	17.3	23.3	10.8	66.9	2.2	1.7	143.5	7.5	4.0	124.93
June	69.6	21.2	27.1	14.4	61.5	2.1	1.6	134.8	9.5	5.0	150
July	48.2	24.3	30.2	17.3	57.5	2.0	1.5	126.2	9.4	5.3	163.37
August	29.7	23.8	30.2	17.3	57.8	1.9	1.4	120.2	9.3	4.8	147.87
September	45.1	18.6	24.7	13.5	68.2	1.8	1.4	116.8	7.0	3.1	92.7
October	40.1	12.3	18.6	7.8	74.9	1.8	1.3	116.3	5.9	1.8	55.8
November	33.0	6.3	11.9	2.1	78.7	1.8	1.3	114.2	4.1	0.9	27.6
December	22.2	2.1	7.8	-2.5	79.3	1.8	1.4	118.9	3.7	0.7	20.46
	471.0										972.88
Aridity Index	0.484										

January	21.7	3.3	9.7	-1.7	72.4	2.2	1.6	139.3	3.9	0.97	30.07
February	32.0	3.7	12.2	-1.0	73.7	2.1	1.6	134.2	4.2	1.36	38.08
March	44.7	6.7	16.3	1.4	73.1	2.3	1.7	147.1	4.7	2.14	66.34
April	44.8	12.5	21.6	6.5	68.6	2.0	1.5	127.0	6.0	3.16	94.8
May	64.9	17.5	26.7	11.4	66.4	1.9	1.5	125.9	7.5	4.31	133.61
June	78.8	23.8	32.1	16.8	62.4	1.7	1.3	112.4	9.5	5.39	161.7
July	51.2	27.4	33.6	20.5	61.7	1.6	1.2	106.0	9.4	5.44	168.64
August	40.3	26.4	34.3	20.1	64.1	1.8	1.3	113.2	9.3	5.06	156.86
September	48.3	22.9	30.5	17.2	70.5	1.7	1.3	111.4	7.0	3.51	105.3
October	46.2	14.1	22.7	8.5	76.5	1.7	1.3	108.0	5.9	2.01	62.31
November	37.2	9.0	16.8	4.2	76.8	1.6	1.2	103.4	4.1	1.12	33.6
December	24.9	5.5	11.4	0.5	76.5	1.6	1.2	103.7	3.7	0.74	22.94
	534.9										1074.25
Aridity Index	0.498										

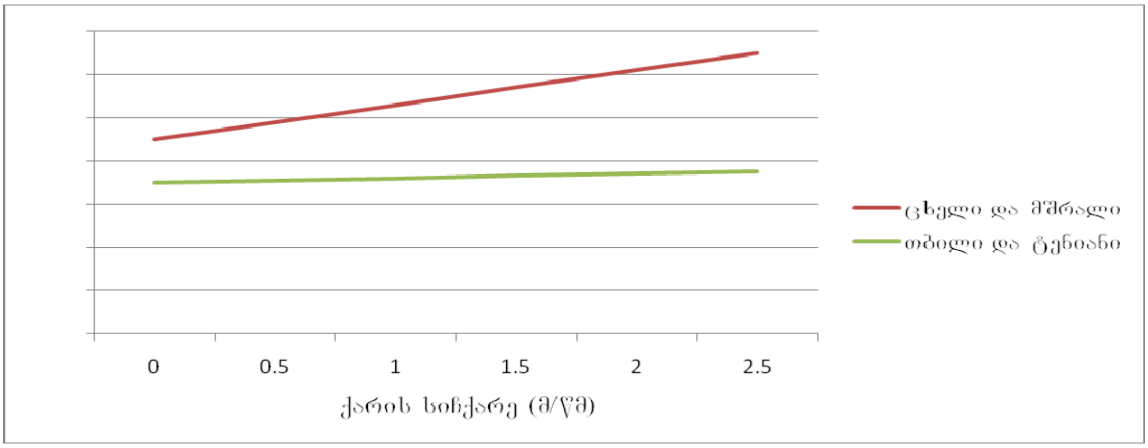
Annex 10. Parametres usin for assessing aridity index and water shortage

A model CropWat, being applied for evaluating the aridity index and water shortage, uses the following input parameters: the average max and minimum temperatures, relative humidity, the mean speed of wind, duration of sun shining and geographical coordinates.

The model for evaluating the water shortage calculates a potential evapo-transpiration and then the water shortage is calculated as an amount of water that remains after precipitations as a result of evapo-transpiration. As it is known, the evapo-transpiration is possible by those meteorological parameters which are generating the energy for water evaporation or removing water steams off the earth surface. The main meteorological parameters listed above can be described as follows during the evapo-transpiration:

- **Sun's radiation:** Evapo-transpiration happens by the energy enough for water evaporation. Sun's radiation is the biggest energy source – it can turn the big masses of water in steam. A potential intensity of the radiation which can reach the earth's surface independently very much depended on a location of that surface and a season. The potential radiation differs on the different latitudes and the time of the season. Intensity of the sun's radiation that is reaching the earth's surface is depended on atmospheric fogginess and cloudiness, because clouds are reflecting and absorbing significant part of the radiation. While evaluating the sun's radiation, one fact must be considered that the radiation is not evaporating water only and the energy is warming atmosphere and soil.
- **Air temperature:** Sun's radiation absorbed by the atmosphere and the heat emitted from the surface of the earth are increasing the air temperature. Hot air transmits some intensity of its energy to plants and enhances the evapo-transpiration. Thus in a sunny and hot weather the evapo-transpiration is higher than in cloudy and cool weather.
- **Air Humidity:** the energy received from the sun and the air is the main reason for the water evaporation. But for determining how much steam the air can absorb, the relative air humidity must be identified. When humidity is high i.e. air is absorbed by water, and has less capacity to absorb more which reduces evapo-transpiration.
- **Wind speed:** Removing the water steam off the earth's surface is very much depended on the wind speed. It takes the air currents from the earth's surface. While water is evaporated, the air above the earth's surface is highly saturated by steam. If this air is not changed by other dry air, then it fully be saturated by steam and evapo-transpiration would be reduced. Wind is moving the air and thus increasing evapo-transpiration.

A combined effect of the climatic factors over the evapo-transpiration is shown on a drawing 1 for two different climatic conditions. In a dry and hot weather, evapo-transpiration is increasing due to the air dryness and intensity of the energy. Under such conditions, the air can keep more steam, but the wind helps moving the air currents and evaporating more water. On the other hand, the water is evaporated less intensively in a humid weather with a high humidity level and clouds, thus there is less evapo-transpiration. The drawing is showing the wind effect by the graphic line leaning. The drier is the atmosphere the bigger is the influence of the wind over the evapo-transpiration. In a humid weather, the wind only slightly can replace highly humid air, by less humid one, therefore its influence on evapo-transpiration is less effective. In the arid climatic conditions, the wind is more effective on evapo-transpiration because a slightest increase in its speed can cause the immense changes to its intensity.



Drawing 1. Influence of the wind on the evapo-tranpiration under different climatic conditions

The monthly mean values of following parameters are input values CropWat model for assessment of water deficit of different plants:

- Geographical coordinates (for calculating the sun's radiation);
- Sun shining daily duration (for calculating the sun's radiation);
- The average of maximum temperatures;
- The average of minimum temperatures;
- Relative humidity of the air;
- The mean speed of the wind;
- Sum of Precipitation;

The first six out of the list are used for calculation of potential evapo-transpiration by a help of Penman-Monteith method recommended by FAO. Except of those data, it is necessary to indicate additionally a crop variety, a planting time (vegetation period), moisture absorbing coefficient, a depth of roots, productivity and depletion level. The water shortage for a crop can be calculated by comparing crop's water demand to the precipitation level, which would remain after evapo-transpiration process.

Meteorological data are recorded in different types of stations. For plants by their evapo-transpiration standards, meteorological data for determining the water shortages must be recorded in the agro-meteo-stations which are located directly in plots and all devices are under same climatic conditions as surrounding vegetations. The air temperature, relative humidity, wind speed, duration of sun shining in such stations are measured on 2 m heights only. Data identified in other meteorological stations require analysis and re-modification that increases the indefinity of data caused by a model. In all selected regions, the meanings of the climatic indicators in the basic periods are taken from the meteorological stations which are not agro-meteo-stations. Those stations do not register sun shining daily duration, therefore the parameter has been calculated using averaged quantities regsitered in the Shiraki meteorological station for Eldari and Udabno, radiation parameters of the Teleti station for Sagarejo and Dedoflistskaro, and data registered by the Tbilisi hydrometeorological station for Gori and Gardabani.

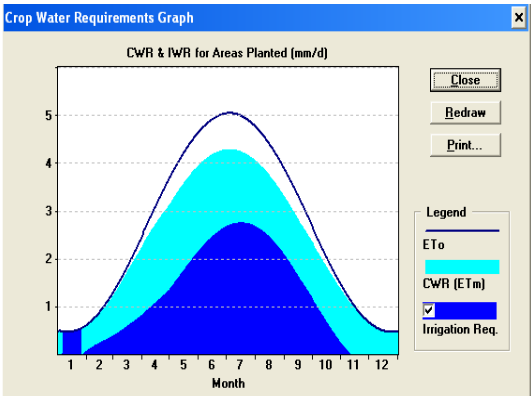
Besides the wind speed are measured on 10 meters in such stations and to downscale a value measured on 10 to 2 meters, a special logarithmic formula was used for it. [Crop Evapotranspiration – Guidelines for computing crop water requirements, FAO Irrigation and Drainage Paper 56, http://www.fao.org/docrep/x0490e/x049e00.htm]

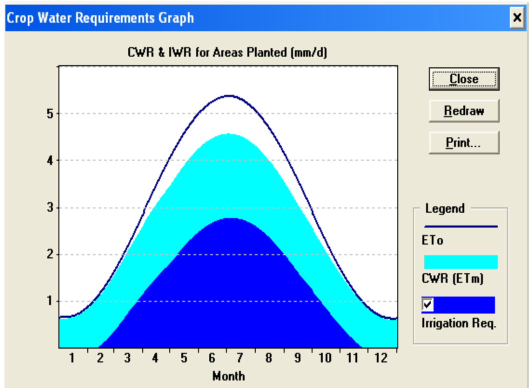
Annex 11. Assessment of water deficit for some agricultural cultures in semi-arid areas

Meteostation	Time period	Crop	CWR mm/a	IR mm/a	% of deficiency
Udabno	1963-1992	Pastures	812.54	388.5	0.47813
Udabno	2021-2050	Pastures	883.23	437.37	0.495194
Eldari	1951-1965	Pastures	842.42	424.51	0.503917
Eladi	2021-2050	Pastures	934.52	450.56	0.48213
Gori	1980-2005	Winter wheat	738.55	443.78	0.60088
Gori	2021-2050	Winter wheat	868.72	549.01	0.631976
Udabno	1963-1992	Winter wheat	652.13	350.85	0.538006
Udabno	2021-2050	Winter wheat	695.00	386.04	0.555453
Gardabani	1980-2005	Winter wheat	762.14	503.04	0.660036
Gardabani	2021-2050	Winter wheat	779.82	509.81	0.653753
Eldari	1951-1965	Winter wheat	683.48	385.47	0.563981
Eladi	2021-2050	Winter wheat	743.46	413.06	0.555591
Gori	1980-2005	Cabbage	439.8	294.53	0.669691
Gori	2021-2050	Cabbage	495.26	346.47	0.699572
Gardabani	1980-2005	Cabbage	475.45	353.78	0.744095
Gardabani	2021-2050	Cabbage	462.28	346.77	0.75013
Eldari	1951-1965	Cabbage	405.01	261.87	0.646577
Eladi	2021-2050	Cabbage	431.94	262.42	0.607538
Udabno	1963-1992	Cabbage	387.36	234.33	0.604941
Udabno	2021-2050	Cabbage	410.56	255.64	0.622662
Gardabani	1980-2005	Tomato	700.71	517.33	0.738294
Gardabani	2021-2050	Tomato	689.8	514.19	0.745419
Gori	1980-2005	Tomato	656.04	443.2	0.675569
Gori	2021-2050	Tomato	744.96	530.87	0.712615
Udabno	1963-1992	Tomato	576.59	348.19	0.603878
Udabno	2021-2050	Tomato	609.83	382.15	0.62665
Eldari	1951-1965	Tomato	605.75	381.92	0.630491
Eladi	2021-2050	Tomato	647.06	400.47	0.618907

Annex 12. Daily water demand and deficit for agricultural cultures assessed during one year

In the graphs below the dark blue line shows potential evapo-transpiration of the area, the blue space shows water demand of the concrete culture and the dark blue space shows water deficit or demand for irrigation. The horizontal axis stands for months, while the vertical one shows quantity of water in millimeters



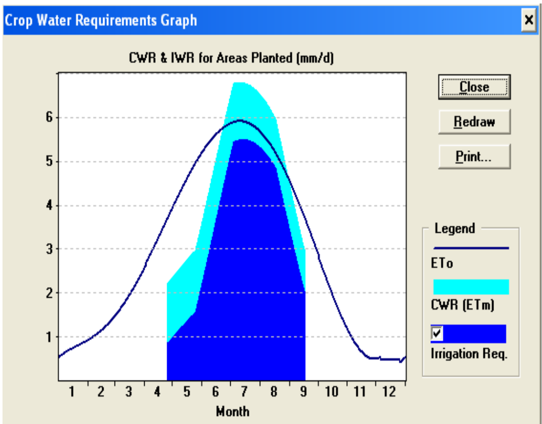


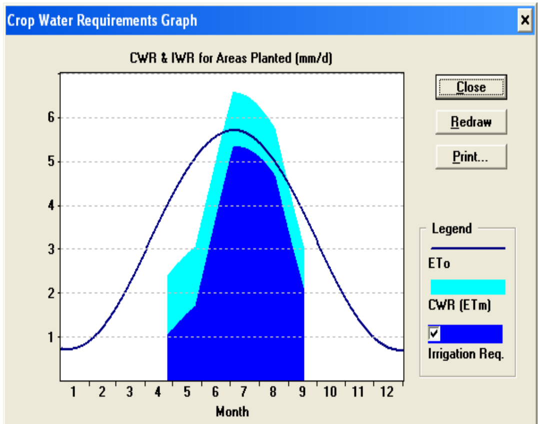
Grasslands in Eldari

1951-1965

Grasslands in Eldari

1921-1950



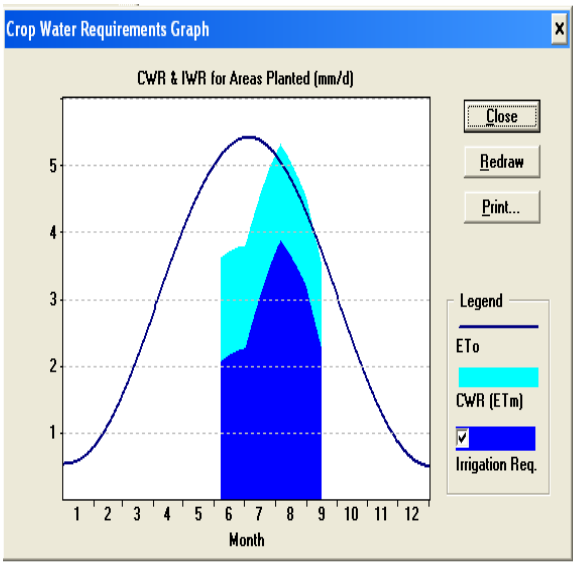


Tomato culture in Gardabani

1980-2005

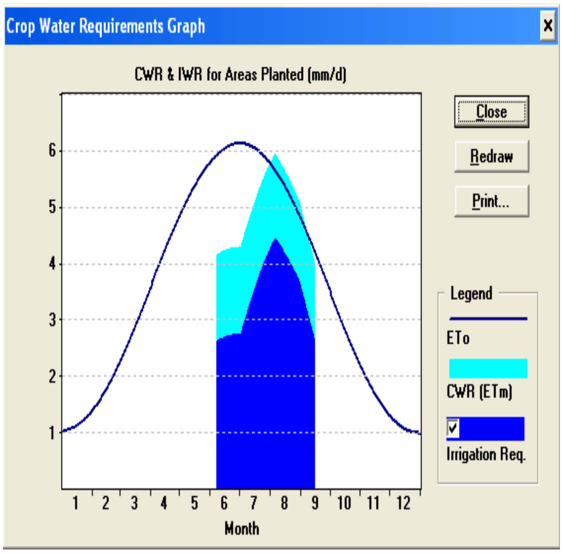
Tomato culture in Gardabani

2020-2050



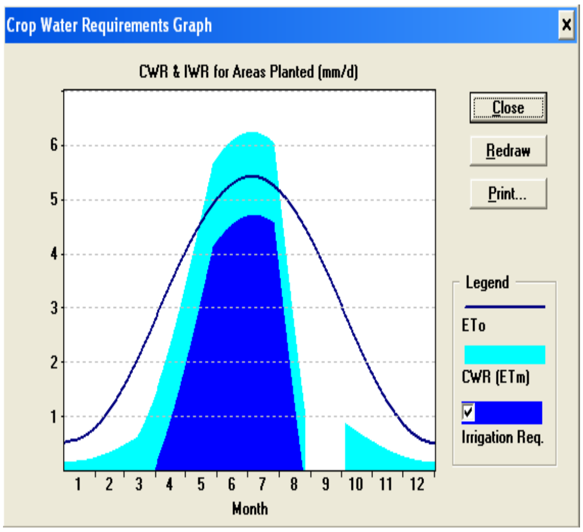
Cabbage culture in Gori district

1980-2005



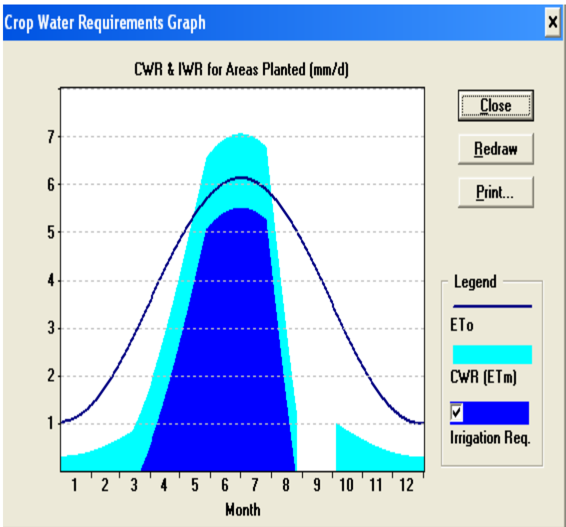
Cabbage culture in Gori district

2021-2050



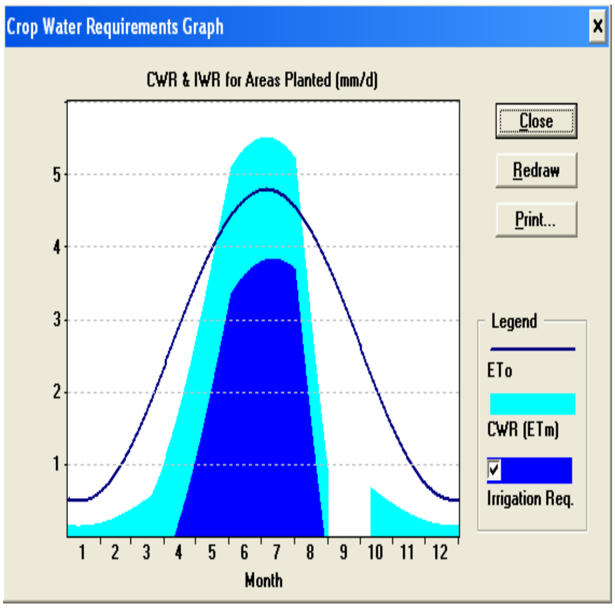
Wheat culture in Gori District

1980-2005



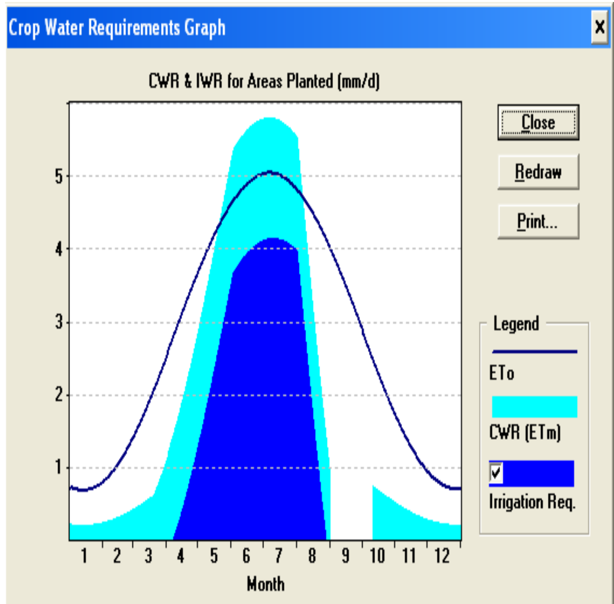
Wheat culture in Gori District

2021-2050



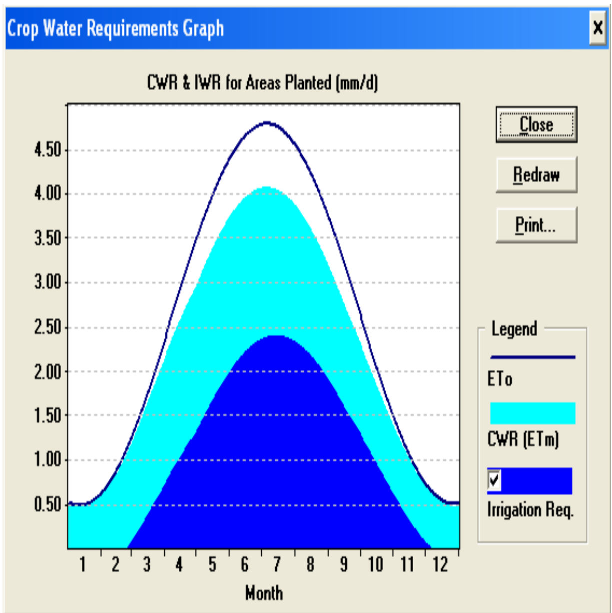
Wheat culture in Udabno

1963 -1992



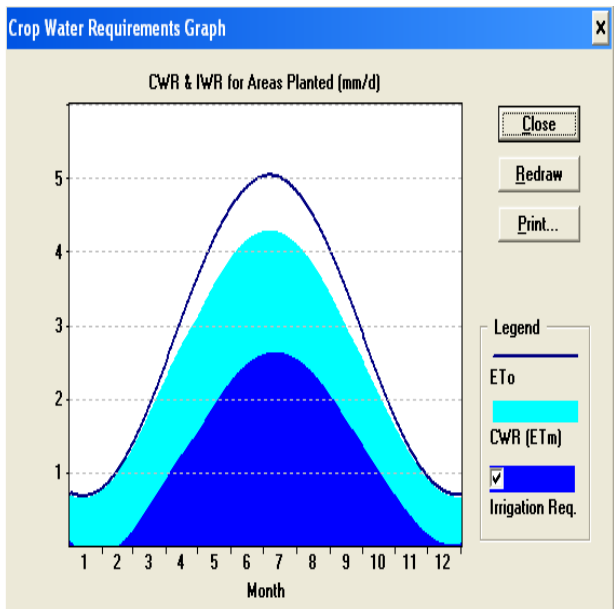
Wheat culture in Udabno

2021-2050



Grasslands in Udabno

1963 -1992



Grasslands in Udabno

2021-2050

Annex 13. Determining vulnerability coefficients for indicators

Scoring system

The following two examples explains how the figures provided by experts were scored and ranked:

Example 1: highest value is aasigned 1.00

Suppose that from the data provided by the national experts on the difference between average annual rainfalls of 1991-2010. vs. 1961- 1990., the following results are obtained:

	Region A	Region B	Region C
Difference in rainfall (mm)	77.30	76.20	41.90

We see that Region A has the biggest difference in rainfall, which hypothetically makes it more vulnerable than the other two regions. We assign this region vulnerability coefficient 1.00, which represents the highest vulnerability coefficient (on a scale from 0.00 to 1.00). The vulnerability coefficients for the other two regions are calculated by dividing their rainfall difference values by the rainfall difference for Region A. So the vulnerability coefficient for Region B is 0.99 (= 76.29 divided by 77.30) and for region C 0.54 (= 41.90 divided by 77.30).

	Region A	Region B	Region C
Vulnerability coefficient	1.00	0.99	0.54

In the above example, region with the highest value has been assigned vulnerability coefficient 1.00. However, this is not the rule for each criteria (sub-indicator). For some criteria we'll assign the highest vulnerability coefficient of 1.00 to the region for which we obtained the lowest value. The following example illustrates it well.

Example 2: lowest value is aasigned 1.00

Suppose that from the data provided by the national experts on the average monthly salary, the following figures are obtained.

	Region A	Region B	Region C
Avarage monthly salary (EURO)	150.00	165.00	180.00

In this case, the most vulnerable (at least hypothetically) is not region with the highest figure (as was the case with the difference in rainfall), but the region with the lowest figure (salary). In this case, we assign the highest vulnerability coefficient of 1.00 to the region with the lowest value. In our case it is Region A (again). The vulnerability coefficients for the other two regions are calculated by dividing the salary of Region A with their salaries. So the vulnerability coefficient for Region B is 0.91 (= 150.00 divided by 165.00) and for region C 0.83 (= 150.00 divided by 180.00).

	Region A	Region B	Region C
Vulnerability coefficient	1.00	09.91	0.83