IMPACT OF CLIMATE CHANGE ON LIVELIHOODS AND FOOD SECURITY IN ARMENIA

CLEAR | Consolidated Livelihood Exercise for Analyzing Resilience

UN WFP World Food Programme

PRISMA RESEARCH AND ANALYSIS

Contents

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Abbreviations

CC	Climate change
CLEAR	Consolidated Livelihoods Exercise for Analyzing Resilience
FGD	Focus Group Discussion
HH	Household
KII	Key Informant Interview
NAP	National Adaptation Plan
RA	Republic of Armenia
WFP	World Food Programme

Executive Summary

Climate change is a complex issue that poses a worldwide threat to human development and requires ambitious and bold collective actions. Numerous assessments[1] indicate that there will be significant change in Armenia's climate over the next century: temperatures will rise; precipitation, river flow and lake levels will fall; and heat waves, droughts, landslides, mudflows, and floods will become more common.

These climatic changes will, in turn, impact the economy and specifically the agricultural sector in Armenia affecting business revenues, jobs, household income and food security. The economic impact of climate change will also include food shortages and increased food prices[2]. Immediate actions on adaptation measures are necessary in order to reduce the negative effects of the climate change on Armenian families, their livelihoods[3], and the economy, in general.

Complementing the existing evidence on climate change adaptation in Armenia, WFP proposed to carry out a Consolidated Livelihood Exercise for Analyzing Resilience (CLEAR). The CLEAR study assesses the ability of households to cope with the climate risks as well as the impact of predicted climate change on livelihoods and food security.

The **objectives** of the CLEAR analysis are:

- to contribute to designing targeted resilience and/or climate change adaptation activities by WFP, the Government, and other stakeholders.
- informing existing livelihood programmes of climate risks by shedding light on how current and future climate risks are affecting vulnerable people.
- providing a climate lens to livelihood and food security monitoring and early warning systems.
- serving as an emergency preparedness tool and a policy advisory and advocacy tool for the Government.
- providing recommendations on how to best strengthen household resilience towards climate risks when needed.

Methodology

The CLEAR analysis is focused on rural and peri-urban areas of Armenia. Yerevan, where livelihood sources are less climate sensitive and more diversified, is excluded from the analysis.

The CLEAR methodology is designed around the identification and analysis of a) the main sources of livelihoods, b) the level of resilience of settlements, c) the impact of current and predicted climate risks on the household food security and livelihoods.

The CLEAR analysis employed a mixed method of primary and secondary data collection and analysis. The methods applied included desk research, focus group discussions, regional meetings and key informant interviews.

The contextualized CLEAR methodology for Armenia was divided into four main components – 1) Livelihood zone mapping; 2) Resilience ranking of the zones and settlements; 3) Climate projections; 4) Mapping of climate change impact on livelihoods and food security.

Key findings

[1] Climate change: Impacts, vulnerabilities and adaptation in developing countries, United Nations Framework Convention on Climate Change (UNFCCC), 2007, The Socio-Economic Impact of Climate Change in Armenia, UNDP, 2009, Social snapshot and Poverty in Armenia, Statistical committee of RA, 2021, Climate risk and vulnerability assessment (CRVA) report, UNDP, Green climate fund, Ministry of Environment, CARD, 2021

[2] Fourth National Communication on Climate Change. Yerevan, RA Ministry of Environment, UNDP Armenia, 2020

[3] Livelihood zone is an area within which people share broadly the same pattern of livelihood, including options for obtaining food and income and market opportunities.

Based on the livelihood zones mapping 7 livelihood zones were identified[4] in Armenia. The zones are grouped based on the level of livelihood dependency on agriculture, meaning that the 1st zone has the biggest dependency and 7th zone, respectively, the smallest. These zones are spread all over the country without clear geographic borders and are sharing similar patterns of livelihood and other characteristics.

The ranking of the resilience level of settlements and the livelihood zones to the external shocks, including the climate change, was done. Resilience index was calculated for each of 876 settlements and per livelihood zone. The settlements were distributed into 4 clusters based on their level of resilience. As a result, 303 settlements were found to have high resilience, 272 - moderate, 177 - low to moderate and 124 - low resilience.

To further estimate the vulnerability of settlements towards climate change, the expected changes in the temperature, mean annual precipitation, and river flow for the 50 years' perspective were considered[5]. As a result of cluster analysis, 3 clusters were created – cluster 1 includes 186 settlements where high climate change will be observed, cluster 2 includes 507 settlements where moderate climate change will be observed, cluster 3 includes 183 settlements where low climate change will be observed.

The analysis of impact of projected climate change on various types of agricultural production and animal husbandry as well as on the livelihoods and food security of the population showed that 138 settlements is under high impact, 325 settlements - high to moderate impact, 270 settlements - moderate impact and 143 settlements - low impact.

The regions that will be highly impacted by climate change are Ararat, Tavush and Armavir. The lowest impact is seen in Gegharkunik, Vayots Dzor and Shirak regions.

Overall, all climate change clusters will have negative effect on agriculture. Among the negative effects for various crops the evaporation from the soil, decreased level of ground-waters, reduction of photosynthesis resulting in flower bud abortion, the growth of pest population, risk for fungal diseases and epidemics, shift in crop production season and in dormancy period, crop freeze, reduction in yield quality and quantity, as well as decrease in the number of cattle are predicted. On the other hand, due to the described climate changes, the geography of fruit and vegetable growing will change in the country. Some marzes will become more favourable for crops that were not common there.

Recommendations

Based on the findings, the recommendations are drawn to improve the governance and policy, water management, strategies for horticulture and strategies for animal husbandry.

Governance and policy: It is recommended that the Government and donors direct their efforts to promote income diversification in settlements that are categorized as "high impact", to build the capacities of farmers to the necessary changes of the agricultural activities expected as a result of the climate change, as well as expand the coverage of the agricultural insurance, raise awareness of farmers on its benefits.

Water management: It is recommended that water management systems are improved including artesian waters, installation, and renovation of irrigation systems, introducing water collection systems may reduce climate change impact in the settlements.

[4] The statistical cluster quality was estimated "good", the average silhouette4 was 0.6. The quality of clustering is measured through average silhouette which determines how well each object lies within its
cluster. The average silhouette score varies between -1 and 1.

[5] Data for the analysis was gained from the Hydrometeorology and Monitoring SNCO of the Ministry of Environment and has also been used in the preparation of Fourth National Report on Climate Change (2020).

Strategies for horticulture: Cultivation of new crops and breeding livestock more adapted to climate change, construction of greenhouses, installation of anti-hail stations, introduction of new agro-techniques, and consultancy.

Strategies for animal husbandry: It is recommended to diversify the crops, improve the access to remote pastures through improving infrastructures, and introduce insurance for animals from negative impact of the extreme meteorological and climate events.

Introduction

Climate change is a complex issue that poses a worldwide threat to human development and requires ambitious and bold collective actions. To cope with the climate change crisis, the international community adopted the Paris Agreement in December 2015, which entered into force in November 2016. The Armenian Parliament ratified the Paris Agreement in 2017 and, jointly with all signatory countries, works to limit and reduce greenhouse gas emissions[6].

Numerous assessments[7] indicate that there will be significant change in Armenia's climate over the next century: temperatures will rise on average by 4^0 by 2070; precipitation, river flow, lake and artesian water levels will fall; and heat waves, stronger winds, droughts, landslides, mudflows, and floods will occur more frequently. These climatic changes will in turn impact the agricultural sector in Armenia: over the next 100 years, it is expected to see increased soil water deficit by 25-30%; reduced productivity of irrigated land by about 24%; degraded lands and pastures[8]. In addition to the reduced productivity of irrigated lands, inefficient water management practices and water losses are also of great concern especially for the agriculture sector. Moreover, climate change is likely to cause a decrease in overall pasture area and in pasture yield by 7-10%; decrease in fodder production volumes, and crop yield decline by 8-14% by 2030.

Climate change is expected to have serious economic impact in Armenia affecting business revenues, jobs, household income and consumption in general. The economic impact of climate change will also include food shortages and increased food prices as agricultural productivity falters[9].

Unless immediate action is taken on large-scale adaptation measures, it is unlikely that Armenian families, their livelihoods[10], or the economy will be unscathed by climate change. Armenia's poor and especially rural poor population is particularly vulnerable to the effects of climate change and concrete action aimed at preparing the communities to adapt, respond to and recover from climate shocks are critical.

The Government of Armenia introduced a National Adaptation Plan (NAP) in 2021 which sets out the strategic framework for climate change adaptation in Armenia and defines efforts towards national adaptation plans.

In the framework of the NAP, a common evidence base on climate change is planned to be developed to serve as a reference for stakeholders when designing strategies and projects. Therefore, climate risk and vulnerability assessments will be conducted on a periodical basis to enable setting implementable, concrete measures, identified by multiple stakeholders, that are essential for reducing current and projected climate change impact. Two regional vulnerability baseline assessments have already been conducted in Shirak and Tavush marzes.

With the recently increased attention given to the climate change issues in Armenia, several studies analyzing climate risks, predicting the scale of the climate change, and assessing its impact on agriculture and the environment have been carried out by various national and international actors. This analysis, among other things, have been leveraged to inform the NAP and relevant policies of the Republic of Armenia (RA), as well as targeted programmes and projects implemented by stakeholders. However, none of the studies has specifically covered the livelihood and food security aspects of the expected changes.

[6] Fourth National Communication on Climate Change. Yerevan, RA Ministry of Environment, UNDP Armenia, 2020

[7] Climate change: Impacts, vulnerabilities and adaptation in developing countries, United Nations Framework Convention on Climate Change (UNFCCC), 2007, The Socio-Economic Impact of Climate Change in Armenia, UNDP, 2009, Social snapshot and Poverty in Armenia, Statistical committee of RA, 2021, Climate risk and vulnerability assessment (CRVA) report, UNDP, Green climate fund, Ministry of Environment, CARD, 2021

[8] http://documents.worldbank.org/curated/en/2600514682%2021982009/pdf/733320WP0ARMEN00Armenia0Jun20Arm.pdf

[9] Fourth National Communication on Climate Change. Yerevan, RA Ministry of Environment, UNDP Armenia, 2020

[10] Livelihood zone is an area within which people share broadly the same pattern of livelihood, including options for obtaining food and income and market opportunities

Complementing the existing evidence on climate change adaptation in Armenia, WFP proposed to carry out a Consolidated Livelihood Exercise for Analyzing Resilience (CLEAR). The CLEAR study assesses the ability of households to cope with the climate risks as well as the impact of predicted climate change on livelihoods and food security.

Assessment objectives and coverage

The **objectives** of the CLEAR analysis are:

- to contribute to designing targeted resilience and/or climate change adaptation activities by WFP, the Government and other stakeholders.
- informing existing livelihood programmes of climate risks by shedding light on how current and future climate risks are affecting vulnerable people.
- providing a climate lens to livelihood and food security monitoring and early warning systems.
- serving as an emergency preparedness tool and a policy advisory and advocacy tool for the Government.
- providing recommendations on how to best strengthen household resilience towards climate risks when needed.

The CLEAR analysis is focused on rural and peri-urban areas of Armenia. Yerevan, where livelihood sources are less climate sensitive and more diversified, is excluded from the analysis. With the exclusion of Yerevan from the analysis, 1,871,600 people or 63 percent of the total population of Armenia is covered through this analysis.

Methodology

Focusing basically on rural and peri-urban areas of Armenia, since these areas are more prone to climate change impact, the CLEAR study methodology is designed around the identification and analysis of a) the main sources of livelihoods, b) the level of resilience of settlements, c) the impact of current and predicted climate risks on the household food security and livelihoods.

The CLEAR analysis employed a mixed method approach of quantitative and qualitative data collection and analysis.

- A comprehensive literature and desk review was conducted through collection and analysis of secondary data on households' sources of income, employment and self-employment sectors, food security levels, socio-economic and vulnerability factors, climate change risks and opportunities, including the vulnerability of water resources, agriculture, natural ecosystems, and biodiversity, etc. (see the list of literature and secondary data in the Annex 1).
- Ten focus group discussions (FGDs) (in chosen settlements from 9 marzes (provinces) with higher and lower vulnerability rates) were conducted with peri-urban and rural community members (geographic, socio-economic group representation and gender balance of participants was ensured) to validate the quantitative data collected, to understand deeper the challenges faced in agriculture and their connection with the climate changes, as well as to hear the community members' suggestions on how to adapt and respond to the climate changes in their communities.
- Ten regional meetings (1 in each Marz of Armenia) were conducted with the participation of regional municipality representatives, community local authorities and public service providers.
- Eight key informant interviews were conducted with experts in agriculture, climate change and other relevant sectors to obtain expert assessment and estimation of the impact of climate change on various types of agriculture and collect evidence-based recommendations of the best adaptation actions to reduce the climate change risks.

CLEAR is an assessment methodology which is contextualized for each country. As a result of consultations with WFP Armenia staff and experts in climate change and agriculture, the slightly localized CLEAR methodology for Armenia was divided into four main components, with the following key questions to be answered. The components are built upon each other, and the final assessment results are reflective of the outcomes of each component.

Table 1: Assessment of Impact of Climate Change on Livelihoods in all rural and peri-urban communities of Armenia

Assessment Component	Key Study Questions	Outcome of the Component
1. Livelihood zone mapping	1.What are the main income sources of the households (HH) which will be primarily impacted by the climate change? 2.To what extent do the HHs depend on these sources? 3.Which settlement groups have similar pattern of livelihood?	1.Grouping of the rural and peri-urban settlements of Armenia that share similar pattern of livelihoods into livelihood zones 2.Maps of the livelihood zones
2. Resilience ranking of the zones and settlements	1.What are the key factors influencing the resilience of the HHs, settlements and marzes? 2.How to calculate the resilience index? 3.Which settlement groups have similar resilience index?	1.Resilience index per settlement/livelihood zone 2.Settlement clusters with similar resilience 3.Maps of the resilience clustering
3. Climate Projections	1.What are the projected temperature changes per settlement? 2.What are the expected changes in precipitation? 3.What are the expected changes in river-flow? 4.What are the climate change clusters in Armenia?	1.Climate change cluster descriptions 2.Maps of the climate change clustering
4. Climate change impact mapping	1.What is the impact of projected climate change on various types of agricultural production and animal husbandry? 2.Which are the communities that will have high, high to moderate, moderate and low impact on the livelihoods linked to the climate change risks? 3.What can be done to reduce the risks and respond to them more efficiently?	1.Settlement clustering based on the level of the impact on livelihoods from the projected climate changes 2.Maps of the clusters Recommendations on adaptation measures

Component 1: Mapping of Livelihood Zones

What are the main income sources of the households which will be primarily impacted by the climate change?

The Fourth National Communication report of Armenia and the 2017 Country Diagnosis by the World Bank[11] state that climate change has the strongest impact on agricultural production and on water availability for agriculture and other sectors. At the same time, the secondary data analyzed in the scope of this assessment showed that the top employment sector for the whole population of the Republic of Armenia and for the rural population specifically is agriculture (22% and 47% respectively), followed by wholesale and retail trade (12%) and education (11%) sectors for the whole population and education (10%) and public administration (10%) sectors for the rural population[12].

Table 2: Top employment sectors for the RA population

Employment sector	Whole population of Armenia	Rural population
Agriculture	22%	47%
Wholesale and retail trade	12%	6%
Education	11%	10%
Manufacturing	10%	6%
Public administration and defence	9%	10%
Construction	7%	7%

Thus, considering that this study is conducted for rural and peri-urban communities of the Republic of Armenia, the assessment concluded that agriculture is the main sector which will be impacted by climate change, and at the same time identified agriculture as the primary source of income for almost half of the population in the mentioned communities. The income is one of the main determinators of the household livelihood and in the context of food security, livelihoods are defined as one of the essential means through which people access food[13]. Hence, it was decided to consider the employment and self-employment level in the agricultural sector as the core indicator for the livelihood zone mapping.

To what extent do the HHs depend on these sources?

As part of the decentralization reforms in Armenia, the Armenian villages (settlements) were consolidated into bigger communities. However, the initial data analysis revealed that the best "level" for livelihood mapping is the settlement (the smallest administrative unit in Armenia)[14], as the livelihood profiles significantly vary from one settlement to another even within the same consolidated community. Data on employment and self-employment level in agricultural sector was collected for all 876 rural and peri-urban settlements of Armenia and the analysis of the extent to which the HH's income is dependent on agricultural activities is presented in the below chart.

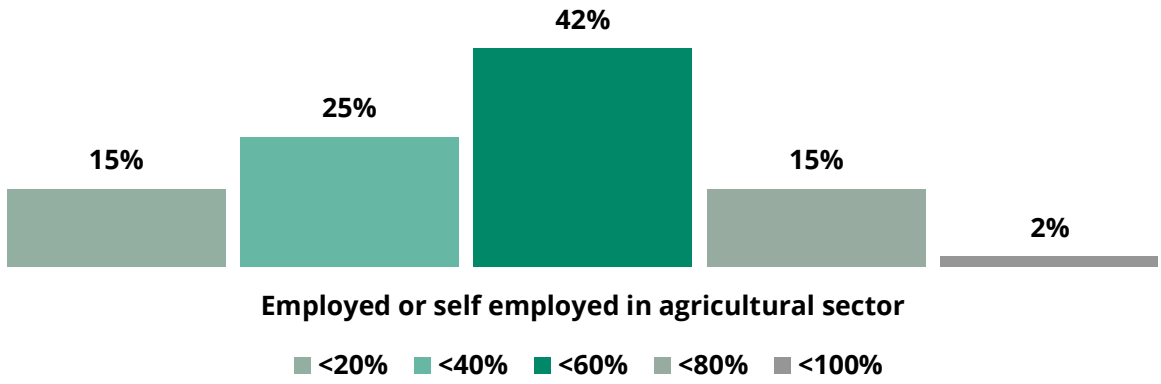
[11] Future Armenia: Connect, Compete, Prosper, a Systematic Country Diagnostic, World Bank, 2017

[12] Statistical Committee of RA, Labor Market in Armenia, 2021, https://www.armstat.am/file/article/lab_market_2021_4.2.pdf

[13] Livelihoods | Famine Early Warning Systems Network (fews.net)

[14] The livelihood mapping included all settlements of RA excluding Yerevan, the capital city.

Figure 1: % of settlements per level of HH income dependency on agriculture



The figure confirms the regional level data, showing that on average about half of the population of the rural and peri-urban settlements is employed and/or self-employed in agricultural sector.

Which settlement groups have similar pattern of livelihood?

From a climate change perspective, it is important to unpack the agricultural profile of the settlement, as different land and crop types may be affected differently by changes. To understand which groups of settlements share similar patterns of livelihood in the context of climate change, secondary data for the following 4 indicators were collected for each settlement and analyzed.

- Employment and self-employment level in agricultural sector (the main indicator);
- Land type (% of arable lands, orchards, vineyards, pastures, grassland)
- Crop type (% of grains, leguminous crops, grape, berries, fruits, vegetables, potatoes, melons)
- Population density.

To delineate livelihood zones, the method of two-step cluster analysis was applied.

At first, cluster analysis was applied for the land types and crop types in order to group similar settlements.

- The land type clustering resulted in two sub-clusters: 1 - arable lands including orchards and vineyards, 2 - pastures including grasslands.
- The crop type clustering resulted in three sub-clusters: 1- grains and leguminous crops, 2 - grapes, fruit and berries, 3 - vegetables including potatoes and melons.

These new sub-clusters of the land type and crop type were used for the final cluster analysis to group the settlements of Armenia based on the **level of livelihood dependency from agriculture** and taking into consideration the **settlement similarities in terms of the population size, land type and crop type**.

As a result, 7 livelihood zones were identified, with the below presented characteristics. The statistical cluster quality was estimated "good", the average silhouette[15] was 0.6.

Table 3: Zones and their descriptions

Zones	Zone description
1	Employment in agriculture: avg. 46%; Population: avg. 1156; Land type: arable; Crop type: grains and leguminous crops
2	Employment in agriculture: avg. 46%; Population: avg. 1377; Land type: pastures and grassland; Crop type: grains and leguminous crops
3	Employment in agriculture: avg. 45.6%; Population: avg. 1856; Land type: arable; Crop type: grape, fruits and berries

[15] The quality of clustering is measured through average silhouette which determines how well each object lies within its cluster. The average silhouette score varies between -1 and 1.

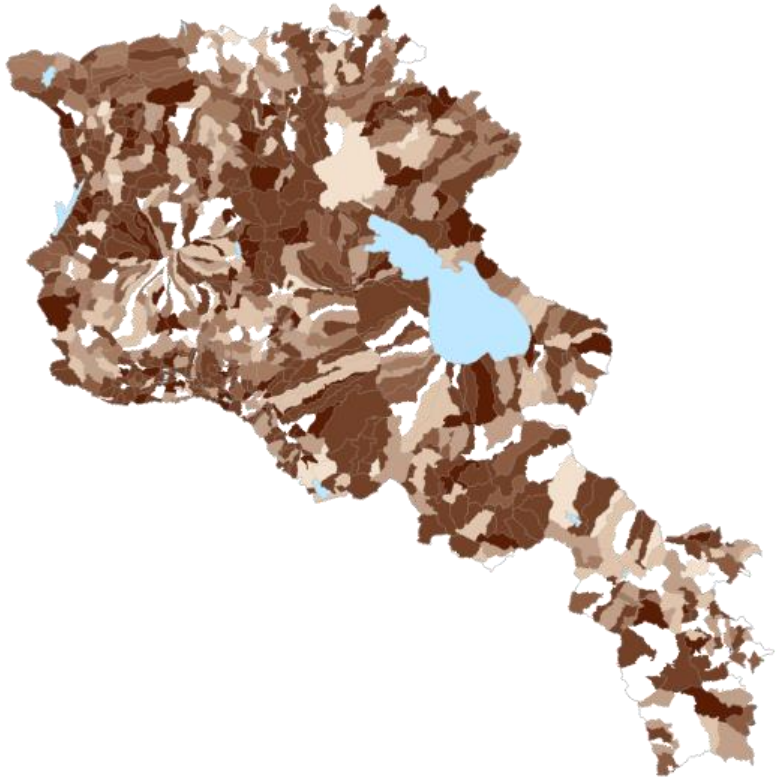
4	Employment in agriculture: avg. 43.6%; Population: avg. 2159; Land type: arable; Crop type: grape, fruits and berries
5	Employment in agriculture: avg. 42.6%; Population: avg. 1491; Land type: pastures and grassland; Crop type: vegetables including potatoes and melons
6	Employment in agriculture: avg. 37.9%; Population: avg. 1809; Land type: pastures and grassland; Crop type: grape, fruits and berries
7	Employment in agriculture: avg. 4.7%; Population: avg. 31315; Land type: mostly pastures and grassland; Crop type: mainly grape, fruits and berries

The Zones are grouped based on the level of livelihood dependency on agriculture, meaning that the 1st zone has the biggest dependency and 7th zone, respectively, the smallest. It should be noted that livelihood zones are spread all over the country without clear geographic borders. These zones are list of settlements representing different marzes of Armenia that share similar patterns of livelihood and other characteristics described above.

The Maps below show the settlements and zones delineation in the scope of the livelihood zoning. Map 1 shows the identified zones by community[16] and Map 2 – by settlement.

[16] For this map and hereinafter do not confuse the term 'community' with consolidated communities of RA.

Map 1: Communities classification based on livelihood zones



Map 2: Communities classification based on livelihood zones (by settlements)

1. Employment in agriculture: avg. 46%; Population: avg. 1156; Land type: arable; Crop type: grains and leguminous crops
2. Employment in agriculture: avg. 46%; Population: avg. 1377; Land type: pastures and grassland; Crop type: grains and leguminous crops
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Livelihood related qualitative data analysis in the context of climate change

In total 10 focus group discussions and 10 regional brainstorming meetings were organized to validate the quantitative data presented above, as well as to learn the stakeholders' perspective on livelihood sources and challenges faced as well as reveal regional specifics of agricultural activities. The summary of the analysis of the qualitative data is presented below.

Overall, according to the findings, the main livelihood source in all marzes is agriculture. Both qualitative findings and statistical data indicate that urban settlements are comparatively less dependent on agriculture and residents of urban settlements have other sources of income such as the service industry, administrative work, tourism, production, manufacturing, mining etc. Specifically, representatives of Kotayk, Lori, Tavush and Syunik marzes mentioned comparatively diverse sources of income such as manufacturing, tourism, mining and construction. Administrative work and work abroad as sources of income were mentioned in all marzes. However, the qualitative data confirm that rural communities in all marzes heavily rely on agriculture.

The main problems and obstacles of the agricultural activities are almost the same across all marzes. High prices of fertilizers, seeds, fuel and agricultural equipment, droughts, hailstorms, poor developed or outworn irrigation system, poor water management system and loss of water, lack of investments, high interest rates for loans, lack of knowledge and skills of farmers on new farming techniques, lack of awareness on agricultural programs, lack of qualified workforce, tensions across the border and poor infrastructure were among the most frequently mentioned problems and obstacles.

The agricultural products are sold to various processing and production companies – diary, canned food, wine, meat factories, dried fruit producers, etc. In addition, some types of products, such as apricots from Ararat and Armavir, potato from Gegharkunik, greenhouse flowers from Kotayk are being exported (mainly to Russia). Yerevan markets and markets in big cities are also consumers of agricultural products. However, for sales of agricultural products, the farmers face challenges such as the low prices of agricultural products, remoteness of the markets and poor developed infrastructure.

The 8 specific types of agricultural activities and challenges faced per Marz are presented in Annex 2.

Component 2: Resilience Ranking of the Zones and Settlements

What are the key factors influencing the resilience of the HHs, settlements and marzes?

The second component of the CLEAR study is focused on the analysis of the level of resilience of the RA settlements to climate shocks. People's resilience to climate shocks is linked with various socio-economic factors, hence, this study selected the following indicators at settlement and marz levels to assess the overall resilience of the settlements.

Settlement level indicators:

- Geographic vulnerability,
- Demographic vulnerability,
- Social vulnerability,
- Economic vulnerability,
- Financial vulnerability,
- Infrastructure vulnerability.

Marz level indicators:

- Poverty rate,
- Food security level,
- Unemployment rate,
- Rate of families in the benefits system,
- Gross agricultural output rate.

Resilience Index Calculation

Since the above indicators show the "negative" aspects of various socio-economic, demographic, geographic and infrastructure factors, while the resilience is the ability of the settlements to cope with the shock, the used formula to measure the resilience index of each settlement is as follows:

Resilience index =1 - (Settlement vulnerability subindex × Marz vulnerability subindex)

Settlement vulnerability subindex

For the settlement vulnerability sub-index measurement, the following sub-indicators were retrieved from the "Review and revision of methodology for assessment and classification of vulnerability of communities and territories" report17. The settlement vulnerability sub-index was calculated by geometrically averaging the scores of the mentioned indicators, using this formula:

$$\text{G. M} = \sqrt[n]{x_1 \times x_2 \times \dots x_n}$$

The Table below shows the variables that comprised each separate indicator mentioned above.

Table 4: Variables that comprised the indicators for the resilience analysis of the settlements

Assessment Component	Key Study Questions
Geographic vulnerability	• Settlement distance from Marz center, km, for both urban and rural communities • Settlement distance from former regional center, km, for rural communities • Settlement distance from Yerevan, km, for urban communities • Settlement disposition to the border
Demographic vulnerability	• Number of populations in the settlement

[17] Asatryan P., Review and revision of methodology for assessment and classification of vulnerability of communities and territories, 2015

Social vulnerability	• Number of 16+ age group actual population having secondary vocational educational level • Number of 16+ age group actual population having higher educational level • Number of 16+ age group actual population in the settlement, people • Number of single not working elderlies (65+) in the settlement – only for rural settlement • Number of families/households receiving family allowances – only for urban settlements • Number of actual households in the settlement, people • Number of 3-6 aged children enrolled in pre-school education (kindergartens and other pre-school establishments) in the settlement • Number of 3-6 aged children in the settlement • Distance (km) of the settlement from the nearest high school, only for rural settlements • Distance (km) of the settlement from the nearest college, for rural and urban settlements • Distance (km) of the settlement from the nearest vocational school, only for urban settlements • Distance (km) of the settlement from the nearest ambulatory/primary health care center – only for rural settlements • Distance (km) of the settlement from the nearest outpatient clinic (adult policlinic) – only for urban settlements
Economic vulnerability	• Total area of irrigated agricultural lands in the settlement – only for rural settlements • Total area of agricultural lands owned by the settlement population - only for urban settlements • Number of heads of cattle in the settlement, owned by settlement residents • Number of operating retail trade centers in the settlement • Number of community-based operating mining, industrial, manufacturing/processing, construction and service enterprises
Fina4ncial vulnerability	• Actual total annual revenues of the settlement administrative budget, 1,000 AMD
Infrastructure vulnerability	• The fact of passing of intercommunity or national public transportation means through the settlement (0-not passing, 1- passing) - only for rural settlements • The length of paved urban road network the settlement, km – only for urban settlements • Availability of operating post office or long/distance/ international phone center in the settlement (1- available, 0- not available) - only for rural settlements • The average daily duration of drinking water supply, hours - only for urban settlements • Number of households in the settlement connected to the centralized gas supply

Marz vulnerability subindex

The Marz level vulnerability subindex is calculated by geometrically averaging the values of the following indicators:

- Poverty rate;
- Food security level;
- Unemployment rate;
- Rate of families in the benefits system;
- Gross agricultural output rate.

The table below shows the vulnerability sub-index per each marz of Armenia, excluding Yerevan.

Table 5: Vulnerability sub-index per marz

Marz name	Vulnerability index
Shirak	0.27
Gegharkunik	0.23
Lori	0.23
Tavush	0.21
Aragatsotn	0.19
Ararat	0.19
Kotayk	0.17
Armavir	0.15
Vayots Dzor	0.15
Syunik	0.10

The settlement vulnerability sub-index and marz vulnerability sub-index per settlement are presented in the Annex 4.

Which settlement groups have similar resilience index?

Final resilience index was calculated for each settlement (see Annex 4), based on which the resilience index was also calculated per livelihood zone, presented in the table below.

Table 6: Resilience index score per livelihood zone

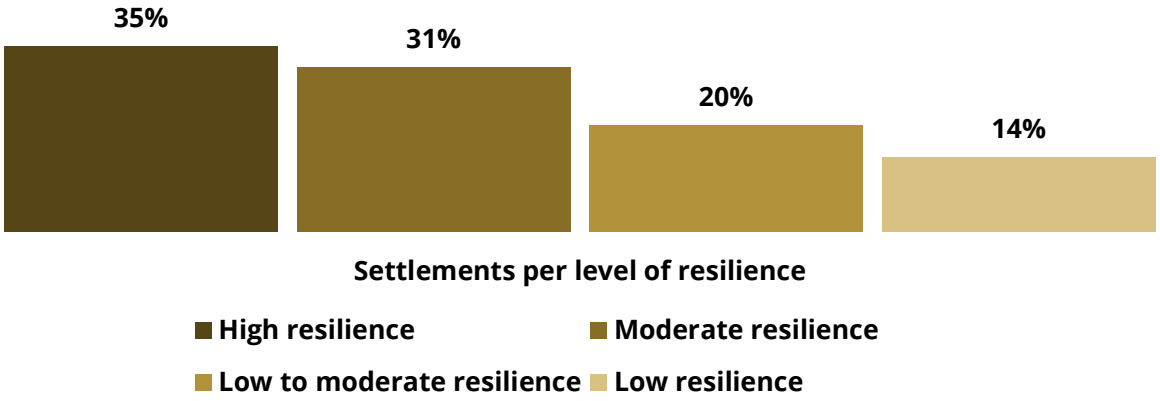
Zones	Zone description	Resilience index
1	Employment in agriculture: avg. 46%; Population: avg. 1156; Land type: arable; Crop type: grains and leguminous crops	0.935
2	Employment in agriculture: avg. 46%; Population: avg. 1377; Land type: pastures and grassland; Crop type: grains and leguminous crops	0.929
3	Employment in agriculture: avg. 45.6%; Population: avg. 1856; Land type: arable; Crop type: grape, fruits and berries	0.950
4	Employment in agriculture: avg. 43.6%; Population: avg. 2159; Land type: arable; Crop type: grape, fruits and berries	0.951
5	Employment in agriculture: avg. 42.6%; Population: avg. 1491; Land type: pastures and grassland; Crop type: vegetables including potatoes and melons	0.933
6	Employment in agriculture: avg. 37.9%; Population: avg. 1809; Land type: pastures and grassland; Crop type: grape, fruits and berries	0.938
7	Employment in agriculture: avg. 4.7%; Population: avg. 31315; Land type: mostly pastures and grassland; Crop type: mainly grape, fruits and berries	0.964

To identify clusters of the settlements with similar resilience indexes, a two-step cluster analysis was applied. The cluster quality was estimated as "good", the average silhouette[18] was 0.6.

As a result, the settlements were distributed into the following 4 clusters (Maps 7 and 8):

- settlements with **high resilience** – average resilience score 0.97, number of settlements 303 out of 876,
- settlements with **moderate resilience** – average resilience score 0.94, number of settlements 272,
- settlements with **low to moderate resilience** – average resilience score 0.92, number of settlements 177,
- settlements with **low resilience – average resilience** score 0.88, number of settlements 124.

Figure 2: % of settlements per level of resilience



[18] The quality of clustering is measured through average silhouette which determines how well each object lies within its cluster. The average silhouette score varies between -1 and 1.

Map 3: Community classification based on resilience level

Map 4: Settlement classification based on resilience level

High resilience

Moderate resilience

Moderate to low resilience

Low resilience

Component 3: Climate Projections

The third component of the analysis is aimed at understanding the climate change projections and associated risks on livelihoods of settlements. This section presents the predictions of changes in climate and its effect on settlement. To estimate the vulnerability of settlements towards climate change, expected changes in the mean annual precipitation, temperature and river flow for the 50 years' perspective were considered[19].

Overall, Armenia is highly susceptible towards climate change across its entire territory. The estimations show that climate change has already significantly influenced different sectors of the economy and thus the livelihood of rural population. Particularly, it is stated that the average annual temperature for the period 1935-2020 has increased by 1.38^0C and the mean annual precipitation has decreased by 14% already[20]. In some years during 2010-2020 the deviation from the norm was 2.7^0C. The rise in the mean summer temperatures is more than the rise in the mean winter temperatures which in turn creates higher demand for water resources to irrigate croplands[21]. That is why along with two climatic parameters, river flow was also considered as the essential parameter to be addressed through CLEAR study.

What are projected temperature changes?

In most of the territory of Armenia, the expected change of temperature will be around 4^0C. Some communities mostly in the western and central parts of Armenia will experience about 2^0C rise, while more areas in the Ararat valley, Vayots Dzor, Tavush and Syunik marzes will experience a rise in temperatures up to 6^0 C. Unfortunately, there will be no settlement with 0 or negative change in the average annual temperature[22].

Considering that the higher increase in the average annual temperature is expected in the main agricultural zones, this will influence the livelihood of rural population more dramatically if adaptation actions will not be employed to address the expected changes. In addition, the expected temperature changes will bring risks such as droughts and forest fires along with the deterioration of soil quality due to erosion, secondary salinization, change in the wilting point and soil moisture capacity. The burden on irrigation systems and thus on the rivers and lentic ecosystems will contribute further on the sharpening of social issues on the entire territory of Armenia and will impact the livelihoods.

The analysis shows that by 2070, 86 settlements are expected to face an expected temperature rise of about 2^0C, 647 settlements will face an increased temperature of about 4^0C and 267 settlements will be subject to temperature increase of about 6^0C[23] (Map 5). The breakdown of this data per marz is presented in Figure 3.

[19] Data for the analysis was gained from the Hydrometeorology and Monitoring SNCO of the Ministry of Environment and has also been used in the preparation of Fourth National Report on Climate Change (2020).

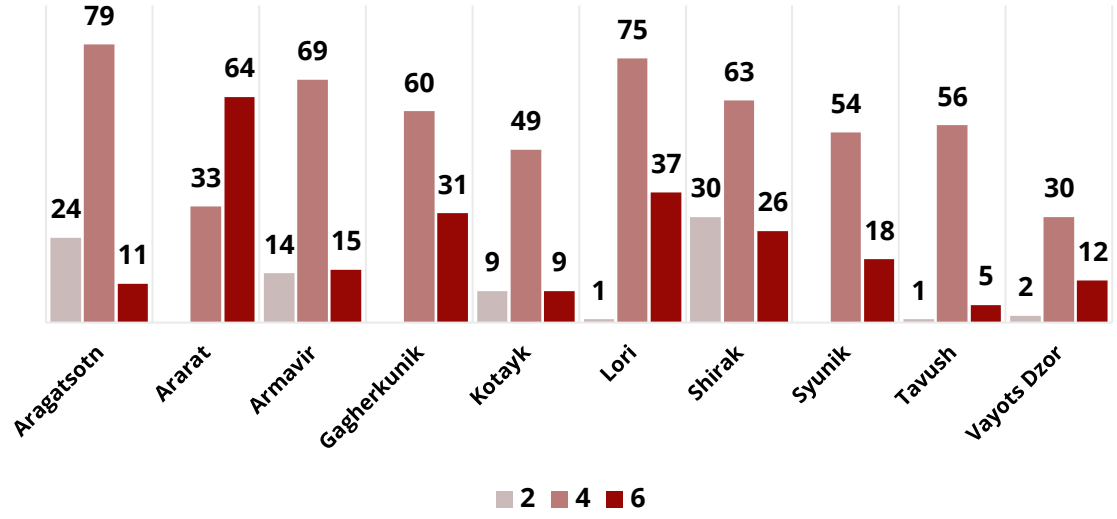
[20] Hydrometeorology and Monitoring Center SNCO of ME Of RA, 2020, Bulletin on the State of the Environment of the RA, http://env.am/storage/files/annual-2020_1.pdf

[21] Data source: Hydrometeorology and Monitoring SNCO of the Ministry of Environment

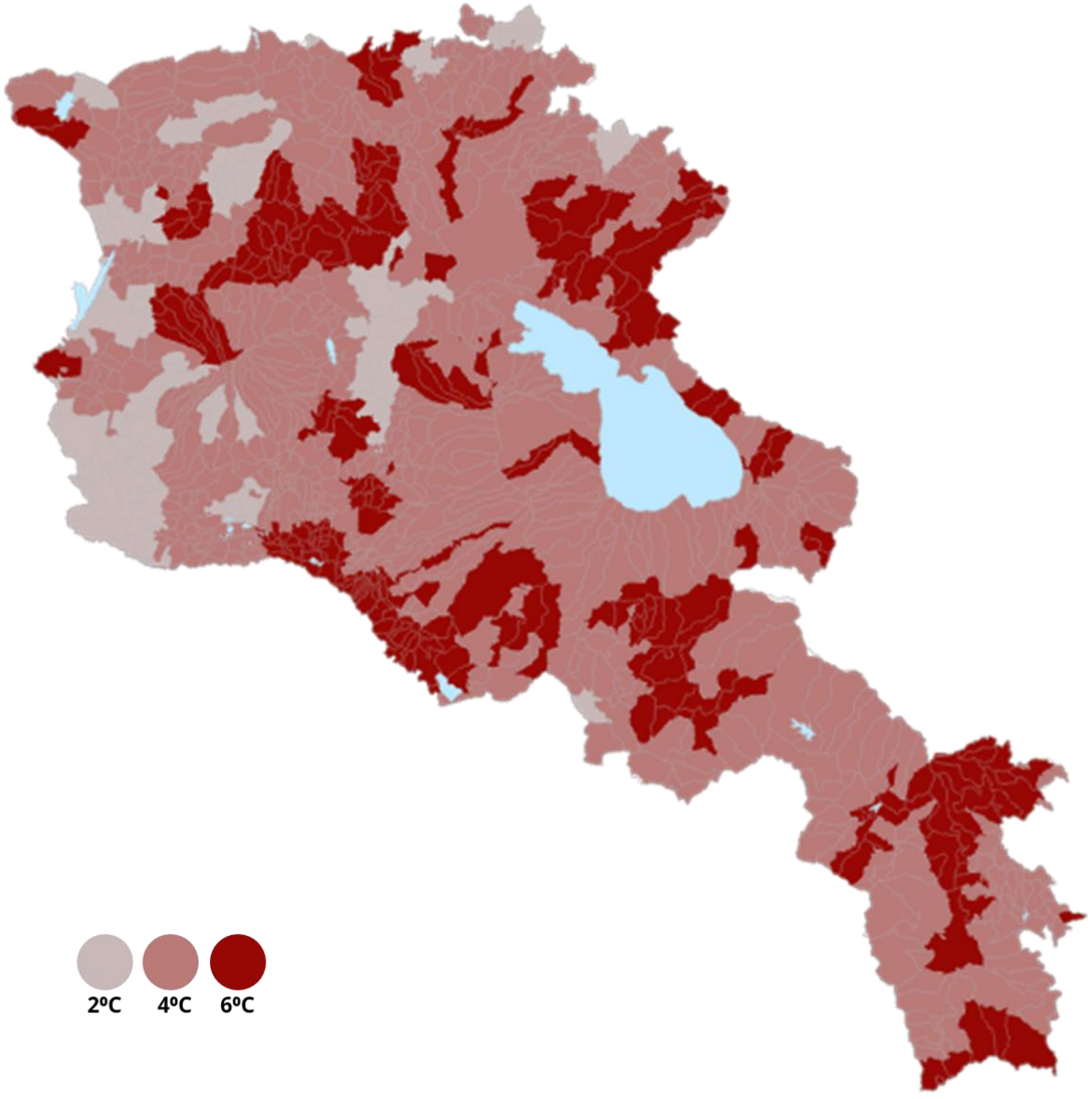
[22] Data source: Hydrometeorology and Monitoring SNCO of the Ministry of Environment

[23] To predict the climate state for the 50 years' perspective we have relied on the same data and analyses like the Government of the Republic of Armenia did when preparing Fourth National Report (2020). Thus, we have used the data from the high resolution METRAS (12x12 km) regional climate model. The model is based on the results of the ACCES, CNRM, MPIM, GFDL global circulation models. Using the METRAS model, projections of average air temperature and precipitation in Armenia were conducted based on different altitude zones, deriving from the RCP8.5 scenario, which is rather pessimistic one. To get the expected temperature change based on the aforementioned scenario, we have compared the expected temperatures for 2070 with the actual temperatures in the territory of Armenia and calculated the difference. Then, we have mapped both the expected average annual temperatures in 2070 for the settlement and community levels and the expected changes in average annual temperatures for the same spatial scale.
Data source: Hydrometeorology and Monitoring SNCO of the Ministry of Environment

Figure 3: Breakdown of expected temperature rise data per marz



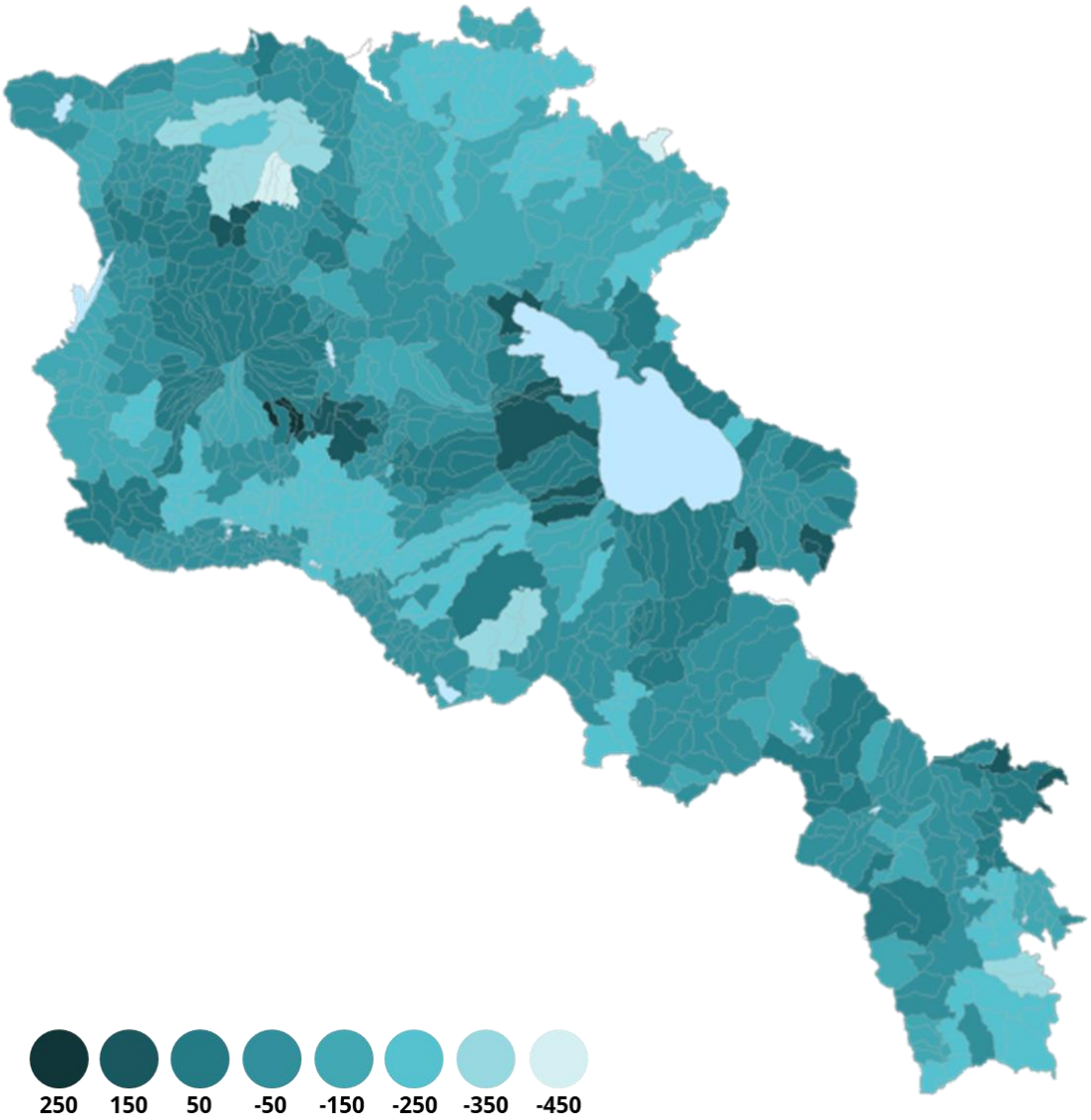
Map 5: Expected change in the average annual temperature (^{0}C) for the 50 years' perspective



What are the expected changes in precipitation?

Another important climatic parameter is the amount of average annual precipitation. It is stated that the average annual precipitation has dropped in the period of 1935-2021[24] everywhere but Shirak plain, Lake Sevan basin and Aparan-Hrazdan regions[25]. Overall, there are 220 settlements where the average annual precipitation will increase or remain the same by 2070[26]. Those settlements are mostly allocated in Shirak, Gegharkunik and Syunik marzes. The highest decrease in precipitation will occur in Tavush and Lori marzes, in the South-East part of the Syunik Marz and in the territory of Ararat valley. The situation is especially critical for Ararat valley - the decrease in precipitation will lead to droughts and thus impact the agricultural production. Ararat valley is currently a strategically important location for agricultural activities in Armenia (the share of gross agricultural output of the valley is 37.7% - the sum of gross agricultural output of Ararat and Armavir marzes[27]) (Map 6).

Map 6: Expected change (mm) in the mean annual precipitation for the 50 years' perspective



[24] Hydrometeorology and Monitoring Center SNCO of ME Of RA, 2021, Bulletin on the State of the Environment of the RA, http://meteomonitoring.am/public/admin/ckfinder/userfiles/files/texekanq/tarekan/Tarekan%202021.pdf

[25] Source: The analysis of climate change data from the Hydrometeorology and Monitoring SNCO of the Ministry of Environment

[26] Like in the case with the temperature parameter, here we also brought the data on the current amount of precipitation and then we juxtapose this data with the expected precipitation from the report and make a database that allows to calculate crude changes for the 50 years' perspective. As it has been expected in most of the cases we conclude on decrease in the mean annual precipitation, which is also negatively contributing in overall livelihood.

[27] ARMSTAT, 2022, Marz Armavir of RA in Figures and Marz Ararat of RA in Figures, https://armstat.am/file/doc/99533608.pdf, https://armstat.am/file/doc/99533673.pdf

What are the expected changes in riverflow?

River-flow is heavily influenced by precipitation and thus, the changes are reflective of the precipitation projections for Armenia. Considering also the areas where no permanent surface flow exists, the rough estimations are concluding that for 471 settlements (almost half of all settlements) located in the drainage basins of the rivers, there will be no decrease in river flow [28].

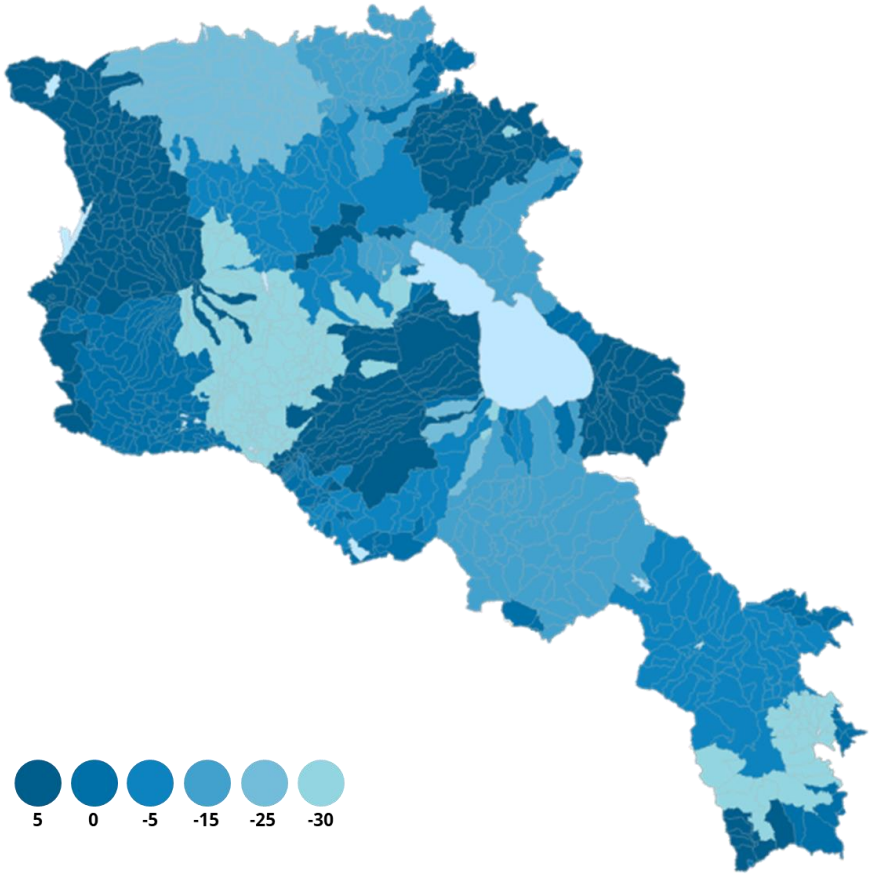
However, the other half of the settlements will see decline in available river water from 5 to 30% within the upcoming 50 years. Considering that those areas are covering most of the Syunik, Vayots Dzor, Kotayk, Lori and Tavush marzes, the decline in the availability and accessibility to river water will have a significant impact on livelihood and food security of the population. On the other hand, the entire territory of Ararat valley is being irrigated mainly from the water derived from Lake Sevan and considering the temperature rise in the Ararat valley, significantly more water should be needed. Because rivers provide with less than 50mln cub m of water to Lake Sevan annually, expected 5% rise in the river flow in the drainage basin of the lake will not address the challenges of decreased precipitation in Ararat valley and the burden on Lake Sevan's ecosystem will increase. The additional stress on Lake Sevan, will negatively impact the livelihoods of Gegharkunik and Armavir marzes. Another problem that the population in Ararat valley will face is the significant decrease of inland (artesian) waters due to the ineffective water management and development of fish-farming facilities established over the past two decades. The artesian water resources have decreased by more than 60% since then[29] (Map 7).

[28] For the assessment of the changes in the river flow on particular settlements we have interpolated the data for estimated rivers into the overall drainage basins and then overlapped spatially with the settlements and communities. Thus, a detailed database was derived where each settlement and community was assigned to the score describing the expected percent change of river flow.

[29] Avetisyan, N., Tadevosyan, L., 2017. How to efficiently utilize water resources in Ararat artesian basin while simultaneously increasing fish production volumes. Bulletin of National University of Architecture and Construction of Armenia, 3 (56), pp. 20-26, in Armenian, http://icare.am/How%20to%20efficiently%20utilize%20water%20resources.pdf

Mkitaryan, A., Musinyan, L., Mirakyan, Sh., Tadevosyan, L., 2018, Feasibility assessment of installation of Recirculating Aquaculture System (RAS) in fish farm operating in Ararat Valley, Armenia. Bulletin of Armenian National Agrarian University, 1(2018), pp 134-138, http://icare.am/3.%20Mkitaryan%20et%20all,%20feasibility%20assessment%20of%20RAS_ANAU.pdf

Map 7:Expected change (mm) in the mean annual precipitation for the 50 years' perspective



What are the climate change clusters in Armenia?

The climate change clusters of settlements were based on the expected changes in the climatic parameters described above – rise in temperature, change in precipitations and change in river flow. Cluster analysis was done which showed that the distribution of the clusters was significant[30]. As a results of the analysis, 3 clusters were identified (Table 7). The climate change clusters identified through the above approach are the following:

Table 7: Final cluster centers for the used parameters in the classification of the livelihood groups

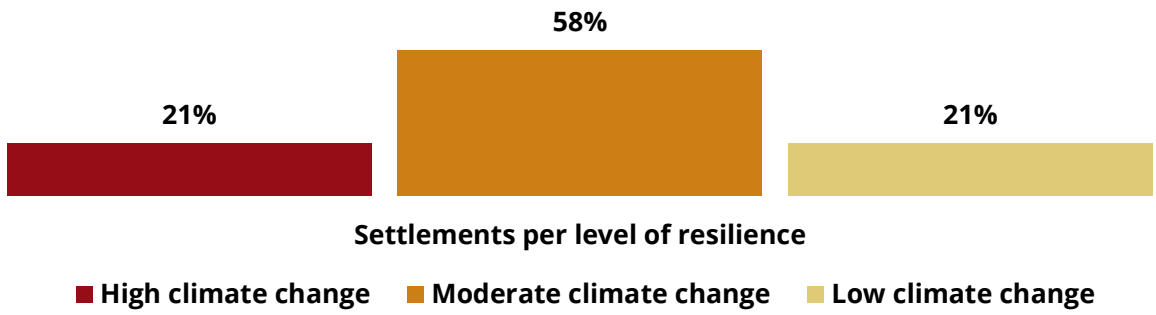
	Cluster 1	Cluster 2	Cluster 3
Expected climate changes	**High climate change**	**Moderate climate change**	**Low climate change**
Expected rise in temperature	4.160	4.410	4.440
Expected change in precipitations	-255.86 mm	-82.26 mm	65.91 mm
Expected change in riverflow	-14.98	-8.98	-6.66

[30] For determination of the clusters, a two-step cluster analysis was applied which gave only one cluster as an output. However, taking into consideration the significance of variations in the mentioned climatic parameters and their possible difference in implications for the livelihood of settlements, another approach was applied.
At first, Hierarchical cluster analysis was conducted, which showed the possibility to determine from 2 to 6 classes (groups) with different proportion of classes in each classification.
Then, K-mean cluster analysis with the ANOVA post-hoc test was conducted to check the significance of input from each of the three variables in each cluster output. Since the significance for all cases (from 2 to 6 classes) was less than 0.05 (meaning that the distribution in clusters was significant), we have looked into the distribution of final cluster centroid values of parameters in each cluster output. Based on that, the expert decision has been made to use 3 cluster output to classify the livelihood risks based on the climate change scenario applied.

According to the results, the main driver of change is the precipitation parameter[31]. As the results indicate, only one group of settlements (group 3) will show some positive change since along with the temperature rise and decrease in river flow increase in precipitation will be expected for those settlements.

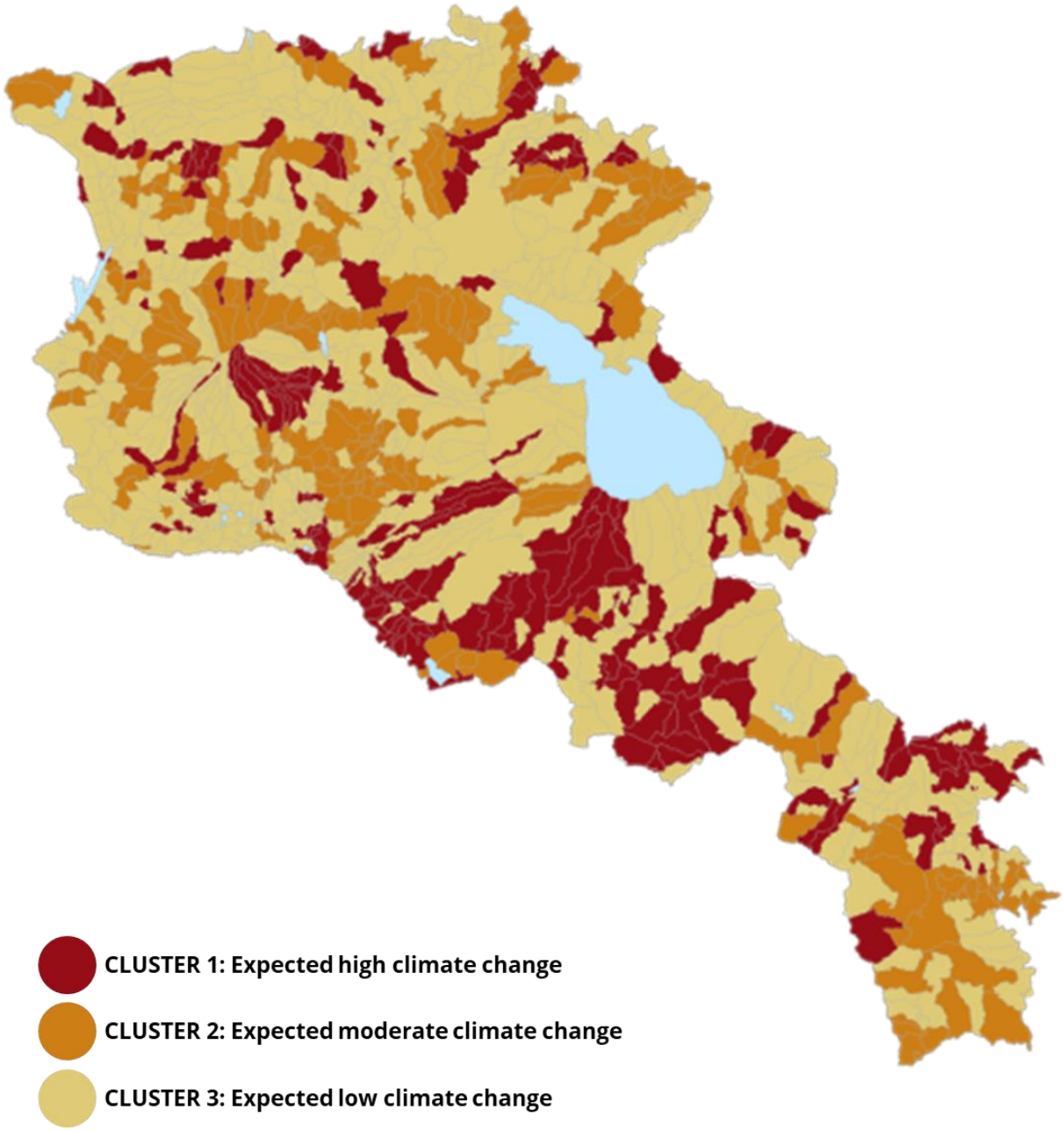
Distribution of the settlements per cluster is shown in the Figure 4 and Map 8 The list of settlements per cluster as well as the expected climate change parameters per settlement are presented in Annex 5.

Figure 4: % of settlements per level of climate change (n=876)



[31] In case of 3 clusters, temperature factor along with the changes in the riverflow do not create major variance but the expected change in the precipitations. Similarly, if we will accept 4-6 clusters output, the variation in expected change in the average annual temperatures and riverflow parameters will not be high. For these reasons it was concluded that the main driver of change is the precipitation parameter.

Map 8: Community classification based on the level of the climate change



Climate Change and its Impact on Agriculture

Expert analysis

Vegetables including melons and potato

Impact, risk description, predictions

Climate change category 1	*Expected rise in temperature 4.16* *Expected change in precipitations -255.86* *Expected change in river flow -14.98*

Most of the vegetables like cucumber and tomatoes as well as melons are mostly grown in Armavir and Ararat Marzes which have high share of irrigated land. Production of vegetables in those regions heavily depend on irrigation.

In the given scenario the ***evaporation from the soil and crop surface will increase*** due to higher temperature, meaning that the crops will *require irrigation more frequently* than before. On the other hand, however, the expected decrease in precipitation and river flows will result in ***decreased levels of ground-waters***, which in some areas of the mentioned Marzes, are the only or major source of irrigation. This will increase *the need for pumping water up more intensively and from deeper depths* having adverse economic and environmental impact. All of this will increase the risk of *desertification* in the area.

Increase of temperature and decrease of precipitation will promote secondary soil salinization and reduce productivity of many agricultural crops, including most vegetables, which are particularly sensitive throughout the ontogeny of the plant.

An increase in temperature in flowering stage can contribute to the ***reduction of photosynthesis,*** *resulting in mostly flower bud abortion*. Drought can result to *osmotic flow out of plant cells and inhibit high respiration and resulting to decrease of vegetable yield*.

Pest population will grow. Due to higher temperature new pests might appear in the area and the development of the existing ones will become more intensive, requiring more intensive pest management measures.

There will be ***reduced risks of development of weeds and diseases*** resulting from the wet soil.

In marzes and communities, where growing season-vegetation period starts later than in Ararat valley have a potential to become suitable for growing the mentioned crops. However other conditions like knowledge, machinery and proper land areas may become bottle necks for organizing production of mentioned crops in these areas with commercial quantities like it is done in Armavir and Ararat Marzes currently.

Potato mostly is cultivated in Shirak and Gegharkunik Marzes and mostly on non-irrigated land plots. Production of potatoes therefore directly depends on the amount of precipitation.

Lower precipitation and higher temperature therefore will directly result in ***decreased potato yield*** quality and quantity. The irrigation sources in the mentioned regions come from higher altitudes and the decreased river flow will also decrease chances for building proper irrigation systems to overcome the climatic challenges described in this scenario.

Potato tubers will lose their qualitative characteristics. If currently they are used for 3 years, a need will rise to change them more frequently.

All other risks related to increased evaporation from soil and plant surface and increased pest population are also associated with potato cultivation.

Climate change category 2	*Expected rise in temperature 4.41* *Expected change in precipitations -82.26* *Expected change in river flow -8.98*

In this scenario the risks described under category 1, exist but are much lower. The shift in agro-ecosystems will become visible in a longer run and again Ararat valley which is the main production area for vegetables will be affected the most. However, the farmers should start tracking and following even the slight deviations for making a shift to more suitable production technologies and to higher heat-tolerant cultivars. The chances for other higher altitude regions are higher to become alternative production area for vegetables so do the protected greenhouse areas.

Stress conditions for the crops will be less as compared to climate change category 1. It will be easier to save the yield; however, serious tracking of climatic shifts and implementation of adaptation measures will be needed.

As in category 1, in this scenario as well increased temperature and decreased precipitation will promote secondary soil salinization and reduce productivity of many agricultural crops, including most vegetables, which are particularly sensitive throughout the ontogeny of the plant. The only difference is that the adverse impact will come a little slower giving more time to react.

Climate change category 3	*Expected rise in temperature 4.44* *Expected change in precipitations 65.91* *Expected change in river flow -6.66*

In this scenario if the increase in precipitation will be mostly in springtime, then ***the root system of the seedlings might not be formed properly***, therefore during later high temperature months more frequent irrigation might be needed. As a result of frequent irrigation or high humidity due to rain, ***risk for fungal diseases will rise***.

Increase of the temperatures can cause faster disease cycles in air borne pathogens and increase their survival due to reduction in frost. The earlier appearance and increase in number of insect populations of viral diseases due to rise in temperature during winter, results ***in increasing diseases of potatoes***. Reduction in frost due to increased average minimum temperatures implies the removal of a limiting factor for pathogens such as ***Fusarium***, which can cause rotting of not only potato but also many vegetables such as eggplants, tomato, pepper, broccoli, etc.

Early spring high precipitation postpones works in the open field and as a result transplanting of seedlings of vegetables and vegetation period.

Production season might shift to later in months and it will become critical to define the right time for planting. The new conditions might require new plant management technologies and skills.

More precipitation and high heat will be stress for the plant, making it weaker and resulting in less yield with bad quality.

If the increased precipitation will be more or less equally through the year, it may have, on the contrary, positive result on vegetable yield.

Grains and leguminous crops

Impact, risk description, predictions

Climate change category 1	*Expected rise in temperature 4.16* *Expected change in precipitations -255.86* *Expected change in river flow -14.98*

Grains and leguminous crops are produced in Shirak, Aragatsotn, Gegharkunik, Kotayk, Lori and Syunik marzes. As these crops are mostly cultivated on non-irrigated areas, they heavily depend on climate conditions and mostly on precipitation. Increase in temperature and reduced

precipitation will have significant negative impact on yield of unirrigated grain production. ***Yield will decrease as a direct result of reduced precipitation***; ***winter crops will freeze due to less snow leading to no yield.*** Prolonged droughts will prolong the fire high-risk season and in case of occurrence the fire may destroy all of the expected yield and the whole field.

Only in few Marzes there is a practice of growing leguminous crops in greenhouses, but this practice is not very common. Usually, beans are grown under greenhouses for soil fertilization. The amount of leguminous crops grown under greenhouses obviously cannot be considered as alternative to the field grown ones, in terms of quantities therefore in this climate conditions the negative impact will go far beyond the farm level and may cause ***food security issues*** for the country.

Spring cereals are usually cultivated for supplying animal husbandry sector. If the yield of grains decreases, ***there will be shortage of fodder for agriculture animals*** and therefore the relevant sectors in agriculture also will be under high risk.

Farmers can consider higher altitudes for cultivation, where however there will be less accessibility for agro-machinery /challenging relief, and soil quality/ etc. Challenge will also arise due to the lack of relevant skills of farmers.

Climate change category 2	*Expected rise in temperature 4.41* *Expected change in precipitations -82.26* *Expected change in river flow -8.98*

All the risks as described in category 1 is applicable to this scenario as well. Because the precipitation will not decrease as much as in the 1st scenario, the risk for frost and fires will be much less.

Climate change category 3	*Expected rise in temperature 4.44* *Expected change in precipitations 65.91* *Expected change in river flow -6.66*

Crop maturing period might shift. Due to high temperature and frequent precipitation, it might be faster. However heavy rains in early spring might ***shift the seeding season*** for spring crops.

There will be an increased risk of ***high number of weeds*** in the field and need for intensive weed management.

In case of increased amount of snow, ***the dormancy period of the crop will be longer*** resulting in ***crops' mechanical damage*** /plant fainting/.

Unexpected heavy rains and increased humidity will ***reduce the yield quality and quantity***.

Grain stagnation and soil erosion are also high risk in category 3 climate change scenario. Increase precipitation may lead to more frequent ***occurrence of hail which possibly may destroy the crops, their yield and the whole fields***, leading to a big economic loss. The cultivation of legumes is also under a big risk in the areas of higher altitude with unirrigated systems of cultivation. Because of ***heavy rains in the beginning of the spring the field work and cultivation season will start late*** and then ***drought through the growing season will decrease the yield of open field legume*** significantly.

Grapes, fruits and berries

Impact, risk description, predictions

Climate change category 1	*Expected rise in temperature 4.16* *Expected change in precipitations -255.86* *Expected change in river flow -14.98*

Grapes, Fruits and Berries with commercial quantities are mostly grown in Ararat, Armavir, Aragatsotn, Vayots Dzor, Kotayk and Tavush Marzes. Some part of Syunik Marz grows

subtropical fruits non-typical for the country. Fruits and grapes are mostly grown in irrigated areas in all Marzes and therefore ***less access to irrigation water resulting from decreased precipitation and river flow will negatively impact the yield quantity and quality.***

High temperature will result in ***more evaporation from fruits surface, lowering its unit weight and damaging its appearance/marketability.***

Pest population will grow. Due to higher temperature new pests might appear in the area and the development of the existing ones will become more intensive. The spread and the geography of pests and diseases will increase because of hot winters spoors of some pathogens such as Oidium for grapes will not die and will start reproduction earlier in the warm spring. This could lead to a higher intensity in labor on the vineyard or an increased use of pesticides.

There will be ***reduced risks for development of weeds and diseases*** resulting from the wet soil.

Because of less snow, there will be increased ***risk for winter frost***. This may completely damage the newly established orchards of fruits and partially the older ones. Grape and Berry orchards are even more vulnerable to winter frosts.

If the temperature is higher than expected at the beginning of winter or in early spring, it will cause ***early flowering of plants, especially fruits, and a loss of yield quantity and quality with the frost event will be experienced afterwards***.

With the regions getting hotter and drier the yield of grapes will be decreased. ***Some regions which are not so favorable for grape production now the yield quality and quantity is likely to increase.*** The increased temperature will also affect the phenology of the grapes and fruits. The ***period of ripening will become shorter*** it will change the whole timing of the orchard management as all the process and works will need to be done in much shorter periods of time.

Berries usually grow best when the relative humidity of air is high. Even though cultivated berries are becoming more common in the country, still big part of berry supplies in the country come from wild collection from forests where it is impossible to manage the new conditions and natural selection will happen only with years, but the existing crops as they are now will be negatively impacted. Reduced berry crops and yields is to be expected in forests.

The increased heat and reduced precipitation will largely impact the berry cultivation in Armavir and Kotayk regions, but it will still be possible to cultivate in Tavush Marz's Noyemberyan and Ijevan regions as the climatic conditions even with the expected changes will remain within acceptable norms for berry cultivation.

Climate change category 2	*Expected rise in temperature 4.41* *Expected change in precipitations -82.26* *Expected change in river flow -8.98*

The risks in this scenario are the same as in climate change category 1.

Unlike the case with grains, leguminous crops and vegetables, the farmers in fruits and berries will not have a chance to restart their business from the next year, therefore slight risks related to climate change will mean losing the farming business for years, requiting high investments to recover.

It is expected that in this scenario some of the berry types like barberry, black and red currant and blueberry will have better yield for example in Shirak marz. With time the geography of the fruit, grape and berry cultivation will also be changed. However, the challenge will be finding the right timing for each agro-technology, starting from planting, fertilizing, pest and disease management, pruning and ending with harvesting seasons.

Enhanced analytical skills of farmers for following the changes and responding to changes will be required. The need for consultancy services will arise.

Climate change category 3	*Expected rise in temperature 4.44* *Expected change in precipitations 65.91* *Expected change in river flow -6.66*

Increased heat and rains for grapes, fruits and berries will mean spread of pests and diseases.

Enhanced precipitation will mean higher than necessary humidity in the air and soil surface. There will be high risk for hail. All of the described conditions will result in ***increased secondary diseases, like botrytis in berries or other fungal diseases***. Hail directly damages the yield or destroys flowers, branches of the crop or leaves depending on season of its occurrence. The mechanical damages of leaves for example can ***result in decreased photosynthesis, which in its tern may leads to low sugar content of the crop.*** **In serious mechanical damages the farmers may lose the yield completely or even the whole orchard especially in case of berries and grapes. Recovery of orchards after such damages may require huge investments and years.**

In this scenario Noyemberyan and Ijevan regions of Tavush Marz will become non-favorable places for berry cultivation. Because of high heat marzes like Armavir also will become less favorable for berries and grapes.

Overall, the geography of fruit and vegetable growing will change in the country. Some marzes will become more favorable but tracking the climate deviations and on-time implementation of the required new agrotechnologies will be problematic for farmers due to lack of skills and access to consultancy. (e.g., As a response to hail damages, even now the farmers use unnecessarily large quantities of herbicides, pesticides and chemical medication to prevent secondary diseases, with that further harming the plants).

Animal husbandry

Impact, risk description, predictions

Climate change category 1	*Expected rise in temperature 4.16* *Expected change in precipitations -255.86* *Expected change in river flow -14.98*

In category 1 climate change scenario the risks for animal husbandry are mainly associated with possible scarce fodder.

Risks related to production of grains and leguminous crops directly relates to animal husbandry sector. Spring cereals are mainly cultivated for animal husbandry sector. The decreased yield of these crops due to climate change will negatively impact the sector as there will be scarcity of fodder. For cattle breeding this will mean ***lower milk and meat yield***. Scarcity in feeding will result in ***decreased heads of cattle*** as the farmers might choose to slaughter the animals rather than shift to other expensive feeding options.

Higher heat and decreased humidity will change the epidemiological conditions, creating ***higher risks of various diseases including new ones***.

The natural pastures will be found in higher altitudes which might not be accessible for farmers and cattle because of infrastructures (housing for farmers and cattle in the pasturelands, proper potable water supplies for cattle).

Climate change category 2	*Expected rise in temperature 4.41* *Expected change in precipitations -82.26* *Expected change in river flow -8.98*

The impact of climate change is already visible on animal husbandry therefore further increase in temperature and decreased precipitation will create the same risks for cattle as described in category 1 climate change.

- ***Scarce fodder and inaccessible natural pastures resulting in low milk and meat yield.***

- ***Higher risks for epidemics, including appearance of new viruses***	
Aside from the mentioned in this scenario we are considering possibility of higher levels of temperature. As the increased temperatures, frequency and intensity of heat waves directly affect livestock health by causing **metabolic disruptions, oxidative stress, and immune suppression causing high risk for infections leading to death**, the mentioned risks are even higher in this scenario.	
Climate change category 3	*Expected rise in temperature 4.44* *Expected change in precipitations 65.91* *Expected change in river flow -6.66*
Increased temperatures, frequency and intensity of heat wave directly affect livestock health by causing **metabolic disruptions, oxidative stress, and immune suppression causing high risk for infections leading to death**.	

Summary of the municipality and community representatives' perspective

Overall, the analysis of the qualitative data shows that all marzes have undergone some changes in climate – increase in temperature and decrease in precipitation has been observed in all marzes. This in its turn had affected the agricultural sector by decreasing the productivity of crops and agricultural products. As it is mentioned, land cultivation has become more challenging for the farmers due to the decline in precipitation, dry weather and lack of water resources. These changes also affected agricultural planning.

According to discussion participants, due to climate changes, various plants ceased to grow in various marzes, however, new types of plants started to be cultivated. For example, crops, more adapted to warmer weather conditions, such as broccoli is now being cultivated in Gegharkunik Marz, oat, bean and walnut in Lori Marz, crops such as kiwi, olives and broccoli in Syunik (Kapan and Meghri) and banana in Tavush marzes, grapes, peach, apricot, blackberry in Kotayk Marz.

The main problem observed by all representatives from all marzes include irrigation systems and water availability issues. Representatives of marzes such as Aragatsotn, Gegharkunik, Lori and Kotayk highlighted the outworn irrigation systems and water loss as a result of it, water decrease due to hotter weather, lack of precipitations and drop of river water levels were mentioned for Vayots Dzor, Syunik, Ararat, Armavir, Shirak and Gegharkunik marzes. Representatives of Tavush Marz also mentioned polluted water of rivers and representatives of Ararat and Armavir marzes pointed out the decrease of artesian waters due to fisheries. This is considered as a serious problem, since the water of fisheries is not circulated and the wastewater is being lost. Another danger for extensively using artesian waters for fisheries is the risk of desertification of the areas. Thus, the main step toward reducing the impact of climate change on communities and household livelihoods is to solve the problem related to irrigation.

According to the community members and Marz administrations, adaptation steps for the described issues can include construction of reservoirs, improvement and optimization of water resources management, and installation of drip irrigation systems.

Other steps for reducing the impact of climate change, pointed out by the participants are the cultivation of crops and breeding livestock that will be adapted to new weather patterns, construction of greenhouses, installation of anti-hail stations, introduction of hydroponics and provision of training and agricultural extension services for local farmers on adapting new agricultural practices.

Only several marz representatives mentioned having implemented adaptation actions to cope with the consequences of climate change. For example, representatives of Vayots Dzor Marz mentioned installation of irrigation system in Areni and construction of water reservoir in Vernashen; anti-hail stations have been installed in Syunik Marz; forest planting programs were implemented in Kotayk Marz; and water resources management improvement program was

implemented in Ararat Marz. A more specific data as well as description of the recommended steps per marz is presented in Annex 3.

Which are the communities that will have high, high to moderate, moderate and low impact on the livelihoods linked to the climate change risks?

As mentioned in the beginning of this report, the CLEAR assessment components builds one on the other. Hence, for defining the level of climate change impact on the livelihood and food security of the population in the settlements, the following factors were considered:

- The livelihood zone of the settlement showing to what extent is the income of the population dependent on agriculture,
- The resilience cluster of the settlement showing to what extent is the settlement able to cope with climate shocks, and
- The climate change cluster of the settlement showing the extent of expected climate change.

As a result, the settlements were categorized through 4 groups: a) high impact; b) high to moderate impact; c) moderate impact, d) low impact. The settlements in each group were distributed based on the various combinations of the above-described factors. Table 11 shows all possible combinations; settlements corresponding to each combination were distributed in respective groups.

Table 8: The impact of climate change on HHs' livelihood and food security matrix

1. High impact High dependency on agriculture + high climate change + low / low to moderate / moderate / high resilience Moderate dependency on agriculture + high climate change + low resilience / low to moderate resilience / moderate resilience	**2. High to moderate impact** High dependency on agriculture + moderate climate change + low / low to moderate / moderate / high resilience Moderate dependency on agriculture + high resilience + high climate change
3. Moderate impact Moderate dependency on agriculture + moderate climate change + low / low to moderate / moderate high resilience High dependency on agriculture + low climate change + low / low to moderate resilience	**4. Low impact** Low / moderate dependency on agriculture+ low climate change + low / low to moderate / moderate / high resilience Low dependency on agriculture + moderate climate change + moderate / high resilience High dependency on agriculture + low climate change + moderate / high resilience Low dependency on agriculture + high resilience + high climate change (cities)

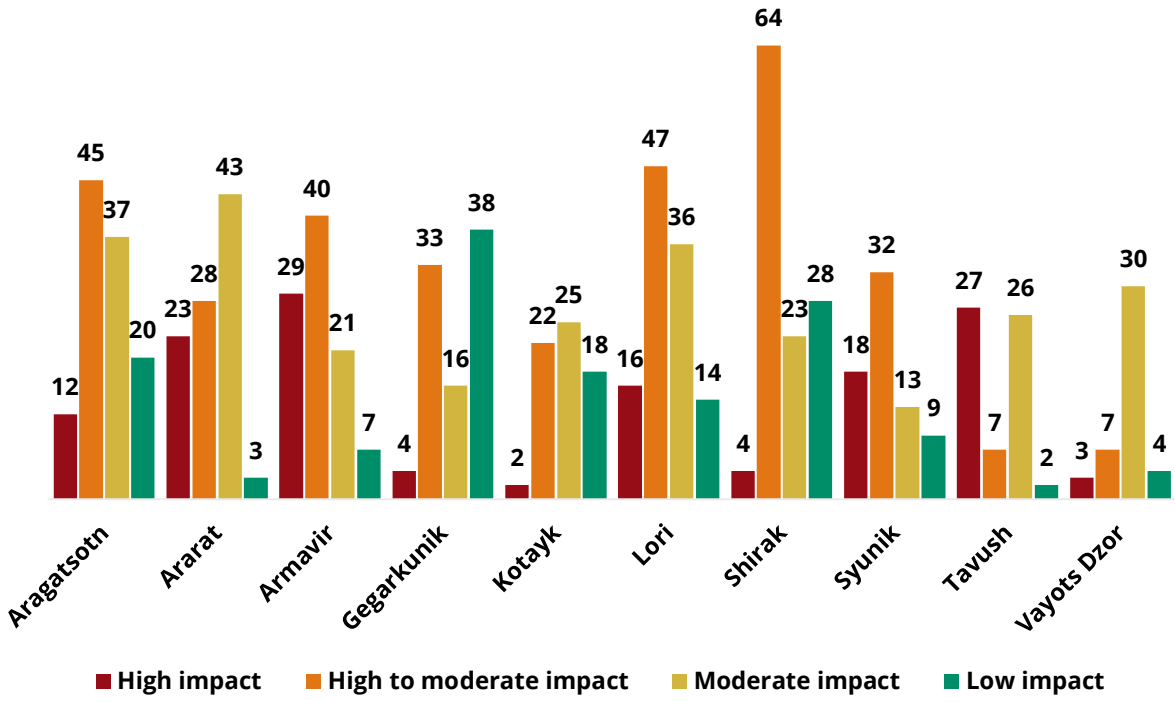
Changes in climate and dependency on agriculture were considered as core factors when distributing settlements among the four groups of impact. The number of settlements in each climate change impact category is presented in the table below. As it can be seen, more than half of the settlements in Armenia will be highly or high to moderately impacted by climate change. The list of settlements per climate change impact are presented in Annex 6.

Table 9: Climate change impact on livelihood and food security of the population

Climate change impact categories	Number of settlements
High impact	138
High to moderate impact	325
Moderate impact	270
Low impact	143

The chart below shows the number of settlements in each climate change impact category per marz. According to the results, marzes that have more settlements the livelihoods and food security of which will be highly impacted by climate change are Armavir, Tavush, Ararat, Syunik and Lori.

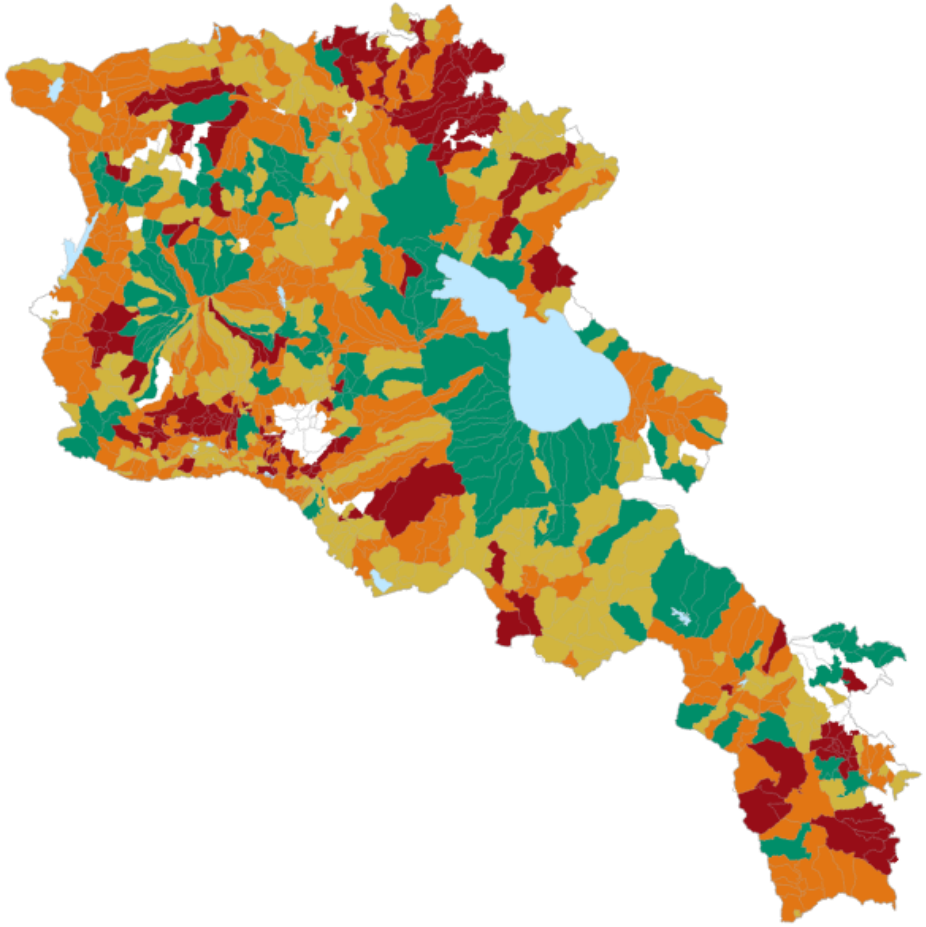
Figure 5: The number of settlements in each climate change impact category per marz



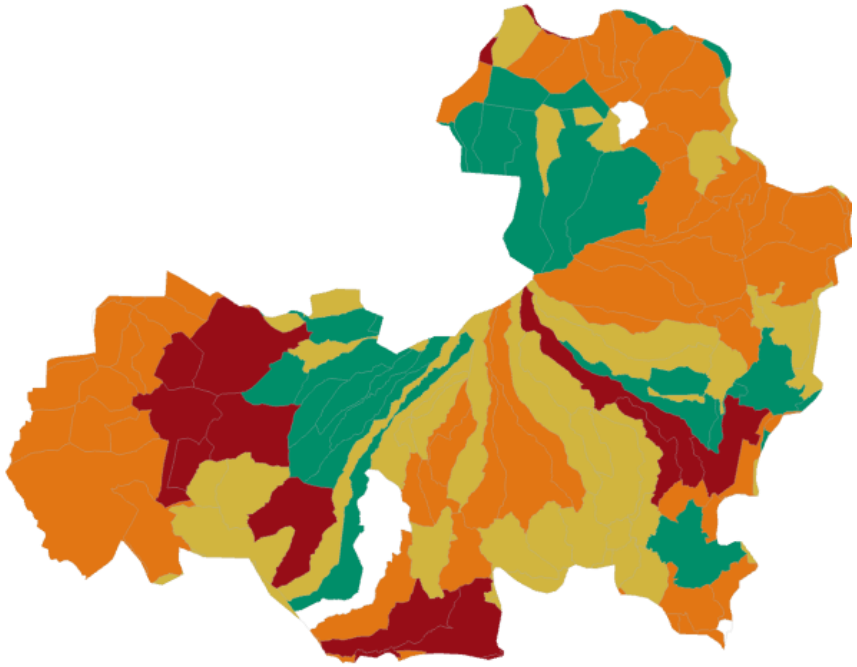
Maps below present the climate change impact categories for the whole country and per each marz separately.

Map 9: The impact of CC on the livelihood and food security of settlements

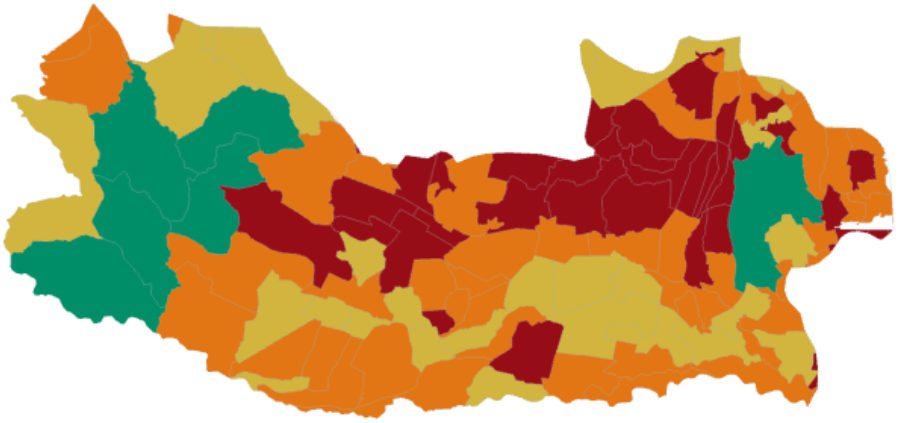
Map 10: The impact of CC on the livelihood and food security of communities



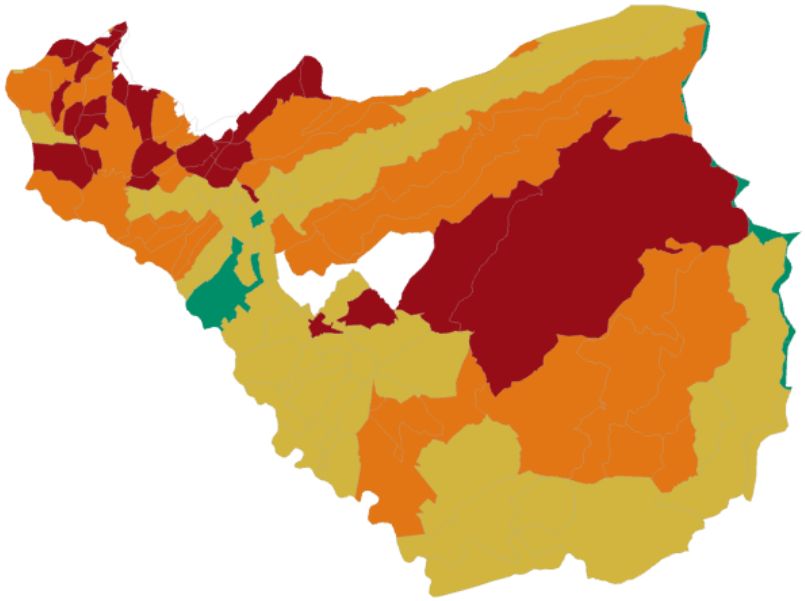
Map 11: The impact of CC on the livelihood and food security, Aragatsotn marz



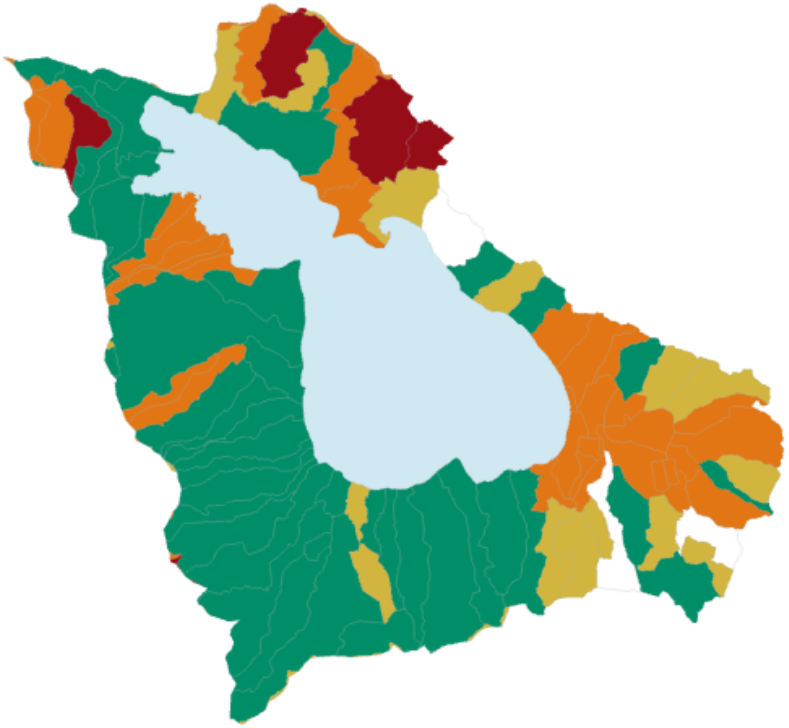
Map 12: The impact of CC on the livelihood and food security, Armavir marz



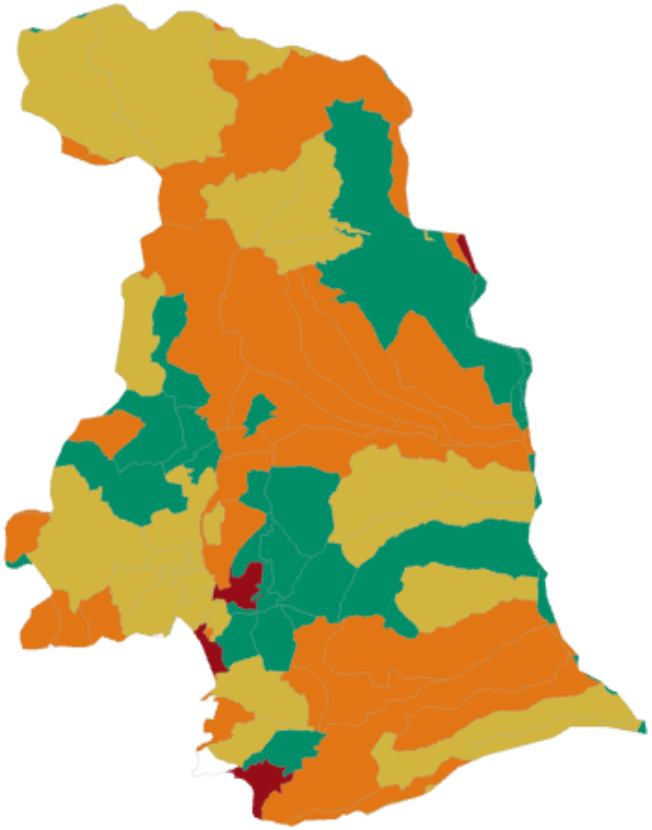
Map 13: The impact of CC on the livelihood and food security, Ararat marz



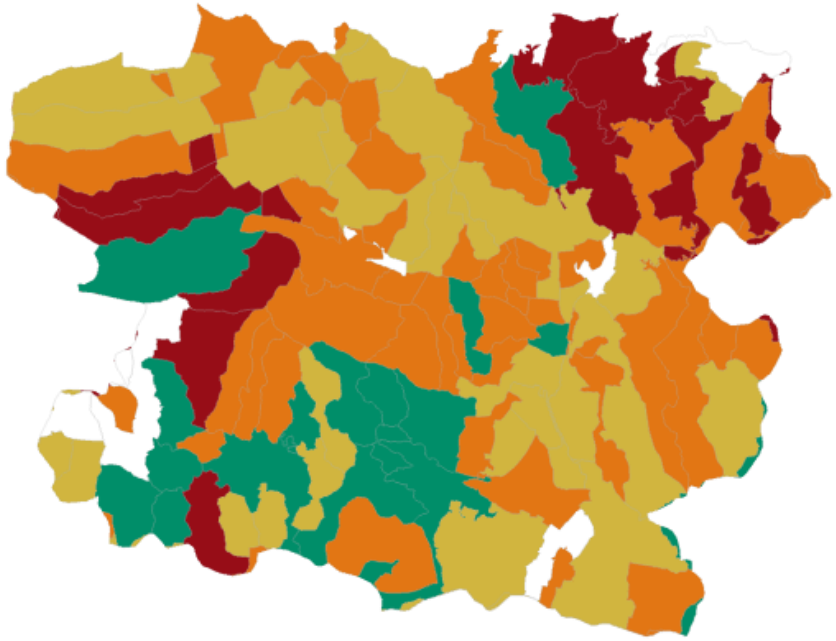
Map 14: The impact of CC on the livelihood and food security, Gegharkunik marz



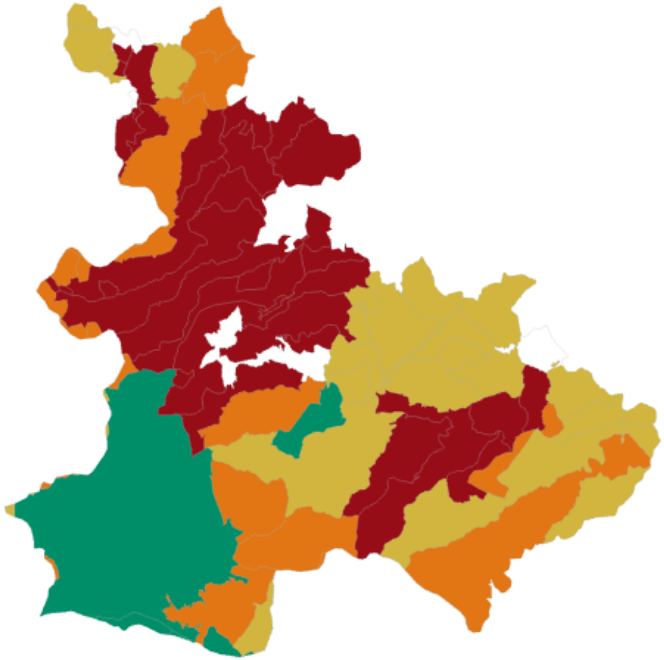
Map 15: The impact of CC on the livelihood and food security, Kotayk marz



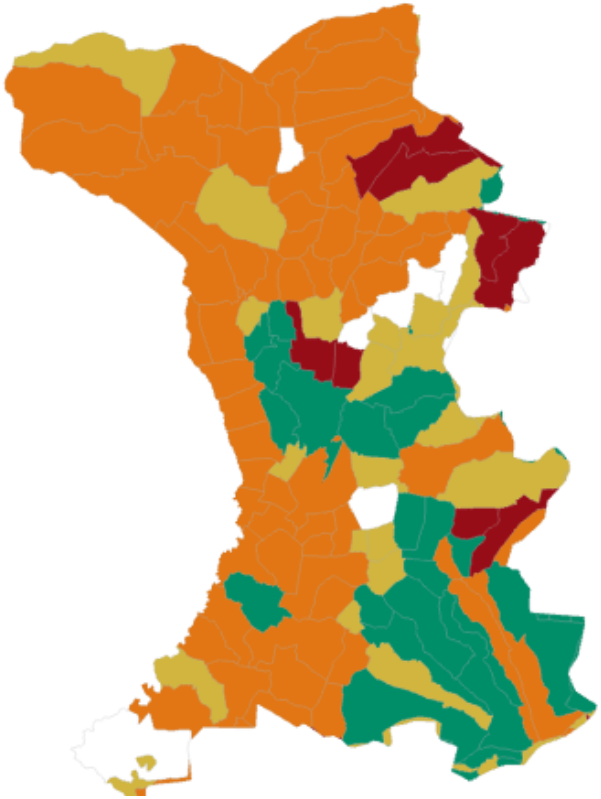
Map 16: The impact of CC on the livelihood and food security, Lori marz



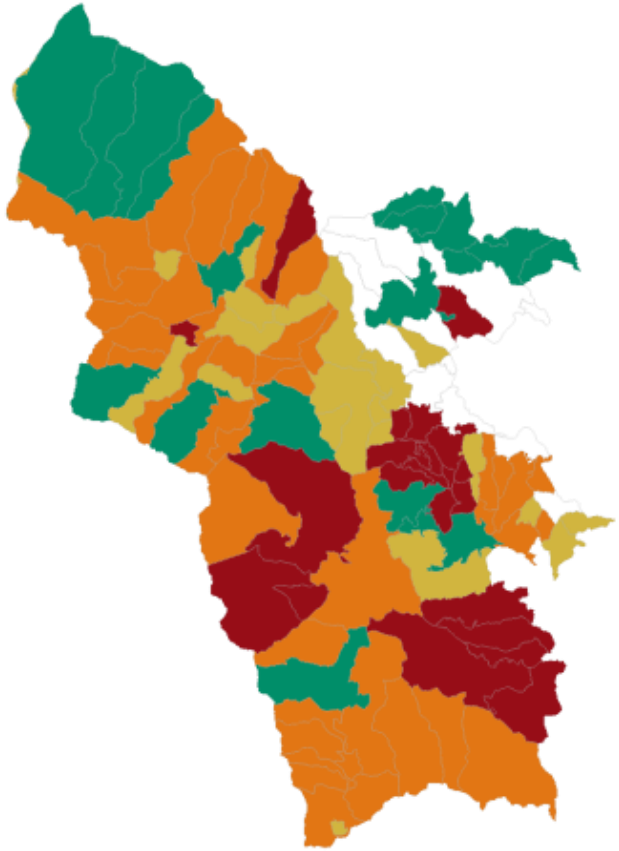
Map 17: The impact of CC on the livelihood and food security, Tavush marz



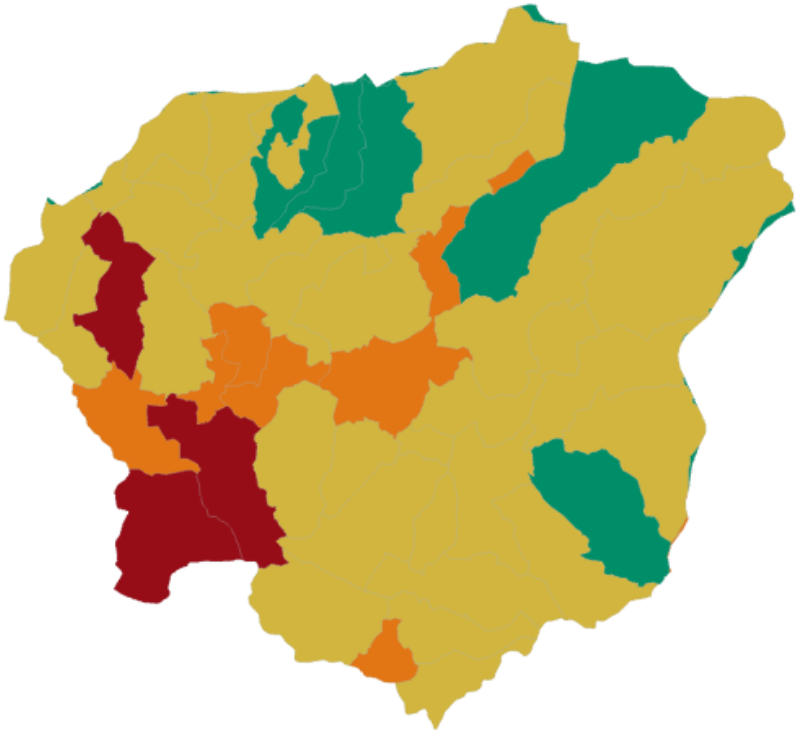
Map 18: The impact of CC on the livelihood and food security, Shirak marz



Map 19: The impact of CC on the livelihood and food security, Syunik marz



Map 20: The impact of CC on the livelihood and food security, Vayots Dzor marz



Recommendations

What can be done to reduce the risks and respond to climate change more efficiently?

The Fourth National Communication on Climate Change report includes various steps and actions that have already been implemented or are in progress to reduce climate change impacts. These steps include legislative reforms aimed at reducing climate change risks on agriculture, Government support through the increase of state budget allocations, institutional reforms, crop insurance programs, installation of hail-protection nets, hail-protection stations, establishment of intensive orchards, replenishment and upgrading of the technical pool of agriculture machinery, development of cattle-breeding though the introduction of new breeds, rehabilitation of pastures, introduction of the best agricultural practices, modernization of technologies, improvement of forecasts of hydrometeorological hazards, improvement of agro-meteorological service, agro-chemical examination of agricultural lands, provision of extension services on field crop farming, horticulture and livestock breeding, collection and study of agricultural monitoring data, programs to improve irrigation, development of water basin management plans considering climate change, assessment of groundwater resources, study related to integrating water resources management, etc.[32].

The Climate Risk and Vulnerability Assessment (CRVA) report within the frames of the National Adaptation Plan also presents adaptability measures for reducing the impact of climate change on agriculture. These measures include the need for knowledge and skills (research) on climate change and its impact, improvement of adaptive capacity of private sector (farmers), adopting of state policies and support programs, compensation or alleviation of damages to farmers, governance and resource management system (accurate and reliable data about land, water and other resources, climate and weather conditions, farmers and markets), strengthening of integrated pest management approaches[33].

In line with the climate change adaptation measures described in the reports mentioned above, the CLEAR study presents below the key recommendations for possible steps that could reduce climate change impact on agriculture and therefore also on the livelihoods of the settlements and their food security levels.

Governance and Policy

- The economic and agricultural policy of the country, as well as state and donor assistance programmes, should promote income diversification in settlements that are categorized as “high impact”.
- State support for import and promotion of new heat tolerant cultivars requiring less irrigation and humidity (e.g., California university is producing samplings which are adapted to expected climatic shifts).
- Prepare (knowledge, skills, equipment, exposure) the farmers to the necessary changes of the agricultural activities expected as a result of the climate change.
- Improve access to markets prioritizing settlements included in the ‘high impact’ category.
- Expand the coverage of the agricultural insurance, raise awareness of farmers on its benefits.

Water management

- Improvement of the effectiveness of the water management system, including shift to multiple use of water, expansion and renovation of irrigation systems, and control over

[32] RA Ministry of Environment, UNDP Armenia, 2020, Republic of Armenia’s Fourth National Communication on Climate Change. Yerevan, pp 87-89, 98-101

[33] CARD, 2021, Climate Risk and Vulnerability Assessment (CRVA) Report in the frames of “National Adaptation Plan to advance medium and long-term adaptation planning in Armenia” project

the underground waters, since water losses are observed due to outworn irrigation systems and ineffective use of artesian water.

- Expansion of reservoirs for water accumulation during non-agriculture season, from rain flows and river flows.
- Support expansion of application of drip irrigation systems, considering that it will ensure minimal evaporation from the soil surface due to high temperature.

Strategies for horticulture

- Introduction and usage of practices and agricultural techniques that will reduce land degradation, will protect the crop and will focus on growing crops that best fit the expected climate change.
- Increase the production in controlled/protected environment (greenhouses, shading nets, hail nets, etc.)
- Usage of agriculture practices that prevent fast evaporation and keep soil moisture (mulching). This can be done by establishing shelter belts for fields to increase soil water holding capacity.
    - Adoption of new strategies in choosing right time for sowing and transplantation of seedlings to adapt to the new high temperature.
- Modification and adaptation of fertilization plans to increase nutrient availability for plants and plant nutrient uptake.
- Usage of grafting for better resistance of vegetables to pathogens, drought and other environmental stresses arising from climate change. Grafting vegetables onto a heat-tolerant rootstock will increase productivity in unfavourable growing conditions.
- Usage of intercropping for increased crop climate resilience, for better pest management and for reduced evaporation from soil surface.
- Introduction of cover cropping systems, green fertilization for slowing soil erosion, improve soil health, enhance water availability etc. (for grains and leguminous crops).
- For a long-term result, introduction of non-tillage system with growing mulching (for grains and leguminous crops).
- Introduction of crop rotation systems for open vegetable fields with the focus of legumes and in salinized areas with licorice to reduce concentration of salt in the soil.
- Integration of new crops in the area in order to disrupt the main host crop chain and the food source of the pests leading to reduction of its population since climate change will also impact on the growth of pest population.
- Introduction of leguminous crop cultivars with shorter vegetation period (cooperation with scientific institutions and gene banks worldwide to find and try the best cultivars for the given new climatic conditions).
- Introduction of vertical farming techniques and High Yielding Varieties of agricultural crops.

Strategies for animal husbandry

- Crop diversification for animal husbandry:
    - Production of crops which provide harvest for more than one time per year, or crops that are (sainfoin, alfa-alfa, clover) nutrient rich, heat, frost and drought tolerant like Jerusalem artichoke.
    - Shift to hydroponic production of fodder.

- Improved access to remote pastures through improving infrastructures:
    - Establishment of water supply on the way to and in the pastures (developing stock watering points, accumulation, storage and use of natural water streams).
    - Improvement of or building roads taking to the new pastures.
    - Establishment of shepherd's accommodation and animal housing conditions in remote pastures.
- Introduction of insurance for animals from negative impact of the extreme meteorological and climate events.
- Animal diversification:
    - Import and introduction of new types of animals which have high resistance to heat and draught.
    - Sheep-breeding especially the current breeds in Armenia should be significantly decreased as they destroy the food stock.
    - Breeding of Caucasian Brown is considered high emission of methane as compared to other breeds. These contribute to climate change; therefore, it is advised to shift to Svic and Holstein breeds of cattle.

Annexes

Annex 1. List of literature and sources of secondary data

Asatryan P., 2015, Review and Revision of Methodology for Assessment and Classification of Vulnerability of Communities and Territories

Database of the Ministry of Territorial Administration and Infrastructure on RA settlements, 2017

Fourth National Report on Climate Change, 2020, http://www.nature-ic.am/Content/announcements/11676/FNC_Eng.pdf, September 7, 2022

Hydrometeorology and Monitoring Center SNCO of ME Of RA, 2020, Bulletin on the State of the Environment of the RA, http://env.am/storage/files/annual-2020_1.pdf

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Livelihoods | Famine Early Warning Systems Network (fews.net)

Statistical Committee of RA, 2021, Labor Market in Armenia, https://www.armstat.am/file/article/lab_market_2021_4.2.pdf

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Statistical Committee of RA, 2021, Social Situation of RA in 2021, Number of Beneficiaries and Average Size of Allowances, https://armstat.am/file/article/soc_sit_2021_en_13.pdf

Statistical Committee of RA, 2021, Social Snapshot and Poverty in Armenia, https://armstat.am/en/?nid=82&id=2438

WFP, 2022, Food Security and Vulnerability Assessment in Armenia: May-June 2022

World Bank, 2017, Future Armenia: Connect, Compete, Prosper, a Systematic Country Diagnostic

Note: Please use Adobe Acrobat to open the attachments

Annex 2. Livelihood of settlements: municipality and community representatives' perspective *(attached)*

Annex 3. Climate change and its impact on agriculture: municipality and community representatives' perspective *(attached)*

Annex 4. Livelihood zone, resilience index, settlement vulnerability sub-index and marz vulnerability sub-index per settlement *(attached)*

Annex 5. Climate change cluster, climate change parameters per settlement *(attached)*

Annex 6. Categorization of climate change impact on livelihood and food security per settlement *(attached)*

THE CLEAR REPORT

Impact of Climate Change on Livelihoods and Food Security in Armenia

CLEAR study can serve as a solid evidence for:

- Targeting and designing resilience and/or climate change adaptation activities carried out by WFP, the government and other stakeholders.
- Considering climate change adaptation and mitigation activities when designing the community development plans and budgets to capture the settlements with high impact of climate.
- Informing existing livelihood programmes of climate risks by shedding light on how current and future climate risks affect vulnerable people.
- Providing a climate lens to food security monitoring and early warning systems.
- Serving as an emergency preparedness tool and a policy advisory and advocacy tool for the Government of the Republic of Armenia.

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