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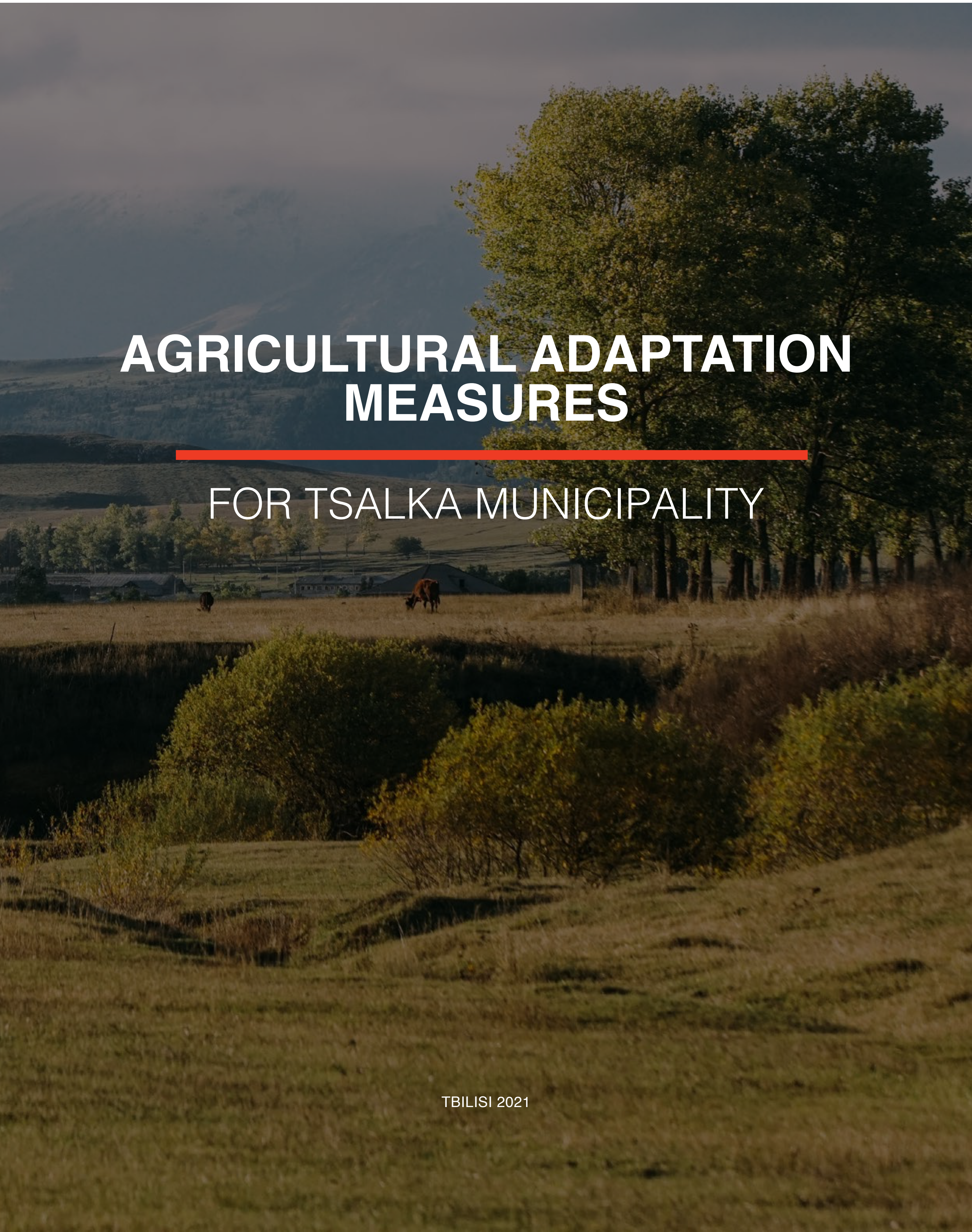

AGRICULTURAL ADAPTATION MEASURES

FOR TSALKA MUNICIPALITY

TBILISI 2021

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INTRODUCTION

The purpose of the present study is to develop agricultural adaptation actions and recommendations for Tsalka Municipality based on climate change scenarios (1960-2050) to assess impacts of climate change on agriculture and identify threats, challenges and new opportunities, and also to promote climate smart agriculture and the introduction of sustainable agricultural practices in Tsalka Municipality.

1. GRAIN CROP PRODUCTION

1.1 Overview of the grain crop production sector in Tsalka Municipality

According to 2014 data, in Tsalka municipality about 7000 ha of lands were ploughed and 6340 ha were sown. Potatoes occupy 3446 ha, wheat - 544 ha, barley - 1068 ha, oats - 914 ha, others- 368 ha. Wheat harvests amounted to 1656 tons, barley - 2379 tons, oats (green mass) - 5000 tons. In total, the share of grain crops is 25% (GeoStat, 2016).

The share of crops in Tsalka municipality according to the sown area is as follows:

1. Potato - 40%
2. Grain crops (wheat, barley) - 25%
3. Cabbage - 10%
4. Roots (beets, carrots) - 8%
5. Onion and garlic - 7%
6. Annual herbaceous crops (oats) - 5%
7. Perennial herbaceous crops (alfalfa, sainfoin) - 5%

This sector is quite developed and profitable. The average grain yield is as follows: wheat - 3 t/ha, barley - 2 t/ha (Operational data, 2019). Oat is used as cattle feed (300 bales per hectare, which is equivalent to 6 tons of dried fodder). Although there is different data, which prioritizes: potatoes (15 t/ha), wheat (1.2-1.5 t/ha), and cabbage (3 t/ a). Yields of these crops have increased by 15-20% in the last decade (Source: Perspectives for the Development of Agriculture in Tsalka Municipality, 2015).

In addition to the fact that the production of grain crops is well-developed in the municipality, they also play a role of an intermediate crop, without which potato growing would not be profitable. The same applies to other crops. Grain crops are also distinguished by the fact that their cultivation on unirrigated soils under climate conditions of Tsakla is quite reasonable. 12 thousand hectares of arable lands owned by the municipality are not used for agricultural purposes.

According to current data, in Tsalka municipality up to 700 ha of lands are ploughed and sown to wheat, and up to 1200 ha - to barley. Municipality yields 5000 tons of crops throughout the year (Source: Perspectives for the Development of Agriculture in Tsalka Municipality, 2015).

A SWOT analysis allows to study the situation regarding grain crop production in Tsalka Municipality.

The strengths of grain crop production in Tsalka Municipality are:

1. Soil-climatic conditions;
2. Market availability/demand;
3. Available lands;
4. Traditions of crop growing.

Unfortunately, grain crop production in Tsalka Municipality is characterized by weaknesses:

1. Lack of quality seed material;
2. Disruption of a seed selection system;
3. Low soil fertility;

4. Fragmented areas;
5. Lack of knowledge of modern technologies;
6. Non-adherence to cropping calendar;
7. Unavailability of post-harvest technologies and infrastructure;
8. Irregular pre-contractual system between farmers and buyers;
9. Lack of qualified staff.

Grain crop production opportunities in Tsalka Municipality:

1. Experience in grain crop growing;
2. Opportunity to expand the areas under grain crops;
3. Raising the level of knowledge and awareness of farmers;
4. Development of seed production;
5. Dissemination of new production technologies.

Threats related to crop grain crop production in Tsalka Municipality:

1. Frequency of prolonged and severe droughts;
2. Increased demand for irrigation water and water shortage in the face of climate change;
3. Damage to crops by strong winds in the absence of windbreaks;
4. Decreased soil fertility due to water and wind erosion.

The proper grain crop production strategy ensures: partial replacement of imported goods, increased yields, production of quality products, increased sown areas, increased level of knowledge and awareness of farmers.

1.2. Challenges in conditions of past and future climate change

Climate change and its negative impact on Georgia's ecosystems and economy pose a great threat to the country's sustainable development. The geographical location of the country, rough terrain, diverse land, and specific climate, which includes almost all climatic zones, creates conditions for a wide range of negative effects of climate change in Georgia. Adaptation of different sectors of the economy and reducing the damage caused by climate change is critical to reducing poverty and protecting the environment from degradation.

The effects of climate change in Georgia have already had a negative impact on natural resources, ecosystems, and almost all sectors of the economy, especially agriculture, which is naturally the most sensitive to climate change. Paris Agreement under the UNFCCC has been enacted for Georgia on June 7, 2017. Paris Agreement is considered to be the beginning of a new phase in world climate policy and its main aims are: 1) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; 2) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.

The Government of Georgia has expressed its readiness to join the global effort to combat climate change by drafting a Nationally Determined Contributions (NDC) document prior to the Conference of Parties to Paris Agreement in 2015. The document of Georgia's Nationally Determined Contributions emphasizes the importance of the agricultural sector: "Georgia's agricultural sector plays an important role in the country's economy. "Georgian farmers must play a key role in meeting the fundamental needs of society - the provision of safe, secure, and affordable food."

Significant steps are planned for the adaptation of the agricultural sector to climate change.

1. Prepare and implement plans for rapid response to droughts, floods, and other extreme events in agriculture;

2. Implementation of innovative methods of irrigation management and water use, etc.

Climate change trends and multiannual indicators have not changed much over the past 60 years for grain crops, and the problems have been easily solved, with a few exceptions (1998, 2008).

Forecast in change of climate parameters in Tsalka for 2021-2050 reaffirms the need for the predominant development of grain crops in this region.

According to the forecast for the next 30 years, the length of the growing season will increase by nine days (up to 223.5 days in total), which is a noticeable change and may have a positive effect on yields, especially on spring grain crops, creating the opportunity to better reveal the potential of specific varieties (Morgounov A, Sonder K, Abugalieva A, Bhadauria V, Cuthbert RD, Shamanin V, et al. Effect of climate change on spring wheat yields in North America and Eurasia in 1981-2015 and implications for breeding. PLoS ONE 13(10), 2018) and cultivate the crops with longer growing season which usually produce higher yields (R.C. Sharma. Duration of the vegetative and reproductive period in relation to yield performance of spring wheat. European Journal of Agronomy, Volume 1, Issue 3, Pages 133-137, 1992). Increased relative humidity (average - 1%) and the sum of active temperatures by 121.7°C will also result in increased yields of spiked grain and grain crops. According to the future scenario, the winter in Tsalka becomes warmer, average winter temperature will increase by 0.6°C, average maximum - by 0.4°C, and minimum - by 2.3°C, which in some years may accelerate the development of spiked grains and make them less resistant to spring frosts (L. Liu et al. Response of biomass accumulation in wheat to low- temperature stress at jointing and booting stages. Environmental and Experimental Botany 157, 46–57, 2019), which is likely to happen as the absolute minimum temperature will be 3.2°C lower than in the past 60 years, despite the general trend of warming. As for droughts and the increase of heatwaves during the forecast period, it will be possible to adapt by means of properly implemented complex agro-technical measures. However, the increased frequency and duration of heat stresses in the future will negatively affect wheat yields, like spring frosts do (KM Barlow et al. Simulating the impact of extreme heat and frost events on wheat crop production: A review. Field Crops Research, Volume 171, Pages 109 -119, 2015).

A particularly noteworthy in the Tsalka climate projection is the likelihood of more severe and prolonged droughts, as measured by both the Precipitation (SPI) and the Standardized Precipitation-Evapotranspiration Index (SPEI), which can significantly increase the risk of damaging crops on non-irrigated lands during droughts. On irrigated lands, a hydrological drought can cause a shortage of irrigation water, the increased frequency of which is evidenced in the last 30 years. Therefore, it will be especially important to maintain soil moisture and adhere to irrigation rules, deadlines, and norms, which will help increase irrigation water efficiency and minimize waste losses.

1.3. Conclusions and recommendations for implementation of proper agro-technical measures in the face of climate change

The Plan of the Development of Agricultural Production in Tsalka Municipality (Source: Perspectives for the Development of Agriculture in Tsalka Municipality, 2015) clearly shows that the diversified farming is a key for success. The world experience in combining multiple areas has shown that proper planning of crop growing and animal husbandry is a prerequisite for increased productivity and profitability. Here, first of all, crop growing is meant as a guarantee of livestock feed supply and, on the other hand, livestock - as a mean of increasing the yields of field crops through provision of organic fertilizers. Therefore, crop grain crop production has a crucial importance.

Due to climate change, Tsalka municipality is especially outstanding as 80% of the lands need irrigation and there are resources available to irrigate all the lands. High-temperature shocks are more important, which will require the introduction of modern technologies, such as rain irrigation, the use of hail protection nets, etc.

The introduction of crop rotation practice is important; As mentioned in the review, potatoes occupy 40% of the arable lands in Tsalka Municipality, 25% are occupied by grain crops. Potato crops are relatively tolerant to repeated sowing in the same plot for 2-3 years, but to maintain soil fertility and increase yields, it is better to rotate the crop annually. This will allow to increase the grain crop field areas up to 35% and reduce the potato field areas to 35%. This does not necessarily mean that the yields of potato will decrease, on the contrary, the yield will increase sharply and reach 40-60 t/ha.

Barley is an important crop. It has a special place in animal nutrition. The yields of barley mentioned in the review will satisfy the needs of only 10-15% of the livestock sector. It should be noted that increasing the areas under this crop should lead to increased yields. Currently the average yield of barley in the world is 4.5-5.5 t/ha.

Under current conditions, in Tsalka municipality preference should be given to the propagation of forage wheat varieties. These varieties, as compared to food wheat varieties (6.5-7.5 t/ha)are characterized by higher yields (8-10 t/ha). The areas under these crops should be planned according to the needs of the livestock sector.

Tsalka is a suitable location for corn growing. Corn will allow to get a high grain yield (10-12 t/ha) and silage (50-60 t/ha). This crop is widely used, although its yields are very low. Preference should be given to intensive varieties of oats, which are characterized by high green mass and grain yield.

To ensure the growth of agricultural production in Tsalka Municipality, the following recommendations should be considered:

1. Introduction of special types of crop rotation according to farms: 5-6 fields, e.g., 1. autumn wheat; 2. potatoes; 3. barley; 4. corn for silage; 5. vegetables; or e.g., 1. autumn wheat; 2. forage perennial grasses; 3. potatoes; 4. corn for food; 5. vegetables; 6. corn for silage.
2. Organic manure should be used to increase soil fertility. Fertilizers should be applied in in turns at a rate of 20-30 t/ha according to the soil analysis
3. To increase soil fertility, the use of intermediate crops, after both potato, and grain crops should be widely introduced. This measure will help adapt to changing climatic conditions, protect the soil from moisture loss and erosion, and create additional green mass for livestock.

4. Due to the climate change, crop calendars should be strictly followed. Given the current climate change and future projections, crop calendars will not change substantially, although the implementation of agro-technical measures in a timely and proper manner will be important. Farmers should make observations and records, which will help them in the effective implementation of the planned works.
5. In order to obtain high-quality seed materials, it is desirable and necessary to establish a seed farm for the region. This will allow to fill the shortage of quality seed materials.
6. As the world experience shows, cooperative farms should be established to increase the productivity and develop production. There is enough experience and appropriate conditions in this area to successfully solve the problem.
7. Acquiring modern technologies is of the utmost importance. The introduction of modern advances in agriculture will help easily overcome the negative impacts of climate change. For example, the use of drones allows timely application of herbicides and fertilizers. Precise agriculture production technology allows irrigation and application of fertilizers or pesticides in the specified area according to the needs of the field. This in turn saves energy and costs.
8. It is important to purchase and use modern equipment. For this purpose the state provides subsidies to cooperative farms. The use of modern equipment is a guarantee of success.

1.4. Recommendations for the cultivation of new varieties/hybrids adapted to the climate

Due to the climate change, grain crops should be selected taking into consideration natural conditions, to ensure the development of agriculture in Tsalka. It is especially important to determine the location considering the sea level. When harvesting twice and using intermediate crops, it is best to select crops with a short growing period. For example, growing vegetables or sowing cover crops after harvesting wheat in autumn.

Modern farming requires the maintenance of green cover on arable lands throughout the year in order to maintain the soil microflora and minimize the impact of adverse effects of climate. Therefore, it is necessary to introduce multicropping and redistribute labor resources throughout the year.

Due to the established agricultural activities, wheat crop is important for the region. In the high zone the local varieties are recommended: Akhaltsikhe red Doli bread (autumn) and Dika (spring), which are more adapted to harsh conditions and produce more stable yields. It is better to sow intensive forage crop varieties, such as: Lomtagora 126, Sauli 9, Tbilisuri 15, Jagger, Pobeda, Spartanka. Yields of these varieties range within 6.5-8.5 t/ha. However, it is possible to get higher yields. For this purpose it is necessary to follow crop calendars and introduce a modern system of fertilization (multiple application). In Tsalka municipality, the sowing dates for autumn wheat and barley are from August 20 to September 15. Before sowing the seeds should be processed using fungicides to prevent the development of fungal diseases. Soil fertilization depends on the level of soil fertility. The type and amount of fertilizers should be determined by taking into account the results of laboratory tests of the soil and the yield per ha of the relevant crop variety. Fertilizers, including organic fertilizers and chloride-containing mineral fertilizers, are applied before plowing. Organic fertilizers should be applied to the previous crop. For this purpose, 20-30 tons of manure is used per 1 ha. Some portion of the fertilizer is also applied during sowing. However, during sowing, only a small part of the nitrogen fertilizer should be applied, while the rest is to be used in spring. In addition to nitrogen fertilizers, fertilizers containing other nutrients are added if necessary. Adding nitrogen fertilizers twice gives good results, which reduces nitrogen losses and has a positive effect on grain quality and yields.

Barley is considered to be the oldest and most strategic crop in world agriculture. In Tsalka region barley is an important forage crop. Spring and autumn and double seeded barley varieties are important for overcoming unexpected climatic conditions. At the same time, in contrast to wheat, barley does not require highly fertile soils. The growing season of barley varies from 75 to 230 days. Due to this feature barley can be used as reserve crop. Six-row forms are distinguished by high yields: local - Kazbegi, Akhalkalaki 198 (autumn), Tsilkani 1, Nutans 32/24 (spring); imported - Pallidum (29631), Pallidum (29613).

Corn is very promising as animal feed in the region. Its yield is much higher than that of other grain crops. It is important to note that there are different varieties, lines, and hybrids of corn - heterozygous forms, that are particularly high yielding. Using such hybrids will lead to higher yields. It should be kept in mind that these hybrids require special conditions. These include water and fertilizers. In this respect, the region is well fixed. Corn easily tolerates climate change, making it possible to get a guaranteed harvest. Local hybrid forms inclide: Kartuli 9, Tsilkani 1, Tsilkani 2, Kartuli 52. imported hybrids include many forms of Pioneer. The silage forms are: Iveria 70, Kartuli 55.

Oat which is actively used by farmers is an important crop for the region. We would recommend them to use the variety “Argo”, which has been developed and introduced by the Georgian Scientific-Research Center. This is a spring crop, characterized by the development of a large green mass - 40-50 t/ha, grain yield - 4.5-5.5 t/ha. Leftovers from seed cleaning can be used in mixed fodder.

2. VEGETABLE AND POTATO GROWING

2.1 Overview of vegetable and potato growing in Tsalka municipality

Tsalka municipality has a high potential for potato growing due to its soil-climatic conditions. There is a good prospect of certifying ecologically clean agricultural products, as air, soil, and water pollution is at minimum levels. The locals have a long tradition of potato growing.

Vegetable growing is not a leading sector in Tsalka municipality, but it occupies a fairly large area.

Cabbage is planted on 200-300 hectares annually. Local cool climate creates favorable conditions for cabbage. In 2018 358 ha (yield - 8950 t) was sown, the sown area in 2019 was 273 ha (yield - 6825 t), in 2020 - 270 ha. The average yield per hectare is 25 tons. The crop is sold locally, as well as in the markets of Tbilisi and Kvemo Kartli region. Sale prices range from 0.5 to 0.7 GEL (Source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environmental Protection and Agriculture).

To facilitate the development of vegetable growing, farmers' cooperation shall be supported, drip irrigation systems shall be introduced, seeding farms shall be equipped with modern technologies, etc. Appropriate trainings shall be also provided to farmers.

Potato growing is one of the leading agricultural activities in Tsalka municipality. The development of this field plays an important role in improving the economic situation in the region. Most arable lands in Tsalka Municipality are occupied by potatoes (up to 2500-3500 hectares). The sown area in 2018 was 3087 ha (yield - 51,400 t), in 2019 - 2806 ha (yield - 45,828 t), and as for 2020, the sown area is about 3,000 hectares. Potato yields depend on irrigation and specific conditions within irrigated and non-irrigated zones. The average yield in irrigated areas is 25 tons, and in non-irrigated areas - 10 tons. The average yield of the total sown area of potatoes is 17 tons (Source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environmental Protection and Agriculture).

Potato harvest in Tsalka starts in early September and lasts until the end of October. The crop is sold at wholesale prices directly from the field, as well as from storage warehouses, and the prices are determined accordingly. Wholesale prices range from 0.5-0.7 GEL, and in case of purchase from a warehouse, the prices will vary depending on the market conditions (Source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environmental Protection and Agriculture).

The share of root vegetables in the total agricultural produce is about 6%. Beets are grown in Tsalka municipality for both household consumption and use as a forage. According to the current data, the yield of fodder beet is 25-30 t/ha, carrots are characterized by similar productivity. In total, the root vegetables occupy about 200 ha and, and a total of 6 thousand tons are produced. Increasing the share of beet crop in Tsalka is important for the development of livestock farming. The development of this crop requires the introduction of modern technologies (Source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environmental Protection and Agriculture).

Onion and garlic crops are quite common in Tsalka municipality. They are produced both for sale and own consumption. Their share in total agricultural produce is 5%. The climatic conditions are quite favorable for the cultivation of these crops. The average yield of garlic is 13 t/ha, and onion - 25 t/ha. It should also be noted that if the irrigation systems are in place and new technologies are introduced, the cultivation of these two crops in Tsalka will be more profitable *(Source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environmental Protection and Agriculture).*

2.2. Challenges in conditions of past and future climate change

Climate change affects plants and animals directly or indirectly, thereby altering the internal natural balance. Understanding and properly assessing the negative impacts of climate change is essential to selecting the right policies and adaptation strategies. Given that the potential consequences of climate change are highly specific, agricultural entrepreneurs have reported the following effects of climate change on the agroecosystems:

- Increased variability and unpredictable indicators of weather and climate events: prolonged and intensified drought periods, rising temperatures, heatwaves, etc.
- Changes in the duration of seasons: the early arrival of spring due to the current and projected warming of the Tsalka climate;
- Plants are affected by heatwaves, the frequency of which in Tsalka is increased during the growing season;
- Degradation of agricultural lands due to their improper use and climate change both in arable lands and pastures;
- The increase in the spread of pests and diseases due to the increase in mean, mean maximum, and mean minimum temperatures, which is confirmed by observations in Tsalka over the last 30 years. The future climate change scenario also confirms the trend of warming, practically throughout the year.

Rising temperatures and drastic variability and intensity of the weather significantly affect crop growing, leading to reduced yields of many crops.

In 2010, the FAO presented the concept of climate smart agriculture at the Hague Conference on Agriculture, Food Security, and Climate Change. Climate smart agriculture combines three sectors – economic, social and environmental - to address food security and climate change challenges. Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives:

- sustainably increasing agricultural productivity and incomes;
- adapting and building resilience to climate change; and
- reducing and/or removing greenhouse gas emissions, where possible.

This does not imply that every practice applied in every location should produce "triple wins". Rather the CSA approach seeks to reduce trade-offs and promote synergies by taking these objectives into consideration to inform decisions from the local to the global scales and over short and long time horizons, to derive locally-acceptable solutions.

Scientists suggest that the situation will worsen in the future, which will be caused by reduced availability of water and other natural resources. Climate variability and the frequency of extreme events will reduce yields and contribute to the spread of weeds, pests, and diseases. Climate change is expected to hit developing countries the hardest.
Reducing stresses has a

lways been a major task for the agricultural sector, however, as a result of climate change, environmental conditions have become much more damaging than ever before. Localized extreme events and the sudden spread of pests and diseases are already causing an unpredictable outcome, which are deteriorating every year and require adaptation measures.

The following measures are needed for intensifying sustainable production of plant products and introduction of modern agricultural practices:

- Maintaining healthy soil, its ecosystems, and proper management of plant nutrition;
- Cultivation of a wide range of plant species and introduction of seed rotation;
- Use of highly productive varieties and high-quality seed materials;

Today, many agricultural practices and approaches are available. Their introduction in farming will address not only environmental sustainability issues but also increase the productivity of farms. It should be noted that these measures should be considered comprehensively and selected for the specific farm by taking into account the existing ecological, social, political, and economic background.

Below are listed some approved and effective examples of practices:

- Conservation agriculture;
- Mulching;
- Integrated plant protection;
- Organic farming;
- Water and irrigation management;
- Soil and nutrient management;
- Seed rotation and plot rotation;
- Crop diversification;
- Use of high quality seeds and nursery material that are adapted to a specific environment.

Most of the listed measures can be implemented at the individual farm level, although some of them require extensive infrastructural interventions and investments.

2.3. Conclusions and recommendations for proper agro-technical measures in the face of climate change

კლიმატის ცვლილების ზემოქმედების ხარისხიდან გამომდინარე, სრულიად ბუნებრივია, რომ Depending on the level of the impact of climate change, it is natural that agriculture is strongly affected by climate change, not to mention the dependence of this sector on the climate and environmental conditions. Agriculture is the most "classic" sector in terms of the impact of the climate change. Changes in temperature, precipitation, seasons and growing seasons, soil moisture, as well as extreme weather events (drought, floods, heavy rainfall) cause soil degradation, erosion, depletion, and consequently, declining productivity in both crop production and livestock farming, which in turn will disastrously affect the quantity and quality of food.

Studies in the US have shown that potato yields decrease if the plant suffers from water shortage for more than 5 days. However, the effects of water stress vary according to the growth stage (Table 2.3.1.).

Table. 2.3.1. Impact of water stress on potato yield

Growth Stage	Soil Available Water Requirement	Yield Losses IF Available Water Below Required Levels
Sprout Development	75%	Short periods of drought stress do not reduce yield
Vegetative Growth	75%	5%
Tuber Initiation	80%	10%
Tuber Bulking	90%	40-60%
Tuber Maturation	60-65%	Water deficit causes tuber dehydration

Given the ongoing climate change in Tsalka Municipality, an increase in the intensity and duration of droughts is expected, which will further increase the demand for water and the risk of crop losses in the absence of adequate water supply. Therefore, timely watering of potato crops and reduction of water losses from the soil will be very important. In order to maintain moisture in the soil, it is important to cultivate the crop in a timely manner, break soil crusts and prevent its further hardening and cracking, which will significantly increase water losses from the soil. Mulching hepls regulate soil moisture and temperature, which also limits the development of weeds and protects the soil from erosion. Moisture loss from the soil intensifies in windy weather. Even slow winds accelerate the soil drying processes. According to the Tsalka climate change projections, the average wind speed increases slightly: by 0.2 m/sec in spring and by 0.1 m/sec in summer. It will be necessary to plant windbreaks to protect the crop. According to studies, potato yields in wind-protected areas are increased by 4.8 and 9.3% compared to unprotected areas (Wright, A.J., and S.J. Brooks. 2002. Effect of windbreaks on potato production for the Atherton Tablelands of North Queensland. Aust. J. Exp. Agric. 42:797-807), in some cases, the yield is increased by as much as 35% (Sturrock, J.W. 1981. Shelter boosts crop yield by 35 percent: also prevents lodging. New Zealand J. Agric. 143:18-19).

Potato crop is also sensitive to high temperatures. 20-25° C is favorable for photosynthesis, stem growth, and flowering. At 30°C growth of potatoes is inhibited and at above 35°C is completely stopped. At high temperatures, photosynthesis decreases, the plant begins to shed flowers, and the stem withers. In high-temperature conditions, the root plants degenerate. According to the Tsalka climate change projections, the warming trend is maintained during the growing season. Rising temperatures in spring can have a positive effect on accelerating the process of sprouting and the use of wet period, although the risk of spring frosts cannot be ruled out. Potatoes are relatively tolerant to small frosts from 0 to -1.5°C, although a drop in temperature to -2 - -4°C can significantly damage the overground part of the plant. Temperatures below -4.5°C in autumn usually cause the growth cessation. The probability and severity of frosts are higher on plains and in depressions. The crop is relatively protected from strong frosts on slopes and elevated places. Mulching also provides some protection from frost.

Absolute maximum annual temperature in Tsalka is expected to rise by 3 degrees, reaching 36.6°C in August, which is a significant change, although the damage caused by it will depend on the duration and frequency of hot days. Mulching and planting windbreaks will significantly reduce the damage caused by high-temperature stress.

To maintain high yields, varieties/hybrids that are characterized by high resistance and tolerance to climate change should be selected.

The small yields of vegetable crops in Tsalka Municipality are due to lack of irrigation and high labor demand.

To achieve a significant increase in agricultural production in Tsalka municipality, the following recommendations should be considered:

The soil should be cultivated in time, which will help increase production of vegetables and potatoes.

Before planting vegetables and potatoes, the plot should be prepared, which implies cleaning and tilling. Prior to tilling, the plot should be cleaned of plant debris from previous crops. This is very important as waste may cause the spread of pests and diseases.

To get a good yield, all crops need to be fertilized. Fertilizing the soil, means providing the plant with all the necessary macro and micronutrients for its growth and development.

To ensure the proper supply of nutrients, it is necessary to obtain information about the soil, its structure, and composition, which allows to accurately determine the amounts of applicable nutrients for a particular crop.

To determine the elements and their amount to be applied to the soil, an agrochemical analysis of the soil should be carried out.

The purpose of soil tilling is to create the necessary conditions for plant sowing, planting, germination, growth, development and to yield high-quality products. This means establishing the optimal balance of nutrients, air, and water in the soil. Achieving such an optimal regime is possible only in the loose soil layer, for which the soil is mechanically treated in various ways.

Mechanical cultivation of the soil improves soil fertility, increases water content, destroys weeds, stops erosion processes, facilitates intake of nutrients in the lower layers by plants, and regulates microbiological processes.

When cultivating soil for planting vegetables and potatoes, the main goal is to create a nutrient-rich, sufficiently moist, loose layer of the soil. For this plowing should be done as deep as possible - at 28-35 cm.

In early spring, as soon as the tilled soil dries, in order to maintain moisture, the soil should be cultivated with a disc cultivator accompanied by a harrow. 5 days before planting, nitrogen fertilizer should be applied with a duck foot cultivator, with teeth attached. After that, the plot is ready to plant vegetables and potatoes. Potato planting should start when the soil temperature at a depth of 10 cm reaches at least 7-8°C. The planting depth should also be taken into account, on soil of light granulometric (mechanical) composition potatoes are planted at a depth of 10-12 cm, and on heavy soils - at a depth 6-8 cm. In Tsalka, the majority of the arable lands are within the zone of black soils, therefore, the sowing depth will be 6-8 cm in most cases. Sowing depth should be specified for each plot based on the results of laboratory tests.

Fertility is the most important feature of soils. Fertility is the ability of soils to provide plants with required nutrients and water, create appropriate air and heat conditions, and thus ensure a high-quality and high yields of crops.

The soil is a source of micro- and macro elements required for the plants. Plants intake them through both the root and the leaves system.

Lack of micronutrients in the soil leads to disastrous consequences, which are reflected on declined vital processes, reduced crop yields and crop quality. Fertilizers with their amazing properties have a strong positive impact on the vital processes of plants and enhance their immunity even when applied in small quantities.

Based on the results of the soil sample analysis, the elements and their quantities to the applied to the soil is determined. Fertilizers are applied using special gear and protective equipment.

Quality seeds, the import of which is quite expensive for the farmer, play an important role in the vegetable and potato growing sector. It is therefore advisable to set up a seed farm in the region to produce high quality seed material.

Crop rotation which is one of the prerequisites for a high yield is important.

Different types of plants consume different substances from the soil. If crop rotation is not applied, the soil will deplete. Microorganisms and pests that cause diseases of a particular crop accumulate in the soil and on its surface, and will more actively attack the same crop next year.

Crop rotation facilitates:

- increase in yield;
- growth of biodiversity;
- increase and maintenance of soil fertility;
- regulation of pests, diseases, and weeds;
- forage for livestock.

Seed rotation is effective if properly planned and consistently implemented. Planning should take into account conservation considerations.

Table. 2.3.2. Examples of seed rotation in Tsalka municipality:

Crop	Recommended next crop	Unrecommended next crop
Potato	Cabbage	Potato
Onion	Potato	Representatives of the lily family
Garlic	Potato, cabbage	Representatives of the lily family
Cabbage	Potato	Cabbage varieties
Carrot	Potato, cabbage	Carrot
Beet	Potato, cabbage	Beet

2.4 Recommendations for the cultivation of new varieties/hybrids adapted to climate change

Potatoes and vegetable growing requires timely soil tillage, watering, and fertilizing, planting high yielding and hybrid varieties, optimizing the use fertilizers on the basis of chemical analysis of the soil and the amount of crops, targeted application of pesticides and automatization of labor.

The cultivation of any crop is based on the knowledge and application of the most important biological rule - the unity of the organisms and the environment. The main task of a farmer is to meet the needs of a plant to get a high yield. Each plant has specific requirements to environmental conditions.

Proper selection of the varieties of potatoes and vegetables, considering local environmental conditions is important for the development of the agricultural sector of Tsalka municipality. Proper selection of varieties/hybrids and proper implementation of agro-technical measures are key to high yields.

It is important for Tsalka Municipality to select varieties/hybrids which are distinguished by high resistance to diseases, and the varieties with medium growing season, which will be able to complete the whole growing cycle in local conditions. For example, local varieties: Meskheturi Tsiteli, Meskheturi, Javakheturi, which are resistant to diseases and droughts and produce high yields. These varieties have moderately longer growing season and their yields vary within 40-45 t/ha.

VARIETIES OF POTATO RECOMMENDED FOR TSALKA MUNICIPALITY:

Variety	"Meskhuri Tsiteli"
Manufacturer	Local
Growing season	Mid-season, late
Yield	40-45 t/ha
Flower	Light violet
Tuber	Oval, elongated
Skin	Red mesh like
Holes	Sat down
Pulp	Light yellow
Yield	High
Resistance	Resistant to diseases
Culinary Properties	Typical food

Variety	"Meskhuri"
Manufacturer	Local
Growing season	Mid-season, late
Yield	40-45 t/ha
Flower	White
Tuber	Oval, elongated
Skin	Yellow
Holes	Sat down
Pulp	Light yellow
Yield	High
Resistance	Resistant to diseases
Culinary Properties	Typical food

Variety	"Javakheturi"
Manufacturer	Local
Growing season	Mid-season, late
Yield	40-45 t/ha
Flower	White
Tuber	Oval
Skin	Yellow
Holes	Sat down
Pulp	White
Yield	High
Resistance	Resistant to diseases
Culinary Properties	Typical food

Variety	"Jelly"
Manufacturer	EUROPLANT
Growing season	Mid-season, early
Yield	30-35 t/ha
Flower	White
Tuber	Oval
Skin	Yellow smooth
Holes	Sat down
Pulp	Yellow
Yield	High
Resistance	Resistant to diseases
Culinary Properties	Typical food

Variety	"Agria"
Manufacturer	"AGRICO"
Growing season	Late
Yield	30-35 t/ha
Flower	White
Tuber	Oval
Skin	Mesh yellow
Holes	Sat down
Pulp	Light yellow
Yield	High
Resistance	Resistant to diseases
Culinary Properties	Typical food

Variety	"Marfona"
Manufacturer	"AGRICO"
Growing season	Mid-season
Yield	30-35 t/ha
Flower	White
Tuber	Rounded, oval
Skin	Yellow
Holes	Superficial
Pulp	Light yellow
Yield	High
Resistance	Resistant to diseases
Culinary properties	Typical food

Variety	"Picasso"
Manufacturer	"AGRICO"
Growing season	Late
Yield	30-35 t/ha
Flower	White
Tuber	Oval
Skin	Yellow
Holes	Sat down
Pulp	Light yellow
Yield	High
Resistance	Resistant to diseases
Culinary Properties	Typical food

Variety	"Fabula"
Manufacturer	HZPC
Growing season	Mid-season, early
Yield	30-35t / ha
Flower	White
Tuber	Oval
Skin	Yellow
Holes	Sat down
Pulp	Light yellow
Yield	High
Resistance	Resistant to diseases

2.5. Recommended varieties/hybrids of vegetable crops for Tsalka municipality

When selecting vegetable crops, the length of the growing season in Tsalka municipality, which has increased by 1 day compared to the period of 1960-90, should be taken into account. Accordingly, the following varieties have been selected considering the existing and projected characteristics of the Tsalka climate. According to climate projections, further warming and increased growing season by 9 days will make possible to grow varieties with medium growing season on larger areas, instead of early varieties, which will increase the yield and give the possibility to store harvested products for a longer period.

CABBAGE VARIETIES/HYBRIDS

Early harvest cabbage varieties/hybrids are tender, juicy and have good nutritional properties, but early cabbage cannot be stored for long.

Recommended early cabbage varieties for Tsalka are: Gribov 147, Express, Kharisgula.

Varieties/hybrids with medium growing season are high-yielding, with well-developed dense heads, and suitable for processing.

Mid-season - early varieties: Slava-1305, Slava Gribovskaya-231, Tashkenti 10, Borjomi Ideal (Georgian local).

Table. 2.4.1. Early cabbage crop calendar for Tsalka municipality:

1200-1700 m above sea level			1700-2200 m above sea level		
Sowing	Planting	Harvesting	Sowing	Planting	Harvesting
March 1-March 10	1 May- May 25	July 30 – August 25	March 25- April 10	15 May- 1 June	August 15 - September 1
April 10 -May 5	June 1-June 10	September 1- November 1	May 10 - May 20	June 15- June 25	September 15 - September 25

Table. 2.4.2. Mid-season and late cabbage crop calendar for Tsalka municipality:

1200-1700 m above sea level			1700-2200 m above sea level		
Sowing	Planting	Harvesting	Sowing	Planting	Harvesting
April 10 -May 5	June 1-June 10	September 1- November 1	May 10 - May 20	June 15- June 25	September 15 - September 25

CARROT VARIETIES/HYBRIDS

In the case of carrots, varieties/hybrids with shorter growing season are recommended for Tsalka. These include early, mid-season-early, or mid-season-late varieties.

Anti 11 - mid season-early, the growing season is 110-115 days. It produces high yields and can be stored for a longer period. The mass of the root is 700-720 g.

Laguna F1 - an early high yielding hybrid, root mass 750-760 grams;

Goruli Nanti: mid-season - late crop, growing season - 100-110 days. The total crop yield is 41.2- 85.2 t/ha. Root mass - 53-116 grams. Taste properties as rated are 3.6-4.2. Storage efficiency in winter is 79.4-84.4%.

Shantene 2461 – mid-season-late variety, the growing season in Georgia from germination to maturity is 109-147 days. The total crop yield is 35.4-80.8 t/ha.

Geranda – mid-season-early variety. Weight of roots - 220 g in average. The ratio of the root mass to leaf mass - 5: 1, the variety is high yielding and can be stored for a longer period.

Table. 2.4.3. Carrot crop calendar for Tsalka municipality:

1200-1700 m above sea level		1700-2200 m above sea level	
Sowing	Harvesting	Sowing	Harvesting
April 10 -May 10	September 15 -October 1	April 20 -May 10	October 1-October 20

FOOD BEET VARIETIES/HYBRIDS

Larka - a mid-season beet variety. It can be consumed both in a raw and processed form. It can be planted early. The growth season lasts 98-100 days. The average weight of the root - 60-65 g.

Egyptian flat - an early high-yielding variety, the growing season - 80-100 days. The average weight of the root - 60-65 g.

Pablo F1 - Mid season-early high-yielding hybrid. The average mass of root is 50-55 g, the growth season is 107-110 days.

Table. 2.4.4. Beet crop calendar for Tsalka municipality:

1200-1700 m above sea level		1700-2200 m above sea level	
Sowing	Harvesting	Sowing	Harvesting
April 10 -May 10	September 15 - October 1	April 10 -May 10	September 15 - October 1

ONION VARIETIES

Skhvilisi local – this variety has a relatively short growing season as it has been bred in a mountainous, cool area. It takes 80 days from sowing to harvesting. This variety is distinguished by its long shelf life. Develops quite large, rounded bulbs with a dense structure, average weight -120 g, quite resistant to pests and diseases.

Kartli local – mid-season late crop. The growing season is 110-120 days. The bulb is rounded, slightly rounded at the neck. There are mostly single bulb forms, rarely – double bulb forms. In terms of morphological and agro-biological properties, it is very similar to Skhvilisi onion. Kartli onion is high yielding if irrigated - 20 t/ha. Yields are very low under unirrigated conditions. It is quite resistant to pests and diseases.

Kakhetian flat - Kakhetian flat is an early variety. The growing period from emergence to the ripening of the bulb is 80-85 days. Develops a flat-shaped bulb, the bulb can be single-, double- or multi-stemmed, with medium density. The yield of the Kakhetian flat is 19-20 t/ha. The quantity of stem affects the storage period of the variety. It is quite resistant to diseases and pests. Kakhetian flat is the sweetest onion among the varieties common in Georgia.

Pink-32 - is a late crop according to the growing season, it takes 130-135 days from emergence to full biological maturity. It is distinguished by long storage period. It is semi hot onion, the bulb is single-stemmed and flat. Bulb size is medium, weight - 115-120 g. Bulb yield is 27-29 t/ha when irrigated. Moderately resistant to pests and diseases. Bred at the Gardabani Experimental Station of the Institute of Agriculture, from the variety "Kakhetian flat" by the method of mass selection.

Table. 2.4.5. Onion crop calendar for Tsalka municipality:

1200-1700 m above sea level		**1700-2200 m above sea level**	
Sowing	Harvesting	Sowing	Harvesting
April 1 - April 20	August 15 – September 20	May10 – May 20	August 1 -September 10

GARLIC VARIETIS

Common garlic - is the best table variety, characterized by medium yield, the disadvantage of the variety is the short storage period.

Meskhetian violet - the variety is medium-sized and medium yielding, characterized by long storage period. Imeruli №23 - the variety is a medium-late and medium yielding crop, distinguished by good resistance to fungi.

Goruli local - medium yielding variety, non-flowering, autumn crop, growing season when planted before winter is 181-262 days.

Table. 2.4.6. Garlic crop calendar for Tsalka municipality:

1200-1700 m above sea level		1700-2200 m above sea level	
Sowing	Harvesting	Sowing	Harvesting
September 1-October 1	August 10-September 20	May 1- May 10	August 1 - August 15

3. LIVESTOCK FARMING

3.1 Overview of livestock sector in Tsalka municipality

Tsalka municipality has always been considered one of the leading centers for the development livestock farming in our country. The local population being confident in the advantages of this sector is trying to expand livestock breeding activities. Today, a family that does not own cattle can be hardly found in Tsalka.

Table. 3.1.1. Total Quantity Cattle *(Source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environment and Agriculture).*

#	Administrative unit	Cattle (heads)		
		Total:	Cows	Cow %
1	Avranlo	1156	74.0	74.0
2	Aiazma	350	88.9	88.9
3	Ar-Sarvani	1965	84.5	84.5
4	Artsivani	660	75.0	75.0
5	Ashkala	1242	66.1	66.1
6	Bareti	3785	85.3	85.3
7	Berta	300	85.7	85.7
8	Beshtasheni	2854	85.3	85.3
9	Burnasheti	365	89.3	89.3
10	Gantiadi	1086	88.9	88.9
11	Gumbati	850	79.4	79.4
12	Trialeti settlement	1532	88.8	88.8
13	Darakovi	295	84.1	84.1
14	Dashbashi	450	70.0	70.0
15	Tejisi	742	90.0	90.0
16	Kizil-Kilisa	1325	58.5	58.5
17	Kokhta	1591	90.0	90.0
18	Kushi	698	74.5	74.5
19	Nardevani	1100	90.0	90.0
20	Ozni	424	90.1	90.1
21	Rekha	679	90.0	90.0
22	Sameba	833	90.0	90.0
23	Sakdrioni	1217	90.0	90.0
24	Tsalka town	2540	89.8	89.8

25	Kaburi	450	90.0	90.0
26	Chivt-Kilisa	587	89.9	89.9
27	Tsintskaro	1365	74.9	74.9
28	Khando	1079	90.0	90.0
29	Khachkovi	521	85.6	85.6
30	Bediani settlement	50	90.0	90.0
total:		**32091**	**26878**	**83.8**

According to data, there are 32091 heads of cattle are in the municipality, including 26878 cows, making 83.8% of the total amount of cattle. There are more than 1000 heads of cattle in 14 villages (23837 heads in total), which make 74.3%. The percentage of cows in the municipality is high (74.9-98.8%), which indicates the production of milk. The amount of cows is high in the following villages: Avranlo, Aiazma, Ar-Sarvani, Bareti, Burnasheti, Gantiadi, Trialeti settlement, Tejisi, Kokhta, Nardevani, Ozni, Sameba, Kaburi, Chivt-Kilisa, Khando, Bediani settlement.

Up to 300 thousand tons of milk and hence 30 thousand tons of cheese are produced in the municipality throughout the year *(source: Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environment and Agriculture).*

3.2 Common cattle breeds in Tsalka municipality

Fig. 3.2.1. Caucasian Tsabla breed cow

Caucasian tsabla. გIs bred in the South Caucasus countries and Dagestan by crossbreeding of local cow “Shvitsuri” and related breeds.

Intensive breeding work began in the 40s of the XX century, the breed was approved in 1960. It optimally combines the qualities of the bred varieties: it inherited a large weight and high milk yields from the Shwits breed, and relatively high-fat milk and adaptability to environmental conditions from the Georgian mountain cows. This breed in the Georgian environment is smaller than the Swiss breed. The standard weight for cows is 370-430 kg, for bulls - 570-680 kg. The milk yield standard I, II, III, and more lactations for dairy cows is 2000, 2500, and 2800 kg of milk, with 3.7% fat content.

Fig. 3.2.2. Shwits breed

Shwits breed. It is one of the oldest breeds in the world. According to available data, it originated in the territory of Switzerland 2000 years ago.

Experience has shown that Shwits cattle are more biologically resistant than all other breeds, which explains its wide spread in cold and tropical climates, as well as in lowland and highland areas.

In Switzerland, the height of cows of this breed is 125 - 135 cm, and that of bulls - 140 - 150 cm. The average weight of adult cows is 500-600 kg, that of bulls - 800 - 1100 kg, and that of newborn calves - 35 - 40 kg. During the intensive growth and fattening, the daily weight gain is 900 - 1050 g, and the slaughter quantity is 55 - 58%. The average milk production in Switzerland is 4000-5000 kg of milk with a fat content of 3.8 - 4.5%.

In the United States, a typical dairy breed has been developed, called the brown Shwits. In this country, the weight of the brown Shwits breed is in the range of 550 - 700 kg, and it has higher milk fat content and the longer productive period than the Holstein breed. Lactation yield is 7000-9000 kg.

Fig. 3.2.3. Holstein breed

Holstein breed has been bred in the USA and Canada through improvement of the Dutch breed. They are black and white spotted, however red spotted Holsteins are also found. It is a large animal. The height of a cow 142-145 cm, that of bulls 155-160 cm. The weight of adult cows 600-700 kg, that of bulls - 950-1100 kg. Newborn calves weight 30-35 kg. Milk yield 9000 kg (USA) – 12000 kg (Israel) with 3,6-3,8% fat content. Holstein cow is a champion in lactation yields. In the USA the average productivity of a cow is more than 9000 kg. With the increase in productivity, the trend of reduction of the number of farms and their extension is observed in the USA. The largest farm in California includes up to 15,000 Holstein cows, and the Holstein Association has 19 million registered animals in the country.

Fig. 3.2.4. Jersey breed

Jersey breed cattle ɡis one of the oldest breeds. Its name originated from Jersey Island (Great Britain). It is the smallest among diary breeds. Its height is 120-123 cm, weight of adult cows 360-400 kg, that of bulls - 600-700 kg. Annual milk yield - 5000-5500 kg. Milk of Jersey cows is distinguished by high content of fat (5,0-6,0%, (up to 7) and proteins (3,5-4,0%). Jersey cow can be first mated when she is around 12-14 months old and therefore has her first calf when she is 21-23 months old. In the Great Britain milk yield is 4500-5000 kg, in the USA and Canada - 4537 kg with 4,95% fat content. Some farms achieve 7-9 thousand kg, while some champion cows give 11-12 thousand kg of milk. Advantages of this breed include: high productivity of milk, high content of fat, proteins and calcium, and low feed consumption due to their smaller size.

In Georgia this breed was used for cross-breeding with the Georgian mountain breed: the 1st generation of crossbreed exceeded local cows in terms of weight, milk yields and fat content of milk.

Fig. 3.2.5. Simmental breed cow

Simmental breed - was bred in Switzerland in the valley of the Simme river. Moderate warm climate and productive pastures and relatively low mountains favored to the development of a large and tolerant cattle.

The high of cows is 138 – 145 cm. the weight - 500 – 650 kg, lactation yield - 4500-4900 kg of milk with 4,0 – 4,1% fat and 3,3 – 3,5% protein content. The weight of bulls is 900-1200 kg and that of newborn calves – 38-40 kg. Along with high milk yields this breed is characterized by the high growth potential and beef production. The weight of individual calves reaches 500 kg at the age of 1 year.

Fig. 3.2.6. Estonian Red cow

Estonian Red. In the 19th century the native Estonian breed was crossed Angeln and later with Danish Red cattle. This breed was first recorded in 1885. The animals are strong and light and dark red.

The height of this breed is 127,6 cm, the weight of newborn calves - 31-33 kg, the weight of cows is 450-550 kg (max 780 kg) and that of bulls – 900-900 kg (max 1000 kg). Milk yield – 4620 kg, fat content - 4,2 %, proteins - 3,3%. The 305 days yield of the best cows – 5100 kg, fat content - - 4-4,2%, yield of champion cows - 9610 kg.

3.3 Studies conducted for Tsalka Municipality

Changes in precipitation, increased mean temperatures, frequency and scales of natural disasters are forcing to seek for innovative solutions to adapt to climate change. Although these changes and their consequences affect the whole world, the rural population is most vulnerable.

Environmental conditions are very important for economic management of livestock. The efficiency of breeding different breeds of cattle (cow) depends not only on their genotype but also on the degree to which the biological characteristics of the animal are adapted to environmental conditions.

Cattle breeding is one of the leading directions of the agriculture in Tsalka Municipality. Production of cattle commodity depends on the degree of climate change.

Adaptation has its threshold, i.e., sometimes adaptation is impossible and the animal either gets sick, or changes that are incompatible with life occur. The completeness and perfection of adaptation to extreme environmental conditions depend on the level of health and productivity of the cow.

Current and forecasted climate change in Tsalka Municipality can affect animals in many ways:

- Heat stress is the most important impact from those that directly affect cattle;
- Impact on essential nutrients contained in feed and water;
- On the growth and development of animal forage plants and their productivity (quantity);
- Chemical composition of forage plants, and the accumulation of toxic substances in them;
- Populations of vectors (insects, rodents); Climate change can awaken forgotten pathogens, or activate current ones;
- Change the area of spread of diseases and the ways of their transmission;
- Excessively warm winters can facilitate the spread of exotic diseases (insects) from the southern hot countries to the north; Warm weather in winter can also contribute to the spread of a number of diseases from lowlands to mountains.

The main factor that strongly impacts animal productivity and health is the ambient temperature. Low temperatures - cold - helps to reduce the number of leukocytes and phagocytic activity in the blood, while moist air and high temperatures prevent the release of heat from the body, which causes overheating - heat stress. According to the climate projections, summers in Tsalka municipality in the next 30 years the will be more humid and warmer, and therefore a favorable environment for the propagation of microbes will be created. High density of animals in stalls with high temperatures and insufficient ventilation leads to the accumulation of harmful gases. In addition, the increased air humidity favors the propagation of microorganisms and the spread of airborne infections. Under unfavorable climate, keeping animals in unhygienic conditions weakens the body's defense mechanisms and accumulates a large number of microbes, which subsequently leads to the emergence of various diseases. Products produced in such conditions (primarily milk) are highly contaminated with bacteria and harmful to humans.

Increased ambient temperatures reveal many, often difficult problems, including the issue of animal water supply. Observations on the water supply of cattle in hot summer days have shown that water supply decreases daily with increasing ambient temperature. The productivity of cattle of any breed is one of the indicators of the adaptation of animals to the environment.

In the case of mild heat stress, cattle sweat and excrete more saliva, drink more water, breathe heavily and seek shade, and consume less feed. More pronounced heat stress leads to reduced productivity, deterioration of reproduction rates, and in some cases - the death (fall) of cattle. To cope with temperature fluctuations, cattle need to regulate metabolism. The part of the energy which was needed to produce milk or to gain weight is switched to thermoregulation. As a result, meat and milk production may be reduced. Consequently, as a result of climate change, cattle productivity may increase in warm winters and decrease in hot summers, which, according to the climate projection, is expected in Tsalka municipality.

The intensity of heat stress depends not only on the THI levels but also on the duration of exposure to the stress. At THI = 68 during twenty-four hours, the daily milk yield per lactation decreases by 2.2 liters. The Temperature-Humidity Index is more sensitive to temperature than to relative humidity.

Table . 3.3.1. Dependence of Temperature-Humidity Index on temperature and relative humidity

Temperature, ºC	Relative humidity, %						
	30	40	50	60	70	80	90
25	69,6	70,6	71,7	72,8	70,0	80,0	90,0
30	75,1	76,6	78,2	79,8	81,3	82,9	84,4
35	80,6	82,6	84,7	86,8	88,8	90,9	92,9
40	86,1	88,6	91,2	93,8	96,3	98,9	10,4

According to recent studies, THI (Temperature-Humidity Index) exceeding 68 causes heat stress to animals even at 220C and 45% relative humidity,

Expected heat stress in Tsalka Municipality has been studied in accordance with the climate change projections. The change of climatic parameters for Tsalka municipality was estimated for the 1960-1989 and 1990-2019 periods. The results of the model (on a scale of 10 km) were calibrated according to the actual observations of the Tsalka meteorological station for 1960-2019.

The values of climatic parameters from Annex 1 are taken as basis: Table 1.1. Average air temperature (Tmm), 0C; Table 1.2. Average maximum air temperature (Txm), 0C; Table 1.4. Absolute maximum air temperature (Txx), 0C and Table 1.27. Average relative air humidity.

The Temperature-Humidity Index (THI) was used to measure heat stress during the current period. The stress was calculated using the formula: THI = (1,8 × T + 32) - (0,55 - 0,0055 × RH) × (1,8 × T-26), where T is the ambient temperature in ° C, RH is percentage of relative humidity (8.9).

The THI value determined according to the mean air temperature (Table 3.3.2. (Tmm), 0C) shows that heat stress in both periods (1960-1989 and 1990-2019) is expected in July-August. The THI value from Table 3.3.3. (Txm), 0C shows that heat stress is expected in both periods from May through September.

As for the absolute maximum air temperature (Txx), 0C, the THI value from Table 3.3.4. shows that heat stress is expected from May through October.

Fig. 3.3.1. The first signs of heat stress

Fig. 3.3.2. Recirculation fans

The first signs of heat stress (frequent breathing, accumulation of cattle near water, salivation, foaming at the mouth, etc.). In this case, recirculation fans should be installed immediately on the left and right sides of a farm building at 12-14 m from a feeding platform.

To reduce heat stress the cattle diet should include increased content of calcium up to 1.3-1.5%; sodium - up to 0.5-0.6%; magnesium - up to 0.3-0.4%; chlorine – at least up to 0.25%. These measures will significantly reduce the effects of heat stress and improve animal health.

Extremely high air temperatures in summer can negatively affect grazing cows. Compared to thermoneutral temperature conditions, cows may show an increase in heart rate, breath, and pulse, as well as increase in their skin and rectal temperature, and sweating. The body temperature of some cows may exceed 400C, which significantly exceeds the physiological threshold. As a result, heat stress develops. Under the influence of heat, milk yields of cows of different productivity decreases at different rates. The daily fluctuations in the physiological parameters of cows will correspond with the fluctuations in air temperature. 8–15% of the cattle may show a fairly high heat resistance and adaptation rate, which is extremely important in terms of selection. Heat may also affect hematologic parameters. Decrease in the number of erythrocytes and leukocytes in the blood as well as decrease in the concentration of hemoglobin in the body are expected in the afternoon as a result of increase in air temperature.

Fig. 3.3.3. Light shelter

To increase milk yields in summer, cows should be protected from the heat. Heat stress can be avoided by constructing (erecting) light sheds, using easily digestible carbohydrate feeds, organizing night grazing. etc.

Table. 3.3.2. Average air temperature (Tmm), ºC

Period	Indicator	May	June	July	August	September	October	Year
1960-1989	TºC	10,5	13,7	16,6	15,8	12,4	7,6	6,5
	RH	79,7	79,1	77,4	78,2	79,6	79,9	77,9
	RHI	51,6	52,3	61,4	60,2	22,7	14,9	13,4
1990-2019	TºC	10,7	14,5	17,2	17,3	13,3	8,7	7,1
	RH	79,7	79,1	77,4	78,2	79,6	79,9	77,9
	RHI	19,9	58,1	62,3	62,4	56,1	48,7	46,3

Table. 3.3.3. Average maximum air temperature (Txm), ºC

Period	Indicator	May	June	July	August	September	October	Year
1960-1989	TºC	16,0	19,3	22,2	21,6	18,3	13,2	11,9
	RH	79,7	79,1	77,4	78,2	79,6	79,9	77,9
	RHI	61,1	65,7	70,2	69,2	63,3	55,9	53,9
1990-2019	TºC	16,4	20,4	23,0	23,5	19,3	14,6	12,8
	RH	79,7	79,1	77,4	78,2	79,6	79,9	77,9
	RHI	63,1	70,4	71,5	72	65,9	58,2	56,3

Table. 3.3.4. Absolute maximum air temperature (Txx), ºC

Period	Indicator	May	June	July	August	September	October	Year
1960-1989	TºC	27,1	29,0	30,8	34,6	30,1	24,5	34,6
	RH	79,7	79,1	77,4	78,2	79,6	79,9	77,9
	RHI	78,7	72,8	75,4	90,2	79,4	74,1	89,8
1990-2019	TºC	26,7	29,4	33,6	33,0	29,7	27,0	33,6
	RH	79,7	79,1	77,4	78,2	79,6	79,9	77,9
	RHI	70,3	73,1	88,2	87,4	82,4	77,5	88,2

3.4 Strategies to combat heat stress

During the summer heat stress poses serious problem for high-yielding cows. Effective strategies to prevent milk yield losses are available. High-quality supplements containing protected fats, live yeast, and buffers protect animals from heat stress. Glucose-forming and stabilizing components in the diet protect cows from heat stress. At high temperatures and humidity high-yielding cows reach the threshold of the "thermoneutral zone" very quickly, which causes heat stress. Recent researches have shown that this stress begins when the ambient temperature rises to 22° C and humidity exceeds 45%. High yielding cows show the signs of heat stress earlier.

What happens to the metabolism? Stressed cows consume less feed and produce less milk, often with a lower content of nutrients. Measures should be taken in advance to get prepared for hot weather and minimize the effect of heat stress on cows. In addition to reducing yield (sometimes up to 50%), it negatively affects reproductive functions and impairs the animal's general immunity, resulting in a significant financial burden. Heat stress affects the rumen. Cows try to release some of the heat by more frequent breathing. Along with the air more carbon dioxide is released, causing a loss of CO2 in the blood. There is a constant ratio between bicarbonates and CO2 to maintain the pH balance in the blood. To maintain this ratio, bicarbonates are excreted by kidneys. Bicarbonate becomes insufficient to stabilize the pH balance. In addition, with more frequent breathing, the cow loses saliva, which no longer enters the rumen. Restricted feed intake results in decreased rumination and secretion of saliva which increases the risk of subclinical acidosis. It means that the animal is not supplied with adequate energy. This deficiency occurs in addition to the higher energy demand because stress-stricken cows need more glucose. The most important is the propionate produced in the rumen. Its formation requires a larger share of the combined feed in the ratio, which increases the risk of the development of acidosis.

In terms of animal nutrition, there are various strategies to avoid or reduce negative consequences. The production of volatile fatty acids, especially lactic acid shouls be reduced. For this purpose live yeast is used. Live yeast reduces lactic acid production and stabilizes the pH level, significantly reducing the risk of gastric subclinical acidosis (biologically). Buffer minerals also help to neutralize the secreted volatile fatty acids. The feed mixture should be stabilized and the animal glucose supply should be improved.

Adding fat. The fat added to the diet is of great importance in the measure against heat stress. It reduces the heat generated by the fermentation of feed in the digestive tract, which in turn reduces the overall heat load on the body. Cotton grain is a very valuable feed ingredient used for this purpose. Due to its high energy and cellulose content, it increases both milk production and the percentage of fat in milk. Adding soybean oil or vegetable hydrated fat gives a similar effect. It should be noted that the microorganisms od rumen can only tolerate 3-8% of fat.

Feeding the cows during the heat. Certain changes in feeding and shelter conditions can help to solve the problem of heat stress. When it comes to feeding, one of the main strategies for maintaining productivity during hot months is to change the diet according to the changed needs of animals during this period. It should be noted that one of the mechanisms that cows use to reduce heat generation is reduced feed consumption (Table 3.4.1).

Tab. 3.4.1. Heat stress and feed consumption

Breathing rate/minute	<75	80	85	90	95
Reduction in dry feed consumption,%	0	5	10	15	20
Dry feed consumption kg/day	24,2	22,9	21,75	20,5	19,3

Heat stress increases the amount of energy required by a cow to maintain its normal body temperature (e.g., 20% higher at 35°C than at 20°C). Fast breathing also requires more energy - by 7-25%. Therefore, dry feed consumption should also be higher to meet more energy needs. However, the consumption of dry feed during the heat is reduced, which means that the energy status of the cow is doubly affected - high energy expenditure to maintain a normal body temperature and low feed consumption. In this case, it is not surprising that milk yield decreases (Table 3.4.2.).

Table. 3.4.2. Changes in dry feed consumption and milk yield of cows under the influence of different temperatures

Temperature (°C)	Dry feed consumption (kg)	Milk yield (kg)
0	18,8	27
5	18,4	27
10	18,2	27
15	18,2	27
20	18,2	27
25	17,7	25
30	18	23
35	12	-
40	10,2	-

The situation can be improved by feeding the cows early in the morning and late in the evening. During these cool periods of the day, cows can consume up to 80% of dry feed of the total daily volume. However, in cases where the night-morning temperature-humidity index (TTI) exceeds the upper threshold (72), the amount of feed consumed does not compensate for the significantly reduced feed intake during the day.

Physical cooling of the cows can reduce heat stress and improve their physiological condition and milk yield. A study showed that physical cooling of cows (shower) reduced their respiratory rate from 102 to 80 breaths per minute. Consumption of dry feed increased from 16.2 to 19.6 kg per day, and the average milk yield - from 17.6 to 20.2 kg per day.

Adaptation measures for livestock farming

- Improving methods of predicting animal diseases, monitoring, preventing, and combating pathogens and transmitters;
- Rational use of the potential of existing breeds and increase of the head count to a state of sustainable reproduction;
- Establishment of breeding enterprises to store sperm of local animals;
- Designing standard buildings adapted to local conditions, which will include ventilation, heating, lighting, drainage and storage, water supply, feed distribution (automated);
- Develop animal breeding strategies to strengthen local breeds that are adapted to local climatic stresses and feed sources, and cross-breed them with breeds that easily tolerated heat and are less susceptible to disease.
- Implement institutional and regulatory measures such as the introduction of crisis warning and other systems in livestock farming, as well as ensuring preparedness;
- Establishment of an adaptation monitoring service;
- Study the impact of climate change on animal adaptability and productivity;
- Develop a damage and loss assessment methodology and animal insurance;
- Selection of new breeds more resistant to heat stress, new diseases, and their transmitters. Adjusting the production system to achieve thermo-tolerance in the cows, genetic improvement;
- Monitoring the health status of cattle, lifting/easing restrictions on antibiotics, intensifying the use of new feed, feed supplements, and treatment methods if necessary;
- Improving ventilation and other conditions in cattle sheds;
- Increase the efficiency of water resources management - water collection, supply, and use for the needs of intensive livestock farming;
- Improving the organization of cattle grazing, protection of pastures from the sun by natural and artificial means, restriction of grazing in wet periods. Planting trees on pastures for long-term natural shading;
- Watering animals on pastures during droughts. Supply of drinking water to cattle in the pasture for example, through water tanks;
- Optimization of land use to reduce the impact of new diseases and their transmitters;
- Improving breeding in agriculture - first of all, identification and enhancement of positive qualities of local breeds.

3.5 Forage production

Livestock in Tsalka Municipality is fed with local resources, out of which 30% of the existing stock is sold outside of the municipality or exported. Some years ago 50 thousand of hay bales were exported to Turkey. Therefore, forage production is one of the leading fields in Tsalka municipality.

Forage comes from:

1. Natural grasslands - 89%;
2. Annual grain crops (forage oats) - 8%;
3. Perennial sown grasses (alfalfa, sainfoin) - 3%.

Oats, namely forage oats will play a special for the long-term development of forage production field in Tsalka. Effective measures can be taken for this purpose, e.g., introduction of new varieties, equipping farms with appropriate machinery.

The agricultural machinery available in the municipality partially meets the current demand but still is not sufficient. As of today, 3 million square hay bales are being made, 70% is enough for local consumption, and 30% can be sold.

During summer, all cattle of the municipality is kept on pastures. Important advantages of keeping the cattle in pastures are positive effects, such as: fresh air, unrestricted movement, which stimulates the physiological functions of the organism, promotes normal growth and development of cattle, strengthens the vitality of cells, stimulates and regulates vital processes, activates oxidation processes, blood circulation, metabolism, and resilience, better reveals and uses the genetic potential. As a result of all this, infertility decreases, and fertility increases, calves grow healthy, all the conditions to promote intensive growth and high productivity are created. Cattle kept on pastures in summer can later better tolerate indoor conditions in winter.

Keeping cattle on pastures also has its **disadvantages**. First of all, it is a slight reduction in pasture productivity due to trampling and manure pollution. Relatively high energy costs due moving of cattle to, from and around pastures, that are significantly higher than those incurred in indoor feeding shall be also taken into account. This energy cost is equivalent to the cost of energy incurred to generate 1 kg of milk when moving a cow weighing 500 kg at a distance of 1 km of. There are also additional costs associated with the construction of relevant facilities, sheds, and watering systems that are needed to keep cattle on pastures.

Most of the pastures in Tsalka Municipality are natural ecosystem and play a major socio-economic role. High mountain fields, according to the classes of plant formations are divided into:

- Typical high mountain meadows;
- Subalpine tall grass fields;
- Alpine fields.

The impact of existing and projected indicators of climate change on natural pastures in Tsalka Municipality can be reflected as follows:

- Changes in the life cycle of plants;
- Change in growing and seeding seasons;
- Influence of changes in mean annual temperatures on the physiological processes of the species (e.g., intensification of respiration or photosynthesis);
- Motley grass-cereal and motley grass-legume meadows are widespread that are used as hayfields;
- Changes are expected in the vegetation of Alpine fields, and in subnival complexes, which are

demonstrated by the replacement by heat-loving species whose distribution was previously limited due to low temperatures characteristic for higher altitudes;
- Eroded slopes will be further exposed;
- Xerophilization of the upper and subalpine (moisture-loving) vegetation and predominance of steppe vegetation is expected;
- The productivity of pastures is actually declining, which, along with climate change, may be caused by the poor land management practices.

The following principles and guidelines should be applied when managing natural pastures:

- Maintaining the ecological integrity of pastures;
- Territorial restriction of grazing;
- Implementation of agro-technical measures;
- Pasture monitoring;
- Improving the forage base - improving the quality of natural forage crops and increasing yields; increasing the efficiency of nutrient intake from forage by taking into account changes in feed composition as a result of climate change;
- Diversifying local forage and using forage with high protein content;
- Optimizing the structure of pastures and haylands to increase their resistance to extreme weather conditions; for example, a mixed structure of land use with forested lands;
- Improvement of the natural forage fields - increase of yield;
- Matching cattle breeding capacity and the opportunities for quality forage production.

Natural pastures in Tsalka municipality are currently used in an unplanned, so-called “free grazing” manner. This is a methods of the use of pastures where pasture yields and loads, i.e. amount of cattle per unit of land area, duration of grazing, botanical composition and energy value of grass, or grouping the animals according to sex, age and physiological conditions are not observed. Due to this, a decrease in the share of useful grasses and an increase in weeds, as well as a decrease in the total pasture productivity are observed in the cenosis of natural pastures, especially on the pastures that are located near villages and other types of settlements. In addition, too early spring grazing or even an extension of the grazing period in autumn also affects the productivity and botanical composition of pastures. It shall be also noted, that in the last 20-25 years, farmers have not taken any practical measures to improve their pastures, such as sowing useful grass, applying fertilizers, weed control. etc.

3.6 Improvement of pastures in the face of expected climate change

Taking into account the current state of pastures of subalpine and alpine zones and natural conditions of Tsalka Municipality, measures that will help increase the productivity of the pastures and improve their overall conditions on the background of future warming have been selected. Selected measures include clearing the land from stones, weed control, fertilization, grazing techniques, compliance with grazing deadlines and frequency, introduction of regulated grazing and pasture rotation.

CLEANING FROM STONES

Significant areas of mountain pastures are covered with stones of different sizes and/or rock debris. The percentage of stones on the land surface sometimes reaches 50%, which significantly hinders the development of grassed and can be one of the important factors contributing to the low productivity of pastures. To improve the pastures, stones that are located on the surface and partially buried have to be removed. However, removal of large boulders buried on steep slopes is not allowed due to the risk of erosion, the likelihood of which will increase on the background of future climate change, as an increase in temperatures, especially its minimum values, are observed throughout the growing season from spring to autumn, and are raised by 3.5, 6 and 4 degrees accordingly, which will increase evapotranspiration and reduce moisture in soils.

In most cases, the land is cleaned of stones by hand (small and medium-sized stones). The collected stones can be used to fence pastures or plots, as well as to arrange and/or strengthen access to watering areas. Stones can be collected and removed from pasture throughout the season. Clearing the plot from stones increases the productivity of the plot by 20-30% in 3 years, which is especially important in the face of the projected climate warming.

WEED CONTROL

Weed control measures are divided among several groups, out of which preventive and ecological measures are recommended for Tsalka municipality.

Preventive measures are aimed at reducing the spread of weed seeds. For this purpose, weeds growing near the roads, watering places and stalls should be mowed or cut before the seeds ripen. To achieve a higher effect and suppress weed, they should be mowed before flowering. Weed spread is facilitated by early grazing of grasslands, as weakened valuable grasses cannot compete with weeds.

Ecological measures include restriction of wide spread of weeds through indirect measures, including soil fertilization, pasture maintenance, and proper use of lands, which in turn implies rotational grazing, rotation of grazing and mowing, proper grazing timing and frequency and mowing uneaten grass on pastures.

START AND END DATES OF GRAZING

Start and end dates of grazing have major impact on the vegetation of pastures. Early grazing of cattle soon after the snow melts disrupts the normal sequence of accumulation and use of nutrients in plants, which adversely affects the botanical composition of herbs and ultimately leads to reduced yields. In addition, during early grazing, when the soil is still very moist, sods may collapse leading to reduced productivity and even to the degradation of pastures. Late grazing, when grasses are rough, their nutritional value is low and the productivity of pastures is declined due to the weakened grass renewal processes, also has a negative effect on pastures.

a) Start of grazing. To prevent adverse effects associated with misuse of pasture vegetation, grazing should begin 10-12 days after the emergence of grasses. The first use of pastures in the subalpine zone is possible when the grass height reaches 10-15 cm, while in the Alpine zone the grass height should reach at least 6-7 cm.

b) End of grazing. Timely cessation of grazing in autumn is also very important. Grazing should be stopped 25-30 days before the end of the growing season of plants, otherwise, the grass will not be able to grow and accumulate nutrients to survive winter.

GRAZING RESIDUE HEIGHT

Grazing residue height determines the productivity of a pasture productivity and its ability to regrow. Grazing residue height should not be lower than 4-5 cm. At the same time, grazing residue height should not be higher than 10-15 cm, as in this case the pasture is not fully used.

PASTURE FERTILIZATION

One of the fastest and most effective measures to improve natural grasslands and pastures is fertilization. Rational application of fertilizers dramatically improves the botanical composition and nutrient contents of grasses, accelerates mineralization processes, promoting the assimilation of organic matter by plants. In addition, the application of fertilizers prolongs the growing season of grasses.

Applying manure to pastures is the most efficient and economically viable method of fertilization. As a result of nomadic livestock farming, large amounts of manure accumulate on natural pastures. Pasture rotation during the grazing season can improve significant portion of grasslands.

The current practice of seasonal grazing shows that the cattle spends about 10 hours a day at a specific location for some years where large amounts of manure accumulate. Under the influence of excessive amounts of solid and liquid excrements, grasses around these locations completely degrade and the surrounding pasture will be stripped of vegetation. On the areas used for grazing for a long period of time usually inedible, weed vegetation (nettles, sorrels, thistle, etc.) dominate. Such practice results in the loss of certain areas of pastures and valuable organic fertilizers, which is accompanied by the emergence and spread of animal diseases.

Alternating between sheep/cattle grazing areas can improve a fairly large area of natural pastures without significant costs. Temporary grazing areas should be fenced with portable fences (wooden planks, wire, etc.), one side of which should remain in place, and three sides should be relocated to a nearby plot to arrange a new grazing area. A portable electric fence can also be used to set up temporary grazing areas. Using this scheme, significant areas of subalpine and Alpine pastures in Tsalka Municipality can be fertilized during each grazing season. It should be noted that sheep manure is a better fertilizer for pastures than cattle manure.

The advantage of manure, in addition to the above-mentioned, is its positive impact on the physical-chemical properties of soils. In particular, in acidic soils it improves the pH value, thus contributing to the better development of precious forage grasses. 75% of the applied fertilizers mineralizes and supplies plants and soil microorganisms with nutrients, as wee as enriches the soil, while 25% replenishes the reserves of humus (relatively stable organic matter) in the soil, contributing to the improvement of a soil structure and its ability to retain moisture, which is extremely important in conditions of warming and increased demand on water in the municipality.

PLOT ROTATION

Plot rotation can be considered as an alternative to the existing “free grazing” practice. It involves dividing the pasture of a farmer (farmers’ union or individual farm) into 4-5 equal parts and allowing livestock to graze each plot for 5-7 days. The electric shepherd set consists of 4 portable poles, an uninsulated wire, a power regulator, and an accumulator; the voltage across the wires is 25-36 volts. The device costs about 300$. Such an approach ensures an increase in pasture yields; it is estimated that during free-grazing the animal receives 60-70% of the total mass of the pasture (due to the active movement of the cattle rest is trampled), while during plot rotation this figure is 83-85%. Plot rotation enables: normal growth of grasses, increase of the share of useful grasses and rational use of natural pastures; taking pasture improvement measures; avoiding the spread of parasitic diseases of the digestive system of animals. While grazing, an infected animal secretes parasitic larvae, which take 19-22 days to develop. If these parasites do not find a body again in 20-25 days, they die. Thus, plot rotation is used to clean the pasture from parasites.

The proper management of the use of pastures: to determine the pasture yield, farmers can use the “square mowing” method. It involves mowing, weighing, and determining the average rate of green mass per 1 m2 area at 3-4 different locations of the pasture. Pasture yields per hectare are calculated through multiplying this figure by 10,000. If necessary, this method can be used to determine the botanical composition of grasses (share of grains, legumes, and motley grasse). Nutritional values of grasses can be determined by their chemical analysis.

The need for rotation of plots is determined by visual examination of the vegetation (taking into account the level of grazing). Normally, rotational grazing involving 4-5 plots with a 5-7-day grazing period of each plot is used. An electric fence can be used to separate the plots. To provide one cow with enough green mass, 1-1.2 ha of pasture is needed considering the condition of the natural pasture. The farmer also should consider an additional at least 0.2-0.3 ha per cow in case of unfavorable weather.

To increase the dairy and meat productivity of cattle, in addition to the above-mentioned measures, an area for grass crops should be allocated. The area for cultivated grasses should be determined on the basis of the animals’ need for forage and the productivity of a plot.

Table. 3.5.1. Impact of pasture management on grassland yield and area required for keeping (153 days) one head of cattle on pasture (in Tsalka municipality).

N	Grazing method	Pasture improvement measures	Yield of 1 ha of pasture	Useful Yield centner/ha	Pasture area*** required to feed 1 head of cattle
1	Free	Without improvements	60-70 *	47	1-1,2
2	Plot Rotation	Without improvements	60-70 *	56	0,75-0,85
3	Plot Rotation	Improved **	**75-80	68	0,6-0,7
4	Plot Rotation	Improved + Supplemental feeding ***	**95	85	0,5-0,6

* Official data of Samtskhe-Javakheti Statistics Department
** Fertilizer application + sowing of grasses
*** To get green mass, a sown area is necessary in addition to pasture
*** Actual centner/ha yield during the 153-day grazing period

The table shows that about 125-140 heads of cattle can be fed on 100 ha of pastures if plot rotation method is used, and 80-100 heads of cattle when using the free grazing method. Such results are determined by the more efficient use of pastures. In case of an increase in the yield as a result of application of pasture improvement measures, the area required to feed 1 cow is reduced to 0.6-0.7 ha, and in case of supplemental feeding - to 0.5-0.6 ha; the milk yield of the cows should be also considered:

In the first and second options, during the season (153 days), the feed consumption rate per cow is 47 centners, or 7.3 kg of fodder units per day. Such level of nutrition ensures the yield of 1000-1100 kg of milk from each cow during the summer season.

When using plot rotation (second option), 1 ha of pasture is allocated per one head of cattle. Animals receive 56 centners of green mass per season, which is 8.9 kg of fodder units per day and 1344 centners of fodder units throughout the season. Such nutrition enables an average of 10 kg of milk yield per day. During the grazing season (153 days) the yield of a cow will be 1500 kg.

Rotational grazing on improved pastures (the third option), can produce up to 68 centners of “useful” green mass yield per hectare or 10.7 kg of fodder units per day. Feeding at this level ensures 12-14 kg daily milk yield per cow, and the seasonal yield - 1800-2100 kg.

In the fourth option, when cattle is provided with supplemental feed, the level of nutrition of 1 head of cattle is 85 centners throughout the summer, cows receive 13 kg of feed per day, which is sufficient to get 20 kg of milk yield. During the season (153 days) the potential milk yield per cow will be 3000 kg of milk.

It’s obvious that, when determining the pasture load, selecting feeding standards, and in any other case, the genotype of an animal shall be taken into account, that is, to know how much of yield it can give. Otherwise the desired productivity will not be achieved, the costs of milk production will increase and its production will become inefficient due to the costs of pasture improvement and supplemental feeding.

PASTURE ROTATION

Even if a regulated grazing system is in place, using the same pasture from year to year in a same manner will have a negative impact on the grass yield and its botanical composition. Therefore the pasture rotation practice should be introduced. The basis of pasture rotation is the change of grazing times, frequency of use, grazing and mowing, grazing and resting, using after seed maturation, shifting grazing seasons by years.

Shifting grazing seasons by years is done be changing grazing start dates. On trampled and degraded pastures, grazing should be restricted for one or several years, grazing should be renewed gradually only after its restoration.

For each section of farms located on subalpine and Alpine pastures of Tsalka municipality annual and full rotation regimes should be established.

4. BEEKEEPING

4.1 Overview of beekeeping in Tsalka municipality

Climate change, along with habitat degradation, excessive use of natural resources, environmental pollution, and invasive species is recognized as one of the major factors contributing to the decline of biodiversity.

Mountain steppes and mountain meadows are common in Tsalka municipality. There are found several types of mountain meadows, mostly those where bluestem and feather grass dominate. 140 grain and grain-motley glass formations, consisting of bluestem, feather grass, brome, junegrass, meadow fescue, sheep fescue, bluegrass, timothy, cat grass, knapweed, bentgrass, woundwort, bellflower, buttercup, ribwort, etc., are characteristic for mountain steppes. Shrubbery is formed by Christ's thorn, meadowsweet, firethorn, buckthorn. From 1800 m above sea level (at certain locations from 1600 m) to 2400-2500 m above sea level subalpine meadows are developed, where steppe elements are also found. At higher elevations Alpine meadows of several types depending on dominant species such as: sedges, grain grasses or motley grasses are found. The municipality is poor in forests. Deciduous forest comprised of beech, hornbeam, oak, maple, etc. is found in the Khrami river gorge, downstream of the Dashbashi village (Soviet Georgian Encyclopedia, vol. 11, 1987).

Global warming poses threat to certain ecosystems, especially those that are at the limits of their natural spread.

In terms of biodiversity, Georgian bees deserve special attention, Georgian bee has been adapted to the changing climatic conditions of Georgia for many decades. What is biodiversity? It is the diversity of life on earth, in all its forms and interrelationships. "Without biodiversity, humanity has no future," sais David McDonald, a professor at Oxford University. Georgia is one of the 25 regions of the world that need special protection and care due to unique endemic biodiversity. Biodiversity is most affected by human activity. Climate change, although it may take centuries or millennia, is still a reversible process, but extinct species cannot be brought back.

Beekeeping is an ancient and important agricultural activity. Bees provide valuable food and medicinal products for humans - honey, raw materials for the industry - bee wax. Royal jelly, bee poison, flower pollen, bee pollen, and propolis have great uses in medicine. Bees are especially important for cross-pollination of agricultural entomophilous crops and increase of the yields. Plant is a source of food for the bees, and the bee is a mean of insemination for plants, it is a complex co-evolution and a key aspect of the evolution. The economic importance of beekeeping goes far beyond honey production. Bees are useful not only for beekeepers but also for everyone who grows fruits or vegetables. Overall, one-third of the world's food production is dependent on pollination (the total economic value of pollination in the world exceeds € 1.5 billion, which is almost 10% of agricultural production).

Georgian endemic species - Georgian mountain gray bees are spread almost throughout the country from the mountainous zone to the Black Sea coast. Georgian bees are gray in color, without yellow stripes on the abdomen. They are characterized by gentleness, less rate of division, smaller number of queen cells, high ability to search for nectar, efficient use of small and medium pollen quantity, high wax production, well-planned food layout in cells, dark and wet honey, high propolis quantities in cells, strong defense against other bees, rational consumption of winter feed. The length of the proboscis is 6.5-7.2 mm. The average daily egg production of the queen bees during the period of intensive breeding is 1200-1800 pcs, sometimes even more. According to Georgian scientists, who were engaged in the study of Georgian bee populations, several populations of Georgian mountain bees (Apis mellifera caucasica-Georgia) have been identified: Megrelian, Gurian, Abkhazian, Kartlian, Imereti-Racha, Upper Svanetian and Kakhetian. The most important four breeds of these populations in terms of biological and agricultural indicators are:

Table. 4.1.1. Biological indicators of major populations of bees

N	Indicators	Megrelian	Gurian	Abkhazian	Georgian
1	Coloring	Gray	Gray	Gray	Gray
2	Length of proboscis (mm)	7.1-7.2	7.0-7.1	6.8-7.0	6.5-6.8
3	Cubital index (%)	50-55	50-55	50-55	50-55
4	III width of abdomen (mm)	4.5-4.7	4.5-4.8	4.4-4.8	4.4-4.8
5	Maximum daily egg production of queen bees (pieces)	1200-1600	1200-1600	1100-1700	1200-1800
6	Honey making	Wet	Wet	Wet	Wet
7	Winter endurance	Satisfactory	Satisfactory	Better	Good in our conditions
8	Gentleness a) When opening the hive b) When honeycomb	Gentle, continues to work on the honeycomb	Gentle, continues to work on the honeycomb	Gentle, continues to work on the honeycomb	Gentle, continues to work on the honeycomb
9	Mass of unmated queen bee (mg)	90-100	90-105	90-100	85-100
10	Mass of mated queen bee (mg)	170-180	170-200	170-190	170-190
11	Mass of worker bee (mg)	180-250	180-260	180-250	175-240

Each population has similar honey and wax productivity and therefore their average yield range from 18-25 kg and 4-5 in a built honeycomb. The total strength of the bee family is 15-19 frames.

Beekeeping is one of the most developed activities in Tsalka. Along with bee, flower pollen, royal jelly and other beekeeping products can be produced.

4.1.2. Agricultural cooperatives in Tsalka

*(**Source:** Agricultural Cooperatives Development Agency)*

“Tadagoni” - Tsalka, 12 Kostava str.	Production, processing, packaging, storage, transportation, and sale of plant and animal products (including poultry, fish, silkworms, bees, etc.).	Chairman of the Board Davit Machitidze
“Momavlis Gza” - Tsalka, 74 Aidinov str.	Production and sale of livestock breeding, beekeeping, horticulture products	Chairman of the Board Madona Tavartkiladze
“B Georgia” Tsalka, village Gumbati	Beekeeping, honey production	Chairman of the Board Manana Bolkvadze

Fig. 4.1.1. Number of bee families in Tsalka Municipality as of 2019 *(**Source:** Agricultural Cooperatives Development Agency)*

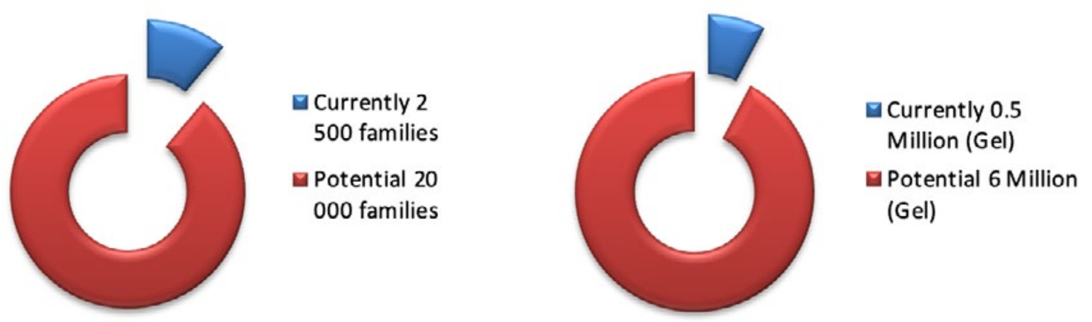
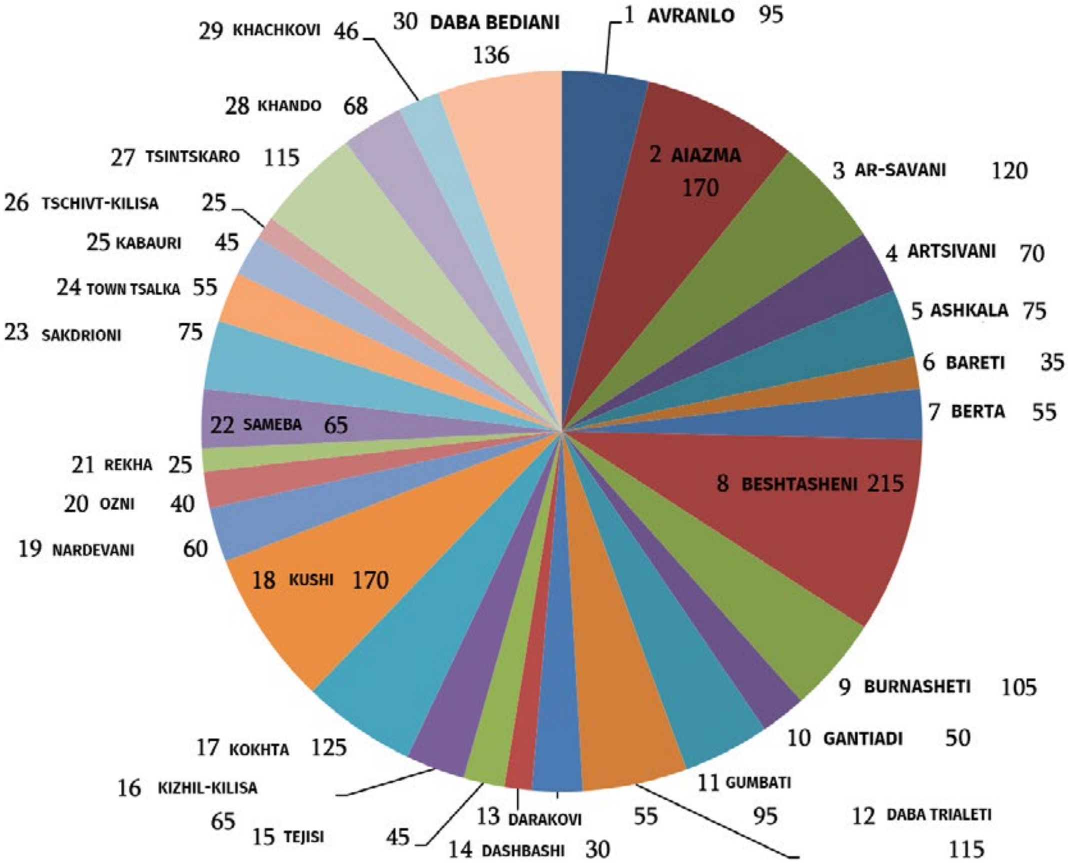


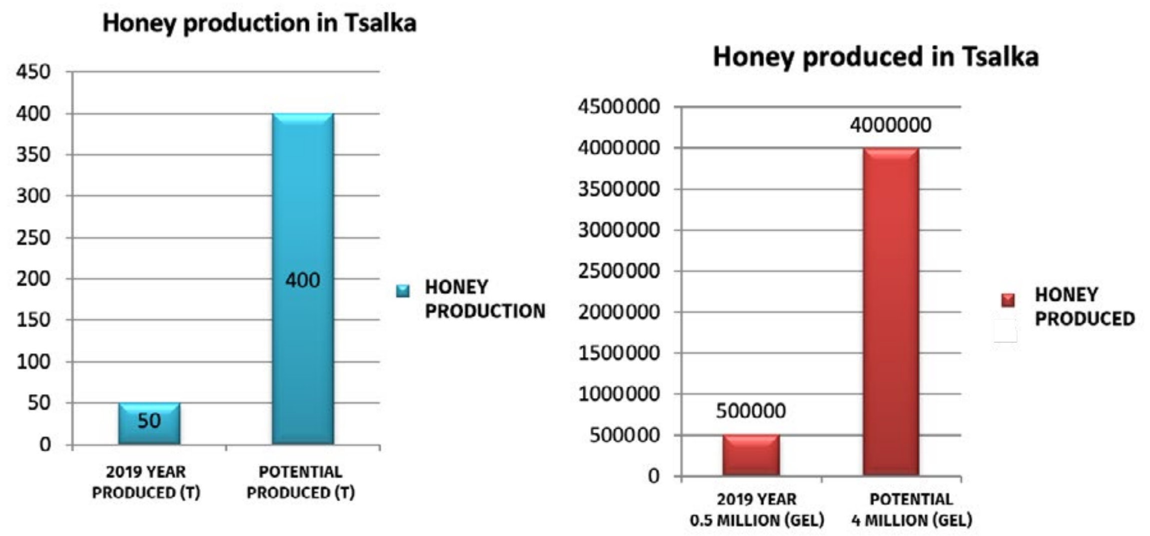
Fig. 4.1.2. Number of bee families by villages



The geographical zone of Georgia is unique due to its climate and, most importantly, due to the diversity of wild and domesticated honey plants which are favorable for the development of beekeeping and allow the production of many types of honey of the highest quality in terms of organoleptic, physical, and chemical properties. Tsalka municipality is not an exception, where the rich flora of Alpine and subalpine meadows provide unique opportunities for bee families to breed and produce the highest quality, ecologically clean, and competitive Alpine honey.

Beekeeping is one of the priority economic activities in Tsalka municipality. As of today, 2,500 beehives are registered with local farmers, but this is a very small number compared to the opportunities which are provided by the region for the development of this activity. In addition, during the summer, many bee families are moved to Tsalka to produce Alpine honey with a pleasant aroma. Its color ranges from slightly colored white to light yellow-amber. In most cases, honey crystalizes in a fine-grained, white or slightly yellowish oily mass. It is produced mainly in the mountains of southern and eastern Georgia. Only meadow honey is produced in Tsalka, which belongs to the Alpine zone and has special medicinal properties.

Fig. 4.1.2. Honey production and its potential in Tsalka



Source: *Information-Consulting Service of the Tsalka Territorial Body of the Ministry of Environmental Protection and Agriculture.*

4.2 Current situation and analysis of problems in the field of beekeeping in Tsalka municipality

✓ INSUFFICIENT LEVEL OF EDUCATION OF FARMERS ENGAGED IN BEEKEEPING

To improve the knowledge and skills of beekeepers, preparatory work should be carried out: teaching using proper textbooks, organizing seminars, hiring qualified teachers.

✓ OUTDATED EQUIPMENT

Beekeeping sectors should be provided with equipment that correspond to the European standards.

✓ NON-COMMERCIAL APPROACH TO THE FIELD

Modern beekeeping technologies, such as new types of beehives, modern methods of their care, disease detection, control and prevention, processing, packaging, branding, and marketing of beekeeping products are not available. The introduction of modern technologies will facilitate the commercialization of the beekeeping sector.

✓ REDUCTION OF FOOD BASE

Reduction of area under honey plants used as livestock fodder, deterioration of pastures, and the impact of other environmental factors resulted in drastic decrease in honey bearing resources.

Seed and nursery plots should be established to improve the honey plants diversity. Bee pollination ptactice in entomophilous plants should be revived.

Cross-pollination of plants produces better quality seeds and fruits than self-pollination. In addition, the crossbreed generation is characterized by higher viability and increased ability to adapt to the environment.

To make beekeeping in Tsalka profitable, farms that will be able to relocate their beehives to lowlands in winter using appropriate equipment (moving platforms for beehives) should be established. As this may not be affordable for individual farmers, farmers cooperation should be encouraged.

4.3 Challenges and impact of climate change on bees and honey plants in Tsalka municipality

In Tsalka municipality, the biggest challenge for bees in terms of seasons is winter - they have to spend three months in colonies, keeping warm and consuming honey resources. They are able to survive even in very cold temperatures, although during this period they need to be supplied with large amounts of honey, as they cannot produce honey in winter.

Bees are able to adapt to different winter conditions. The best temperature for wintering is 2-3° C and 75-80% relative humidity.

How to keep a beehive in the winter? A successful beekeeper must properly assess the condition of a beehive and take proper measures according to the local climatic conditions. Honey bees are characterized by seasonality, therefore at the beginning of any season, the beekeeper shoud take measures that are needed for the specific season to get the desired results.

Fig. 4.2.1. Outdoor wintering

Before wintering, the beekeeper must take into account the following factors:

- Many, high quality and healthy bees,
- A good egg-laying queen;
- Large reserves of feed;
- Good quality honeycombs;
- Determining the number of varroa mites (based on powdered sugar test);
- The quality of beehives (damages, proper ventilation).

The strength of bee families is determined by how many frames are covered by the bees, the mass corresponding to the normal condition is 7 - 9 frames, less than 6 frames means that the bee family is average or weak. Wintering of weak families is associated with certain risks: if the family has a new, high-quality queen, the wintering will be harmless and lossless, otherwise, it is better to merge (unite) weak families, or place in nucleus boxes with blind partitions.

It is not allowed to merge a weak family with a strong one, because the reason for weakness my be a disease that can damage the strong family too.

A prerequisite for a good wintering of bees is the timely narrowing of the bee nest with at least 2 kg of honey on each frame and leaving as many frames in the nest as the bees can cover (winter reserve of honey - 18-22 kg). During the winter the space in the beehive should be controlled. Narrowing of the nest should precede its warming. Beehive ventilation should be ensured.

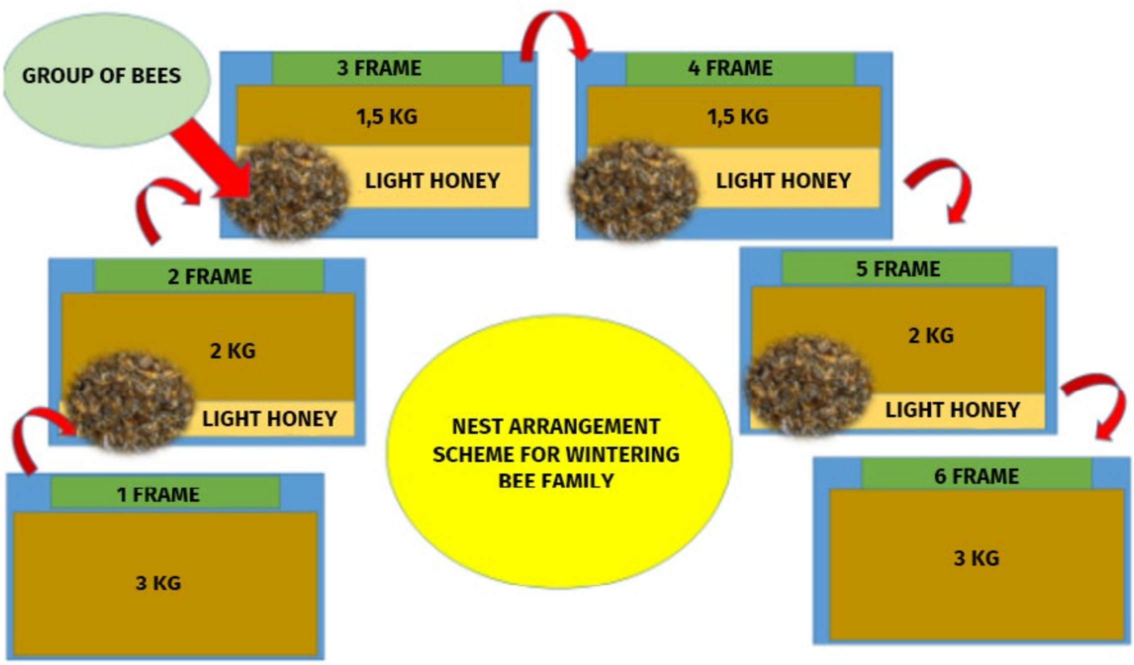
Leaving extra frames creates the need for heating the extra space, which leads to excessive food consumption and tired bees.

The bees are clustered in winter, their vital activity is halted, bees maintain temperature and humidity with minimal food consumption. The cluster is formed when the temperature drops below 8 degrees. Frames filled with honey should be placed on both sides of the nest, frames filled with food cannot be used in the center of the nest, because in winter bees form a cluster on lower side of a honeycomb, on cells that are free of food. The cluster should be warmed with cover fabric and pillows. In winter the nest should be formed at the south or south-west facing wall.

Microclimate of a wintering cluster. ຄImplementation of the recommended actions reduces food consumption and helps bees survive the winter.

The temperature is considered to be optimal in the range of -20 + 20C. The winters in Tsalka became relatively warm, less humid, and windy. The mean winter temperature increased by up to 0.5 degree and currently is -2.3°C. Warming is most pronounced at the end of winter, in February (+ 1.04°C), which creates more favorable conditions for wintering bees, in particular, in terms of consuming less food.

In extreme (difficult) conditions, especially in the highlands, it is possible to install a heating battery in the beehive to maintain the temperature within the above range. The use of foil insulation and styrofoam tiles gives good results in maintaining heat in the beehive. Foil insulation is a foamed polyethylene with a thin foil coat. Comes in 3, 4, 5, 8, 10 mm, with single-sided, and double-sided aluminum foil coat.



Several layers of foil insulation cut to the size of the lid of a beehive can be used as a pillow. Even better results are achieved when covering the dividing board with foil on both sides. The aluminum-coated side should be facing the bees.

For the last few years, in autumn we have been putting 2 cm thick and 31-45 cm sized styrofoam tiles placed in so-called grape bags next to the frames (styrofoam placed without a polyethylene bag is crushed by bees).

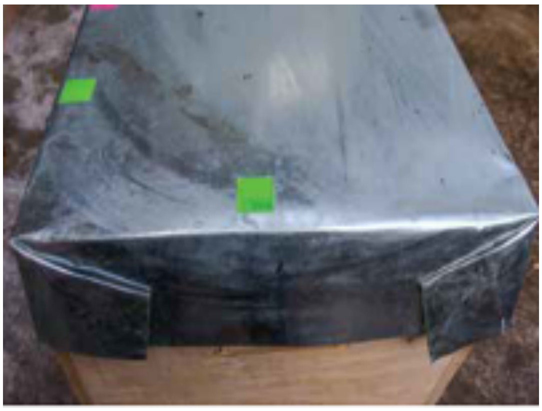


Fig. 4.2.2. Self-adhesive papers on a wooden lid

Fig. 4.2.3. Foil insulation on a beehive lid

Causes of death of bee families in winter include: 1. Hunger; 2. Family weakness; 3. Lack of bee pollen; 4. Nosematosis ; 5. Loss of the queen; 6. Mice; 7. Untreated varroosis.

To examine how the process of wintering is going on knocking on the beehive is often used. Normally wintering bees are characterized by calm and even buzzing. If the loud buzzing does not stop after the knocking and the sound of individual bees is heard intermittently, it means that there is a mouse in the beehive. Chirp sound is a sign of hunger.

FOOD RESERVES

Mandatory reserves of honey for wintering bees differ by regions of Georgia and range from 18-22 kg. For highland areas, it may be even higher. This amount of honey can be replenished later, in autumn. But after removing the honey, the bee family must not be left without a mandatory minimum of food. 6-8 kg of honey and 2 kg of bees pollen are considered to be the minimum amount of food.

Fig. 4.2.4. Styrofoam tile to heat the lid

Fig. 4.2.5. Determining the course of winter

SUPPLEMENTAL FEEDING

Fig. 4.2.6. Death bees by hunger

In case of an unpredictable winter conditions (atypical weather variability, prolonged the cold period) bee food reserved in the nest may not be sufficient. To overcome this problem the beekeeper must ensure supplemental feeding of bees. The foods used for this purpose are usually made up of carbohydrates and are of two types: liquid and pastry-like. Concentrated sugar syrup (Буренин и Котова, 1984) as well as highly concentrated (76-77 mass %) inverted syrup is used as liquid food. The advantage of liquid feed is that its concentration is similar to that of honey, however, as bees deposit some portion of syrup in honeycombs, the risk of crystallization and acidification of the invert syrup is lower due to its high concentration.

One of the advantages of inverted syrup is that it does not promote the activity of the wintering family, which is essential for bees during this period. 0.5-0.8 l of invert syrup is enough to feed a bee family for 15-20 days. More frequent meals are not recommended.

Use of inverted syrup for feeding wintering bees is a relatively new method. The way it is prepared corrects the main negative effects of sugar feeding, namely sugar is broken down into simpler compounds (glucose, fructose) with artificial hydrolyzing enzymes and the water content in the syrup is close to that of honey. This method saves vital energy of bees, minimizes the cost of supplemental feeding, and helps the bees survive winters with physiologically more nutritious feed, which practically does not lead to a decrease in bee productivity.

In winter, during bee starvation, placing a 2-3 kg bee candy on the top of frames gives positive results. If bee candy is not available, sugar syrup in two half-liter jars can be provided. For this purpose, pour 60% sugar syrup into a jar, close it with a polyethylene lid, and make up to ten 1 mm diameter holes using a hot needle in the lid. Jars of syrup prepared in this way are placed one-centimeter wide wooden trays above the frames. They have to be covered with a fabric and a pillow and an auxiliary box or empty body frame has to be put on the top of a beehive. Honeycomb of a body frame or a nest filled with honey can be used instead of syrup jars, which have to be placed above the frames so that the honey part is above the bee family.

In winter, the bee family is provided with supplemental feeding even when the bee family has enough food reserves. In winter, mainly honey or candy is used to feed bees. A beekeeper opens a small area of a honeycomb using a fork and applies honey to the very first bee comb. This is quite an effort-consuming and irritating procedure for the bee family. We recommend using bee candy, as in addition to its cheapness, candy has many other advantages. It does not irritate worker bees and does not force them to fly out which leads to the mass extinction of bees in winter. 2-3 kg of candy can be applies at a time and take a rest for two or three weeks. Stimulating feeding - feeding bee families with inverted food or sugar syrup (consistency: 0.7 kg of sugar and 1 liter of water. The interval between feedings is 3-5 days, and the volume - 300-500 grams (depending on the strength of the family)) should start from March. The ambient temperature during feeding should be + 150C. In Tsalka Municipality, the warming during the season is most noticeable in March when the growth trends for all mean temperature indicators are stable, and the deviations between the two periods are + 0.85°C and + 1.59°C for the average night and day temperatures, respectively. As for the temperature extremes, in the second period the overlap of the absolute maximum temperature was observed in March (+ 3.7°C), when the highest monthly temperature + 23°C was recorded.

Fig. 4.2.7. Shot on top of a group of bees

Fig. 4.2.8. 0.5 L jar on top of the group of bees

Fig. 4.2.9. Honeycomb frames

Fig. 4.2.10. Inventive syrup feeding on a group of bees with disposable plastic

FACTORS AFFECTING HONEY PLANTS

One of the main conditions for high productivity is the abundant nectar supply. It determines the number of bee families in the apiary, beekeeping methods and practices, deadlines, beekeeping measures and activities. Good knowledge of the local food base is necessary for beekeepers.

The condition of a bee family varies greatly by seasons due to its dependence on environmental conditions, the main factors of which are air temperature and the availability of honey plants.

Honey plants are great natural wealth. Nectar released by the flowers is an important product of the nature, but it is dispersed in the flowers and only bees can collect it efficiently. Therefore, maximizing the use of honey bearing resources is more beneficial for the country than increasing sugar production, as honey has a much higher nutritional value compared to sugar.

The main task for the development of the beekeeping is to ensure the collection of sweet juice - nectar secreted by the honey plants. A plant that produces abundant nectar or produces large amounts of pollen is precious for beekeeping.

Plant nectar productivity of a plant depends on a combination of natural and climatic conditions: climate, temperature, relative humidity of soil and air, precipitation, wind direction and speed, light intensity, altitude, plant species, etc.

Temperature - for most plants, the optimum temperature for nectar secretion is 18-250C, at 35-380C nectar secretion ceases. The absolute maximum air temperature in Tsalka municipality is 33.60C, and according to projections, another 3 degrees increase is expected.

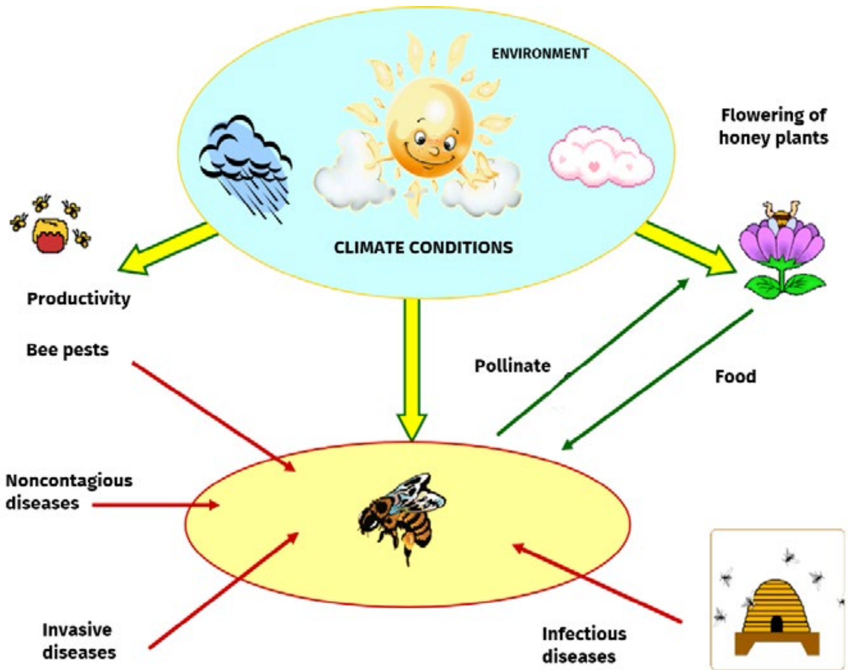


Fig. 4.2.11. Factors affecting the development of the bee family

Air humidity - nectar secretion occurs at 60-80% air humidity. This process is negatively affected by drought, frequent rains, and foggy days. Small rains is good for plants.

Concentration of nectar varies within 10-40%

N Nectar with the concentration below 10% is attractive for bees

Nectar with the concentration above 10% can not be collected by bees

Wind - winds negatively affects the secretion of nectar, the wind dries the nectar. Generally, beekeepers should avoid windy and cold places, but too much heat is not good for a bee family, because when the temperature in the beehive drops by a few degrees, bees consume more honey then when outdoor temperature increases at the same rate.

Duration of sunlight – the data by a number of authors (Darwin, Gubin, Ostashenko-Kudryavtseva, Kopelkievski, Mchedlishvili, Alania and others) evidebce, that the release of nectar under sunlight is 20-30% higher than in the shade. Nectar secretion in most plants stops after sunset.

Daytime period - plants differ from each other in nectar secretion by daytime periods. Most plants secrete nectar in the morning and stop in the afternoon. From 5 PM till sunset, they start to secrete nectar again. The secretion of nectar is stopped en masse in the evening.

The higher a plant is above the sea level, the higher the percentage of sugar in it and vice versa.

Currently the productivity of beekeeping in Tsalka relies on natural meadows. In the Alpine zone of the municipality the following families of honey plants are found: legumes, daisies, buttercups, St. John's-worts, primroses, figworts, buckwheats, goosefoots, spurges, flaxes, umbellifers, etc.

In the last decade the climatic conditions in the country have changed significantly. The onset dates of spring and summer is unstable, making it difficult to determine the exact date of honey plants flowering.

Ways to improve the food base for bees include:
1) Ensure wintering of highland apiaries in lower zones and prepare strong families for spring. Avoid concentration of large number of bees at one place, which, in addition to reducing income, may lead to the spread of infectious and invasive diseases. Use a moving platform for transportation of beehives.

Fig. 4.2.12. Food preparation

Fig. 4.2.13. Beekeeping

Fig. 4.2.14. Rolling platform for constantly sorting food

Before moving bees, the place where beehives will be relocated shall be carefully studied in advance. Honey plants widespread in the area, timing and duration of their flowering, as well as the number and health of local bee families should be determined. Moving occurs at different times. For example, bees from mountainous or late-bloom areas are moved to lowlands, forested or the areas where fruit gardens and orchards are located, in early spring, to help the bees strengthen earlier. A beekeeper develops queen bees and creates new families. Then bees are switched to nectar feeding. By the end of blooming season, the bees are taken back to the mountains, where the Alpine plants allow the bees to produce high-quality honey. In summer, bees are moved only at night. In early spring and late autumn bees can be moved also during daytime.

When preparing a beehive for moving, a wooden lid, cover cloth and pillow should be removed; If the beehive is not filled with frames, the last frame needs to be nailed. Beehives should be covered with a transport net, and the beehives have to be fastened with belts. In the evening the beehive exits should be blocked with a sponge or a piece of wood (nailed).

Before the start of the main nectar gathering season, the beekeeper monitors the flowering of honey plants, activity of worker bees, and a control beehive. Strong bee families are crucial for the maximum use of the flowering period.

The strength of a bee family is determined by the number of worker bees and the fertility of the queen bee, which determines the productivity of the family.

Timely expansion of nests is of great importance to bee families. The expansion of the nest should be done according to the strength of the bee families. For the efficient operation of bee families throughout the flowering period, an auxiliary space or frame box for beehives should be provided.
Honey plants available to stationary apiaries are not able to provide enough food for bee families, so they need to be relocated.
Low productive periods should be compensated by sowing honey grasses. The combination of seeds of cereal crops and legumes should be sowed, which will also increase of productivity of livestock through provision of high quality feed. Sowing of legumes such as sainfoin and alfalfa on fields and pastures (20-30%

sainfoin and alfalfa is sown in Tsalka) is especially important.

The following considerations have traditionally been taken into account in the process of establishing the nomadic routes:

- Ensuring early spring development of bees by taking into account the factors of their care, nutrition, and temperature, even in conditions of restricted (scarce) food base (Gardabani zone);
- Relocation of bees to the transitional zone by the end of the spring, where further development of bees and accumulation of honey will be ensured;
- Relocation of bees to Alpine meadows (from June within Tsalka, and in August - to highland areas: Akhalkalaki, Ninotsminda, Kazbegi) in summer;
- Returning beehives home to feed on autumn honey plants and to stimulate reproduction (Gardabani Nature Reserve);

Before moving, the volume of a bee nest should be increased and aeration should be ensured by a net.

Rising ambient temperatures reveal many, often difficult problems, including animal thirst. Bee families have a particularly high demand for water during spring and summer when bee larvae and pupae are bred. In the spring, placing a water source should precede the first flight of newborn bees. Two buckets with water should be provided. One filled with fresh water, and the other - with salty water. The maximum amount of salt is 1-1.5 grams per 10 liters of water. The area intended for bee families must meet the optimal conditions for food extraction and water supply.
Spring is the most critical period for a bee family. Properly implemented preparatory works is a prerequisite for the normal development of the bee family. After the passive period the family development period begins, which is associated with the hatching. The older generation, due to its hormonal status, acts as babysitters. They have a rather high body fat content, at the expense of which a new generation must grow. Along with feeding, it is very important to maintain proper thermal regime in the family because the larvae need 350C to develop. The bee family is actively developing, the number of bees in the family is increasing. During this period excess frames from the nest (removing unsuitable, black, deformed frames and melting wax) should be removed to facilitate thermoregulation of bees.

With the increase of dry days, the demand for drinking water is expected to increase. Beehives should have proper ventilation to get oxygen and release carbon dioxide and water vapor from the beehive. In summer, especially during hot days, bees facilitate ventilation themselves: when nectar yields are low and the food is not adequately ventilated, bees draw water not only for larvae but also to evaporate water in the nest, to restore moisture level and to lower the temperature. Beehives can be ventilated the lower and upper exits. Strong ventilation of the hive is ensured by a net integrated in the bottom of the beehive.

Fig. 4.2.15. Irrigation system

Fig. 4.2.16. Rolling bottom with integrated mesh at the bottom of the beehive

Climate factors can facilitate the propagation and spread of carriers of infectious and invasive diseases

Dangerous infectious diseases for bees are different types of foulbroods: American and European foulbroods, and mixed infections. The bacteria that causes EFB (European foulbrood) Melissococcus plutonius, unlike the AFB (American foulbrood) causing bacteria Paenibacillus larvae, does not spread by spores, which makes it relatively easy to fight European foulbrood. The diseased larvae initially has no odor and then emits an acidic smell. After the bees clean the cells, the queen lays eggs, causing larvae of different ages to hatch next to each other, and thus creating an uneven or patchy brood pattern. American foulbrood is also characterized by a patchy brood. We must distinguish a healthy cell that is in the process of being capped from a cell that had changed its appearance later due to the disease. The cell that is in the process of building and capping has a hole in the middle and the one damaged by the disease usually has a hole on its edge. The disease is mainly found in hot summers. Its development is facilitated by overheating of the nest (European foulbrood - by cold weather).

It should be noted that both are brood diseases and quite often (depending on the degree of infection) the larvae reach the stage of recapping and look like the larvae that is diseased with American foulbrood even by the stretch of dead larvae. For proper diagnosis tests shall be carried (the Holst Milk Test. American foulbrood can be also distinguished by a specific sign, the so-called "beak".

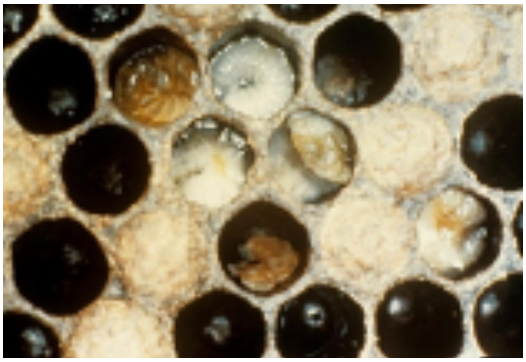


Fig. 4.2.16. European foulbrood

Fig. 4.2.17. American foulbrood

American foulbrood is a particularly dangerous disease, often associated with:

- Period of nectar gathering,
- Black honeycombs in the beehive,
- Violations of hygienic norms.

The use "Bactopol" or "Vesta" against these bacterial diseases is recommended. The honeycombs must be removed and destroyed. All frames with dead larvae and a sign of American foulbrood, the so-called "beak" shall be removed and destroyed.

Antibiotic treatment of the AFB has a temporary effect, as antibiotics only kills bacteria that are in the reproductive phase, and the bacteria that have entered the spore are safe. Bee family with AFB poses a threat to other families and neighboring beehives. The beehive in which AFB was detected shall not be moved. The infected beehive shall be disinfected and then boiled in wax or paraffin.

Nosematosis is a very common and dangerous invasive disease of bees. It is caused by NOSEMA APIS and NOSEMA CERANAE. These two nosemas have different clinical signs. In Georgia Nosematosis and varoatosis are almost in all beehives in a hidden form. Nosematosis became even more dangerous after the invasion of Nosema Ceranae. In our country, nosematosis caused by Nosema Ceranae is rarely manifested in its classical form (diarrhea, dirty walls, frames, and landing planks. Slow crawl of the bees in early summer and small amount of larvae are the main signs of nosematosis caused by Nosema Apis). In the case of Nosema Ceranae, both beehive and honeycombs are clean. Neither slow crawling nor diseased bees can be seen. Simply put, the bees in beehives are rapidly declining and eventually disappearing as Nosema Ceranae halves the lifespan of bees. This reduction - disappearance often happens so fast that in an empty beehive together with honey a small number of capped larvae on 2-3 frames can be found. Beekeepers pay less attention to the prevention and treatment of this disease, but the economic loss from Nosematosis is huge.

The main transmitters of this disease are bee families infected with nosematosis. In late winter, infected bees transmit the disease to other member of the family and the whole family gets infected with nosocomial spores. Spores along with feces are found on frames, honey, wood, honeycombs, walls, and bottom of beehives. The disease can also spread by beekeeping equipment. Although Nosema does not manifest itself in the fall, stress and bad weather can trigger the outbreak of the disease. If the spread of the disease occurs inside of the beehive, the disease can be spread to other families with honey removed from the diseased family. The spread of the disease can also be facilitated by water buckets.

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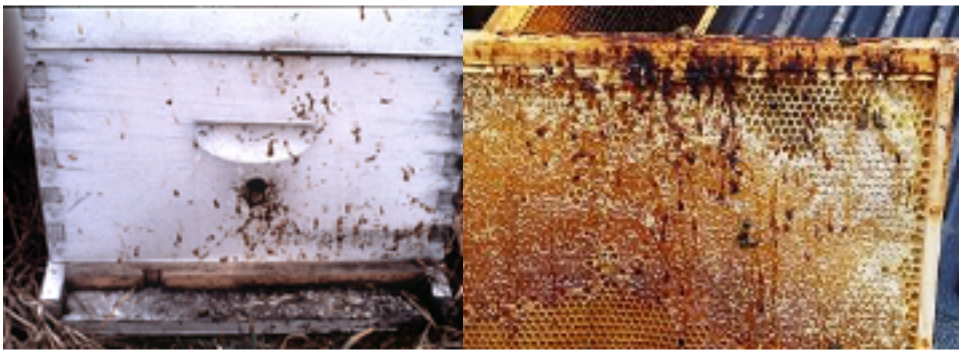

Fig. 4.2.18. Dirty beehive walls and frames

The development of the disease is facilitated by feeding manna honey during wintering, prolonged winter, and high humidity. The bee family should be provided with nutritious food throughout the year.

Both species of parasites - Nosema Apis and Nosema Ceranae pose threat the beekeeping.

Nosematosis is often confused with diarrhea usually associated with first flight.

Ascospherosis, or chalkbrood is a fungal disease caused by Ascosphaera apis. The fungus affects larvae aged 3-4 days. It infects open and capped cells of queen, male, and worker bee larvae. The spores enter the beehive together with the pollen of flowers, brought in by a worker, male, or a thief bee.
Nanny bees transmit spores to larvae together with food. The disease spreads from April to October. Bees do not get sick, they are just carriers of the disease. The larvae are chalked up and resemble a piece of white chalk, the mummified pupa is dark gray or purple. Bee dies at the larvae stage.

The disease is caused by:

- Increased humidity in the beehive,
- Low-quality queen bee,
- Food shortages,
- Old black honeycombs.

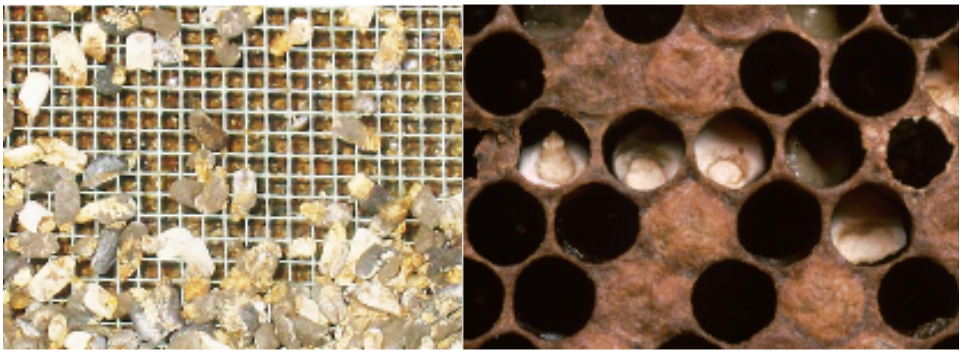

Fig. 4.2.19. Walled-up nestling

Prevention - maintenance of microclimate and hygiene in beehives.
Treatment:

- Antifungal drugs,
- Plant extracts,
- Replacement of a queen bee,
- Removal of severely damaged frames,
- improving ventilation in beehives.

Varroatosis - the agent of this disease is the mite **varroa destructor.** Natural transmitter of bee ectoparasite Varroa is Apis cerana. After adapting to a new host (Western honey bee), it spreads rapidly around the world, causing great damaged to beekeepers.

In addition to the varroatosis, deliberate or unintentional mistakes of beekeepers, facilitated the extinction of bee families.

The mite varroa has adapted very well to the biology of a honey bee, which has made it difficult to fight the disease. The female mite goes through two different stages in life: the phoesis phase when it is present on the body of an adult bee, and the reproductive one, when it is active in the capped cell of larvae during the metamorphosis of worker and male bees.

Fig. 4.2.20. Porous phase

Fig. 4.2.21. Reproductive phase

The female mite seems to perceive the pheromone-signal generated by bee larvae before capping the cell and moves from the worker bee to the cell where it hides under the larva. After the larva is capped, it begins to feed on the hemolymph and lays the first egg from which the male hatches, then it lays a few (2-4) eggs, from which the females hatch. Young mites develop before the bee larva completes its metamorphosis, and are fertilized by males. After pupation of bee larvae, female mites leave the cell and enter the phoresis phase. The male mite never leaves the cell, he has completed the mission and dies there.

It should be noted that the main damage caused by mite is the delay in the development of bee larvae. The female mite waits for the bee larva to be recapped and wounds it to feed itself and its offspring. The new-born bee is weak, its life expectancy is reduced, and is not able to perform its duties.

This factor is manifested especially during wintering, as worker bees, which fed the mite and its offspring, die in the very first months of winter.

One mite can raise 1 or 2 full-grown offspring per one larva of a worker bee. The average rate is 1.3. The mite can lay even 5 eggs in a cell, although only two females hatched from the first two eggs are able to mature (meanwhile, a worker bee hatches, and the rest simply do not have a chance to mature). The mite lays its eggs in the cell once in about every 30 hrs. The development of a male bee in the larval phase is one day longer, this allows the mite to raise 2-3 full-grown mites instead of 1-2. There is a hypothesis that the mite invades the chilled part of a beehive, and this part is a periphery where most of male cells are. The mite is very sensitive to temperature, it feels a change in temperature even by 1 degree. The temperature in the center of the nest is 34-35 degrees, the most favorable temperature for Varroa is 26-33 degrees, so it prefers to reproduce in the peripheries.

RECOMMENDATION:

Control the number of male bee cells in the nest, remove infected honey combs, or periodically remove the sections of newly capped male bee cells.

The source of the disease are infected bee families. Mites are spread by wandering bees, male bees, adding an infected frame with infected larvae to strengthen the family, bee brood, etc.

The degree of infestation of a bee family depends on the amount of spread mites. Worker and male bee death rates are high in an infected beehive. Newborn bees are small in size, less viable, lack proteins, with weak immune system, deformed bodies and damaged wings, poorly developed, deformed abdomen and limbs. The infected family is unable to function normally and completely dies out without intervention of a beekeeper.

In autumn, the development of larvae in the family stops and the number of bees decreases accordingly, which leads to increased amounts of mites per bee. The mites stop reproduction and sticks on the lower part of the abdomen of a bee for wintering.

In case of a strong invasion in autumn, bees leave behives. Bees prepared for wintering are not able to form a colony and the family is doomed to die during frosts.

Fig. 4.2.22. A vessel with which it is possible to control the quantity of varroa

What is the maximum acceptable amount of mites in a bee family and how to determine this amount?

Mite control is essential. A simple method for determining the amount of mites in a bee family is as follows:

Place 100 or more bees in a plastic container, cover with a wire lid and sprinkle with 2 tablespoons of powdered sugar. The bees should be completely covered with the powder, so rotate the plastic container for a few minutes and then turn it over on a white plate. Mites will fall down together with the powdered sugar. If more than 3 mites per 100 bees are found, timely treatment is required.

Organic acids that are highly effective and do not contaminate the products can be used.

For effective treatment of varroatosis, directions for use of chemicals shall be read and the rules concerning the dosage and timing shall be followed. Beekeepers often have to change the anti-varroatosis chemicals (depending on the active substance) to prevent the development of resistant variations of mites.

Drugs used against varroatosis:

formic acid, oxalic acid, thymol
Amitraz – Bipin, Bayvarol
Tau fluvalinate – Mavrik, varocom
Fluvalinate – Aquaflo
Flumethrin - Varostop

The interval between treatment cycles against varroatosis should not exceed 3 months.

There is one thing to keep in mind when using any drug: none of them can affect the mite in cells and their offsprings without harming the larva! The average ratio between the mites attached to the bees and the mites in the cells is 1:10, meaning that the amount of visible mites is about 10 times less than their total amount. Therefore, in such cases, with a single spray of a short-acting drug, only this 10% can be removed.

RECOMMENDATIONS:

1. Use drugs with prolonged action during pupation
2. Take advantage of the period when eggs are not hatched
3. Create larvae-free period to reduce the frequency of drug administration and its doses

4.4 Conclusions and recommendations for beekeepers considering climate change

Bee family is a living system rich in self-sustaining resources, the main issue is their rational use, which depends on the beekeeper.

Remember! Leaving extra frames the beehive leads to the need to heat the extra space and as a result - non-productive consumption of food, which leads to increased bee exhaustion and food shortages!

Beehives should be positioned so that the walls are warmed by the sun from the south and east, and the exits should not be directed to the north to avoid the intrusion of cold air masses. The front of the beehive should be slightly lower to avoid of penetration of rain waters. Ventilation of beehives shall be ensured!

To prepare a bee family for wintering the following in required:

1. Healthy bee families; for this purpose treatment against varroatosis, foulbrood, and nosematosis must be carried out;
2. Minimum necessary food reserves, not less than 6-8 kg of honey and 2-3 kg of beeswax; (do not be mistaken for winter reserves, which should be 18-22 kg pf honey)
3. The amount of bees should not be less than 2.0-2.5 kg and 5-8 frames with larvae;
4. High-quality honeycombs in the middle of the nest;
5. Moderate supply of nectar and beeswax, during unproductive periods - supplemental feeding (2-5% protein supplements are recommended);
6. The quality of bees after wintering is directly related to the amount of beeswax covered by the colony in winter.

The use of foil insulation and styrofoam tiles gives good results in maintaining heat in a beehive.
Bess should be provided with supplemental feeding, when the coloby reaches the upper
Additional food is given to the bees when the family reaches the top of the beehive and therefore will have direct access to the food, otherwise food will remain untapped.

Late feeding worsens the vital activity of wintering bees, which becomes evident at the beginning of the next active season!

Good knowledge of the local food base is necessary for beekeepers.

The optimum conditions for nectar secretion are: air temperature 18-250C, relative humidity 60-80%; warm, calm, sunny weather with short rains (especially at night). Honey plants differ by their requirements to soils. A green nectar conveyer, which will incerase honey production should be provided for stationary apiaries. For this purpose seed and nursery farms of honey plants, shrubs, and herbs should be established.

To protect bees from the adverse effects of unproductive periods that occur quite often during the active season, beekeepers should be assisted in beehive transportation (provision of a moving platform for beehives).

When selecting a site for relocation of beehives, the potential of the honey plants should be determined. More than 60-80 bee families should not be concentrated in one place. Apiaries of this size should be located at a distance 1.0-1.5 km from each other, which excludes the accumulation of large amounts of bees within smaller areas. This measure also prevents the spread of communicable diseases. The whole active season should be planned in such a way that the bees are provided with sufficient amounts of nectar.

Usually, the duration of the flowering period of plants is 2-3 weeks, so moving should be done at different times of the active season, taking into account the vertical zoning of plants.

High temperatures lead to water scarcity, therefore water buckets shall be placed in the apiary, beehives should have adequate ventilation, and shed if necessary.

RECOMMENDATION:

- bern bee families infected with American foulbrood (AFB), however many beekeepers do not follow this recommendation. Here are some tips:

Selection and destruction of infected honeycombs, disinfection of the beehives and beekeeping equipment. Antibiotic therapy has a temporary effect in the treatment of American foulbrood. The treated family should be placed away from other bee families to prevent the rapid spread of the disease.

The use of any veterinary drug carries the risk of contamination of not only honey but also bee wax.

Use probiotics and greater celandine to enhance the hygienic properties, they do not cure but strengthen the bees.

RECOMMENDATION:

Beekeepers should systematically assess the strength of families, monitor their development, and compare these rates between families. This approach helps identify families that do not have the ability to develop and are vulnerable to diseases. Such families need to replace queen bees with queen bees from other disease-resistant families.

RECOMMENDATION:

- The interval between treatment cycles against varroatosis should not exceed 3 months.
- Control the number of male bee cells in the nest, remove infected honey combs, or periodically remove the sections of newly capped male bee cells.
- Use drugs with prolonged action during pupation.
- Take advantage of the period when eggs are not hatched.
- Create larvae-free period to reduce the frequency of drug administration and its doses.

5. SUSTAINABLE MANAGEMENT OF LAND RESOURCES

5.1 The current practice of land management in Tsalka municipality

The total area of Tsalka Municipality is 105,000 ha, agricultural lands occupy 83,000 ha, making 79% of the total area and determining agriculture as the main field of the local economy. The forested areas in the municipality are limited - 9000 ha *(Source: Climate Change Adaptation and Mitigation at the Local Level, Baseline Assessment of Tsalka Municipality, 2013).*

Pastures constitute main part of agricultural lands (73%) - 61 000 ha and create favorable conditions for the development livestock breeding. The area of arable lands is about 21,000 ha (25%), while perennial crops occupy 1000 ha (2%). (Source: Climate Change Adaptation and Mitigation at the Local Level, Baseline Assessment of Tsalka Municipality, 2013

According to the available information, the number of cattle in the municipality is excessive compared to the pasture resources, which is evidenced by pasture overgrazing and soil erosion. Pasture load especially intensifies during the summer when cattle is moved from other municipalities as well.

Most of the arable lands require irrigation, with the efficient use of available water resources it is possible to provide irrigation water for a significant part of these areas. In this regard, the situation is relatively difficult for pastures that are not irrigated or practically cannot be irrigated due to the lack of irrigation systems, lack of access to adequate water resources, and rough terrain.

Most of the arable lands are unprotected from the impact of winds as a result of destruction of windbreaks, which significantly increases the risk of wind erosion and reduces crop yields. Arable lands on mountain slopes are often ploughed downslope, which facilitates the development of water erosion.

Recently, there has been a small increase in crop yields in Tsalka Municipality, however, the potential for the growth of productivity is much higher given the existing highly fertile soils. Approximately 54% of the municipality is occupied by black soils (Table 5.1.1.), which are one of the most fertile soils in Georgia, although proper crop yields cannot be achieved due to many factors. These include the negligence of dates, rules, standards, and doses for the application of fertilizers and plant protection products, and in some cases their improper selection, which reduces their effectiveness and affects the yield and/or quality of products produced.

Table. 5.1.1. Main soils types in Tsalka municipality

Soil type	Area (%)
Androsols	21.1
Soddy-carbonate	1.8
Meadow-brown	2.3
Leptosols umbric	14.1
Leptosols umbric primitive	2.6
Leached brown	0.7
Cambisols	2.6
Leached black	2.6
Black	51.3
Heavily washed soils and exposed rocks	1.0

Along with the development of livestock breeding, the problems associated with livestock waste increase in the municipality, which are mainly caused by improper handling and storage of manure. Rain water washes out large amounts of nutrients from improperly disposed/stored manure, which enter the deeper layers of soils and potentially surface or ground waters thus causing significant deterioration of their quality. Most of the nitrogen contained in manure is evaporated as ammonia. As a result, manure decays over time and, as an organic fertilizer, becomes useless for agriculture.

Improper application of organic and mineral fertilizers on arable lands, namely spreading organic fertilizers, mainly manure on land surface and keeping them exposed for a long period of time, which results in losses of nutrients and reduced efficiency, is a common practice. Similarly, mineral fertilizers are often applied without relevant schedules and regulations, standards and doses are not established according to soil fertility and crop requirements, leading to depletion of soil and/or excess of certain nutrients, which ultimately affects productivity.

The existing practice of household waste management is noteworthy in terms of irrational use of available land resources in Tsalka Municipality. There is only one official landfill in the municipality serving the town of Tsalka and several villages, while the rest of the settlements use illegal landfills results in the loss of large land areas and their physical and chemical degradation, which in turn affects soils, the quality of surface and ground waters, and increases emissions of harmful gases, namely greenhouse gases, specifically carbon dioxide and methane. According to the available data, the Tsalka landfill annually receives around 2,000 tons of household waste, which contains about 50% organic matter, as a result of an anaerobic decomposition of which 72 tons of methane can be released into the atmosphere.

5.2. Impact of climate change on soil and vegetation

Climate is a soil-forming factor and any change in it directly affects the physical and chemical properties of the soil. However, the negative impacts of climate change on vegetation will eventually be reflected on the soil.

Livestock breeding is the leading sector of agriculture in Tsalka Municipality and, consequently, climate change has a significant impact on natural pastures, the productivity of which, along with soil fertility, is determined by climatic conditions, especially when natural pasture improvement measures are not implemented and the pastures are not properly managed.

Climate change also facilitates soil erosion and reduces the ability of vegetation to regenerate on pastures. According to the analysis, the average annual temperature in Tsalka in 1990-2019 has increased by + 0.66°C compared to 1960-89, with a maximum increase of + 1.53°C in summer, namely in August. As the temperature increased, the number of rainy wet has decreased (relative humidity ≥80%, Rh80) and the number of dry days (minimum relative humidity ≤30%, Rh30) has increased, indicating an increase in evapotranspiration and, consequently, a greater demand for water. This cannot be compensated due to the reduction in precipitation, which is observed throughout the year except for the winter season, and precipitation especially decreases (-31%, 24 mm) in the hottest month of the year - July, when the pasture load is maximum. Therefore, the degradation of pastures occurs faster and intensively. Degradation of pastures is facilitated by consumptive use of pastures, lack of plot rotation practice, lack of a system for regulating the number of cattle, the frequency of grazing, and the stay of cattle on pastures, considering the condition and productivity of pastures.

The number of extremely dry days has also increased in the face of climate change, which especially affects pastures in the spring and increases the risk of their degradation, both in terms of delaying normal growth and development of grass cover and increasing soil erosion potential, as under the influence of wind and/or water loss of soils and consequently the loss of soil organic matter and nutrients occur. The analysis of climatic data shows a decrease in average wind speed of 0.3-1.1 per year on average. Despite the decrease in average wind speed in Tsalka municipality, the number of days with strong winds (Wg15) increases almost throughout the year and makes 13 days in average. Extreme winds (Wg25) are most frequent in March. It should be noted that wind even at 6 m/sec speed can initiate erosion on dry soil surface. Erosion intensifies with increasing wind speeds. Therefore, increased number of windy days when wind speed reaches ≥15 m/sec (Wg15) dramatically increases the risk of erosion and accelerates the process of drying of soils, which in turn leads to intensified erosion.

The decline in pasture productivity is especially pronounced during long and severe droughts, the number of which has increased over the last 30 years in Tsalka municipality, contributing to the acceleration of pasture degradation.

By increasing the number of severe and extreme dry months and strong winds (≥15 m/sec) and their extreme manifestations (≥25 m/sec) cause significant damage to arable lands, drastically reducing soil productivity, decreasing moisture in unirrigated soils, causing a sharp decline in yields of crops, especially in annual crops. At the same time, the risk of developing wind erosion increases, which in turn leads to a decrease in soil fertility over time.

Strong winds (≥15 m/sec) and their extreme manifestations (≥25 m/sec) in early spring damage crops, especially autumn grain crops, which are still weak during this period. Studies show that strong winds in spring and autumn reduce crop yields, and wheat yields can be reduced by 46% (N. P. Woodruff, Wind-Blown Soil

Abrasive Injuries to Winter Wheat Plants, 1907, Agronomy Journal, https://doi.org/10.2134/agronj1956.00021962004800110006x), while heavy rainfall combined with strong winds can cause serious damage to crops, reducing yields by up to 80% (Effect Wind Speed, Rainfall on Large-Scale Wheat Lodging in China, 2007-2014, DOI:10.1371/journal.pone.0157677 July 1, 2016).

In Tsalka Municipality, a significant part of the arable land, mainly pastures, are located on slopes with different angles of inclination (Fig. 5.2.1, Fig. 5.2.2.). Although due to climate change the percentage of days with heavy and extremely heavy rain tend to decrease, the possibility of surface runoff is high with degraded pastures where vegetation is reduced and the potential for water erosion is still high, especially after prolonged and/or severe droughts when water absorbing capacity of soils is low.

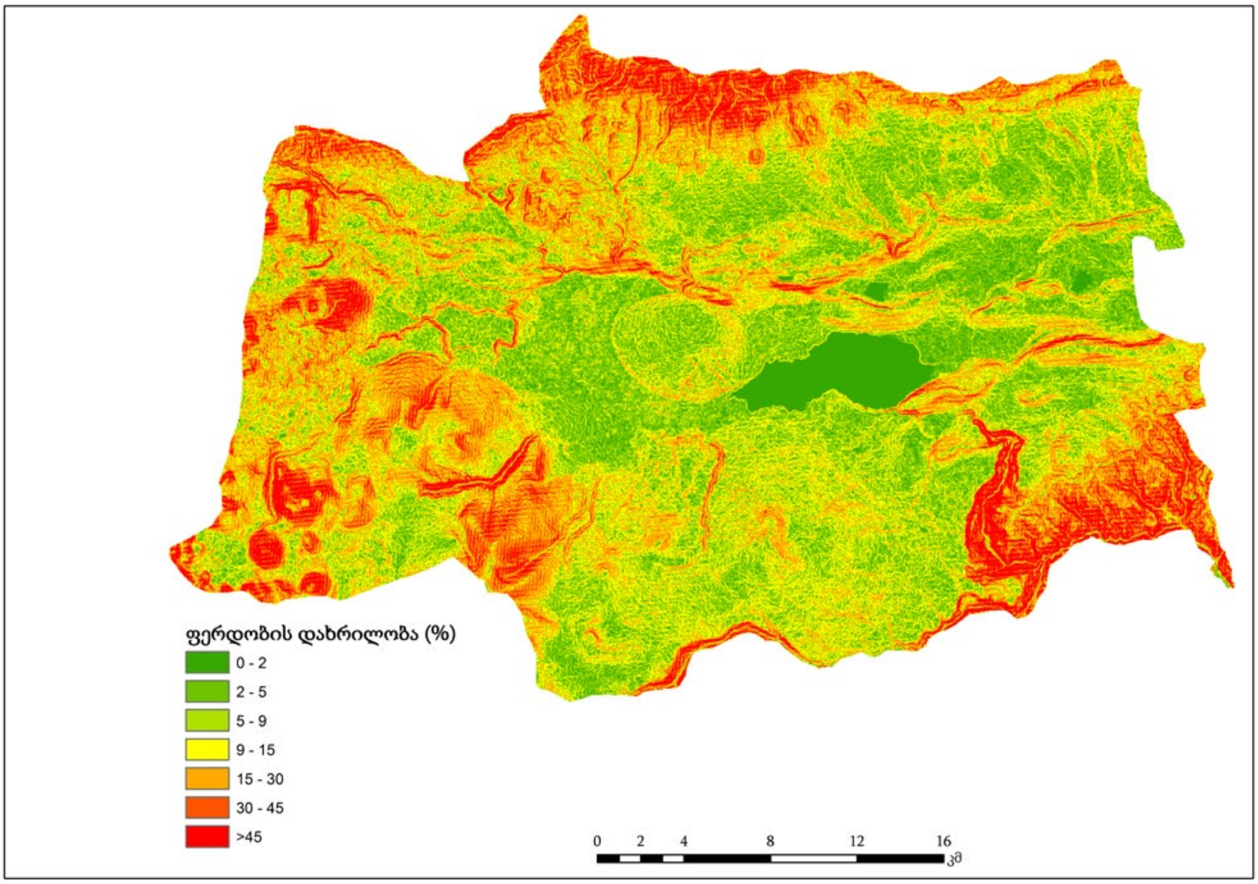

Fig. 5.2.1. Map of slope settlement in Tsalka municipality

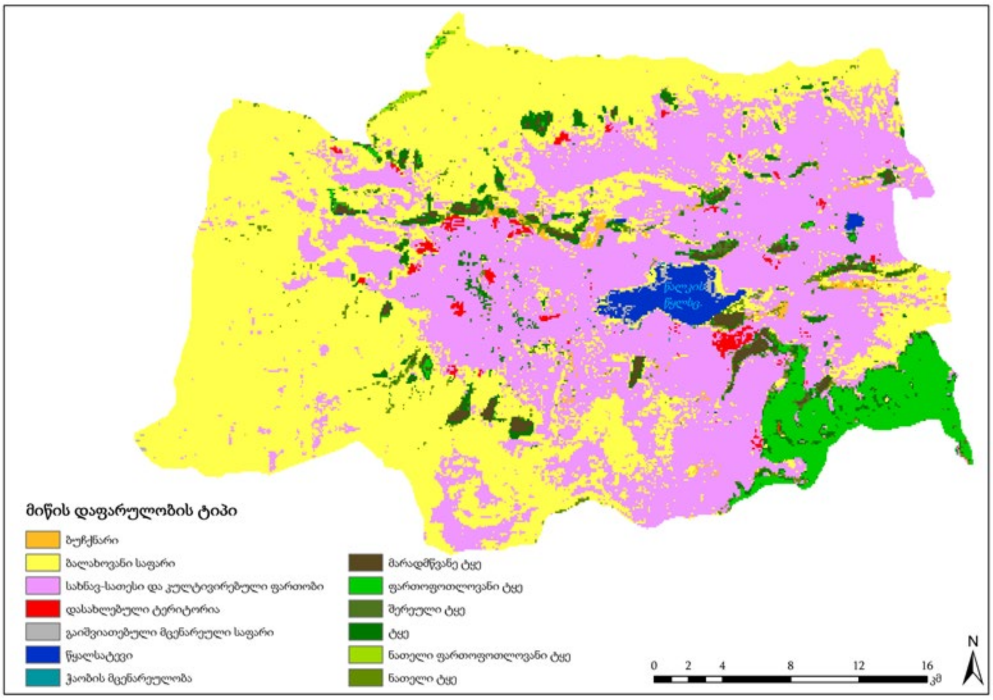

Fig. 5.2.2. Land cover based on satellite image analysis

Soil losses due to erosion have been studied on pastures with different vegetation cover, the results of which are given in Table 5.1.2.

Table. 5.1.2. Loss of soils and soil nutrients as a result of 54 mm precipitation on different vegetation covers

Option	**I**	**II**	**III**
Coverage Percentage	87	69	6
Surface runoff (mm)	1.5	14	38
Soil loss due to water erosion (t/ha)	0.03	0.3	22
Nitrogen loss (kg/ha)	0.14	1.9	15.3
Phosphorus loss (kg/ha)	0.14	1.9	15.3

*(**Source:** Erosion control in grazing lands. Science notes, Land series 91. Queensland Government, Australia).*

5.3. Conclusions and recommendations on sustainable management taking into account climate change

According to the results from the 2021-2050 climate change forecast for Tsalka municipality, the warming trend is maintained and mean temperatures, as well as mean minimum and mean maximum temperatures increase. Precipitation also increases slightly during all seasons. The average wind speed also tends to increase, and together with the increase in temperature will contribute to the loss of soil moisture, which will increase demand on water, and on the background of projected increase in occurrence of droughts, will prolong the time required for natural regeneration of pastures and increase the need for irrigation and maintenance of soil moisture for spring crops.

MANAGEMENT OF ORGANIC WASTE AND COMPOSTING

To fertilize arable lands and areas occupied by perennial crops and to prevent organic waste from landfilling, the use of biodegradable organic waste generated on farms to produce organic fertilizer - compost – is recommended. Compost will help increase the amount of organic matter in soil and its ability to retain moisture, which is especially important given the future climate change scenario, according to which an increase in temperature and, consequently, an increase in water demand are expected.

Materials needed for composting:
Manure (cattle, pig, chicken, horse, sheep), straw (shredded to a size of 10-15 cm), stubble, hay (grain-free), green grass (grain-free), wood chips, thin twigs (finely chopped), fruit tree pruning waste (disease-free), leaves, kitchen vegetable waste, bean or other legume waste, eggshells, ash (in small quantities, maximum 3% of the total volume), all kinds of green mass, except poisonous and thorny plants.

When collecting compost material, it is important to maintain a ratio of dry (e.g., straw, stubble, dried hay, wood chips, dried twigs, etc.) to raw materials (any kind of green mass, kitchen vegetable waste, manure, etc.). 1 part of dry mass should be added to 3 parts of raw mass (depending on the volume), it is possible to have a ratio of 1: 4, especially when making compost during the warm period of the year.

Fig. 5.3.1. Arranging compost in a box

The compost pile should not be too small, preferably at least 1 m3 in volume. The height of the pile should be up to 1.5 m, length - unlimited. The pile can placed in a wooden box (Fig. 5.3.1.), or as a simple pile (Fig. 5.3.2. and Fig. 5.3.3.).

Moisture and oxygen are required for composting, therefore regular moisture shall be carried out using a "fist test" (take the compost mass from the middle of the pile, tighten your fist and press the sample in your hand, if water drops come out between the fingers, it means that the compost is too wet and it is required to add dry mass and turn it over/mix; if the material is dry and breaks down easily when the fist is opened, then water needs to be added).

Fig. 5.3.2. Arranging a compost pile

Fig. 5.3.3. Arranging a compost pile

When making a compost pile, fix the date and mix the pile well with a shovel for the first three weeks, then repeat this procedure every two weeks.

It takes of 3-4 months in average to make a compost, however, the required time is very much dependent on how procedures are followed. The season shall be also taken into accoun, as composting process is slower at lower temperatures, so it is advisable to start composting in spring or summer so that the compost is ready to be applied to the soil before the temperatures drop. To make sure that the composting process has started in the pile, manually check the pile temperature at a depth of 10-15 cm below the pile surface, which will be much higher than the ambient temperature, which indicates that composting process is going on. The temperature may reach 70-80 degrees, although over time it gradually decreases and after 2 weeks drops to 40-45 degrees. The composting process can be stopped due to a lack, or excess water.

The composting process releases certain gases that are characterized by an unpleasant odor, so composting should take place away from the settled areas taking into account prevalent wind direction. It is advisable to have a water source nearby. The compost site should not be located downward of the plot to avoid uphill transportation of ready to apply compost. If the compost pile is protected from rain water, regulation of the humidity in the pile is easier. In the absence of a shelter, the top of the compost pile should be covered with straw, stubble, or dried hay. Such cover should be maintained until the compost is ready to speed up the composting process and improve the quality of produced compost.

The composting process is completed when the temperature inside of the pile drops, the unpleasant odor completely disappears and the smell of compost becomes pleasant like humus and soil. The closer the compost is to full maturity, the more noticeable this smell will be.

After composting, a certain amount of twigs and relatively large debris, etc., may be left unprocessed. Therefore, prior to application, it is recommended to pass the compost through the sieve with a mesh size 10-15 mm (similar to sand used for construction). Residues can be stored and used to for composting.

The compost can be applied to arable land or under perennial crops in an amount of 10-20 t/ha, taking soil fertility into account. The compost should be introduced/ploughed into the soil as soon as it is applied to avoid any losses.

REGULATING SOIL MOISTURE AND TEMPERATURE USING MULCH

Mulching is an important measure for retaining moisture in soils retention. The use of mulch is effective under perennial crops, as well as for production of vegetable crops. Preference should be given to mulch made of hay or stubble, the raw materials of which are locally available. Hay used for mulching should not contain weed seeds, which is achieved by mowing grasses during the flowering period. Application of mulch under perennial crops should be done before spring rains, and in the case of vegetable crops - after transplanting the seedlings or when sprouts reach the appropriate height.

Along with dead mulch, under the perennial crops it is possible to use live mulch, which is achieved by sowing cover crops. Cover crops may consists only of legumes or their combination with grain grasses. Cover crops, while maintaining moisture, nourish the soil, improve its structure, and the presence of legumes (vetch, grass pea, clover, etc.) in cover crops ensures the accumulation of biological nitrogen in the soil, which improves the nitrogen intake of the main crop.

The use of cover crops on arable lands is very important in the case of spring crops, when during the autumn-winter period and early spring the soil is not covered by vegetation. Cover crops can protect the soil from erosion during this period, retain moisture, limit the development of weeds, maintain the level of biological nitrogen, and, at the same time, provide a significant amount of green mass that can be used as green fertilizer and animal feed, as well as to produce mulch and highly nutritious hay.

In conditions of Tsalka municipality a combination of hay or stubble mulch can be applied between the rows of perennial crops. In particular, mulch should applied in the area surrounded by plant roots, and cover crops should be sown between the rows. This measure will help keep moisture for the crop during the drought as long as possible, until the cover crops compete with it in terms of water consumption, on the other hand, cover crops provide additional nitrogen, protect the soil from crusting which eliminates the need for cultivation, reduce rainwater losses and facilitate the accumulation of water in the soil. Mulching can be used successfully for potato and cabbage crops, especially in unirrigated conditions, when maintaining soil moisture is especially important.

The advantages of mulching with plant-based materials are:

- Strengthens the soil's ability to absorb and retain moisture, which reduces the periods of water stress and prolongs and increases the intake of nutrients by plants;
- A source of food and favorable habitat for soil organisms is created; Channels and pores for the movement of air and water are created in the soil; The soil is "biologically processed" and biological processes are activated through the decomposition and processing of organic waste;
- Enhances the process of humus formation;
- Prevents the formation of crust on the soil surface;
- Reduces surface runoffs and erosion risks;
- Higher rate of soil recovery compared to the soil degradation rates;
- Reduces rapid temperature changes on and beneath the soil surface;
- Creates better conditions for root system development and plant growth;
- As a result of the decomposition of plant wastes in the mulch and the activity of microorganisms in the soil, nutritious macro-and microelements become available, which ensure normal growth and development of the plant.

PLANTING WINDBREAKS

According to the climatic data, Tsalka municipality is characterized by strong (≥ 15 m/sec). Extremely strong winds (≥ 25 m/sec) occur relatively rarely. According to the future climate projections, the average wind speed tends to increase slightly. Consequently, the protection of arable lands from the impact of winds will become even more important.

Recommended trees species for windbreaks on irrigated areas include: Oriental oak, Canadian poplar, birch, Caucasian pine, European spruce, Caucasian maple.

Oriental oak, Caucasian maple, birch, and Caucasian pine can be used for windbreaks to be planed on unirrigated areas.

The importance of windbreaks

- Reduces wind speed and the risk of wind erosion;
- Protects crops and plantations;
- Reduces crop losses;
- Reduces sharp fluctuations of air and soil temperatures;
- Protects the soil from drying out;
- Creates a beneficial habitat for insects and birds;
- Provides shade for cattle in hot weather.

FERTILIZATION OF ARABLE LANDS IN THE FACE OF CLIMATE CHANGE

Soil fertilization on arable lands should be based on the results of soil fertility studies and the needs of a particular crop. According to the climate change projections for Tsalka Municipality, mean and maximum temperatures are expected to increase, which, in case of proper supply of moisture, which is expected for the next 30 years, will strengthen the process of decomposition of soil organic matter (humus) over time and accelerate the process of gradual reduction in minerals accumulated over tens and hundreds of years, which may destroy the balance between humus accumulation and mineralization. Therefore, this gap should be filled by the regular application of organic fertilizers. The rate of application of organic fertilizers is determined by the crop and the content of organic matter in the soil and is calculated according to the type of fertilizer to be applied and its chemical composition. In case of using cattle manure, the rate varies from 20 to 50 tons per ha and has to be applied once in 3-4 years. Manure should be immediately ploughed into the soil to minimize the loss of nutrients, especially nitrogen.

Like organic fertilizers, the need for mineral fertilizers and relevant rates should be accurately determined. If mineral fertilizers are applied on the surface, they should be ploughed into the soil. It is also possible to introduce fertilizers directly into the soil by using agricultural machinery for example, during sowing.

Proud to be diverse!

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