Training Manual

Integrating social dimensions into agri-climate change adaptations

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Sveti Nikole, 2024

НАЦИОНАЛНА АГЕНЦИЈА ЗА ЕВРОПСКИ ОБРАЗОВНИ ПРОГРАМИ И МОБИЛНОСТ
EURASIA INSTITUTE
omnia RESEARCH | TECHNOLOGY | DEVELOPMENT
Funded by the European Union

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Publisher:
Association of secondary schools “Tera-Fiton-Animal”

This training manual was done as part of the Erasmus+ project “Integrating social dimensions into agri-climate change adaptations”- 2022-1-MK01-KA220-ADU-000086031.

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Project website:
https://agriclimate.eu/

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Foreword

The manual is intended for training farmers on Integrating social dimensions in the adaptation of agriculture to climate change. The manual was made as part of the Erasmus+ project " Integrating social dimensions into agri-climate change adaptations"- 2022-1-MK01-KA220-ADU-000086031.
The basis for the preparation of the manual is the Training Programme " Integrating social dimensions into agri-climate change adaptations", which was previously prepared within the framework of the project.
The manual includes contents that will enable the participants to acquire knowledge, skills and competencies for:
- sharing information about climate change;
- identifying social drivers and vulnerabilities;
- differentiation of agricultural techniques;
- assessing the impact of climate change on health, food and farm size;
- explanation of mitigation measures and adaptation of agriculture to climate change;
- description of local agricultural practices;
- determination of practical measures to deal with climate effects.

Seven modules are covered in the manual:

- General information about climate change
- Social drivers and vulnerabilities
- Agricultural technologies
- Impacts on health, food and farm size
- Mitigation and adaptation measures
- Local agricultural practices
- Practical handling of climate effects

Each module deals with content that should be implemented in the classroom and on the farm. In this way, the acquired knowledge will be easily applicable in practice and will represent a starting point for the application of practical measures to deal with climate change.

We hope that the processed contents of the participants will represent a starting point for deepening the acquired knowledge and skills in the integration of social dimensions in the adaptation of agriculture to climate change.

From the authors

CONTENT

Foreword

I. MODULE

General Information on Climate Changes

Module 1. General Information on Climate Changes

> ***"Every action we take affects our environment, it's up to us to decide what impact we want to have"***
>
> ***Jane Goodall***

The most important topic in the world today is the topic of **climate change**.
The huge fires that are happening more and more often in the world, the floods that are taking everything before them, as well as the hot summers and mild winters, clearly indicate the fact that the climate of our planet is changing.
Through this training, we will try to answer some of the most frequently asked questions about climate change and help you understand them better, as well as enrich your knowledge on this topic and try to train you in the easiest way to convince people. from your environment that something important is happening.

What is climate?

What is climate and what is weather?

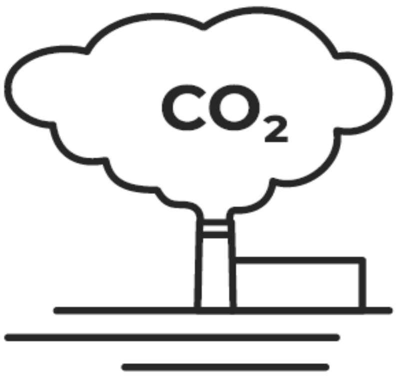
What we hear daily as a weather forecast is simply WEATHER. What is the temperature outside, is it rainy, is it windy, or rather what are the current weather conditions prevailing in a certain area, for example on a certain day of the week in Skopje.
Weather and weather forecast are very important for our daily life, in terms of what the current weather is like and what the forecast is for the rest of the day, we make a decision about how we will dress and whether we should take an umbrella with us.
Climate, on the other hand, is the average weather over a longer period of time, for example over a period of 50 years. If we plan, for example, to raise an apple orchard, we need to know what kind of climate prevails in a certain area where we plan production, in the coming years. So, in relation to those data, we make a decision whether the climate is suitable for a suitable type of production or not.

What is climate change? What is global warming?

Climate change is a long-term change in the climatic conditions of our planet.

Global warming, on the other hand, can be understood as part of climate change.
Scientists have long noticed that the temperature of our planet has been rising for the last 140 years, and during the 80s of the last century this topic became relevant in the general public, so in a way, it can be said that "**global warming**" becomes a popular topic. However, as time passed, it became increasingly clear that the rise in temperature was accompanied by other consequences, such as changes in the amount and intensity of rains, river overflows and catastrophic floods, more extreme events - devastating storm winds, tornadoes and rising sea levels.
Because of all this, we are increasingly talking about climate change as a broader term that includes an increase in the earth's temperature, along with numerous other consequences that follow that change.

Why is the earth's temperature rising? What is the greenhouse effect?



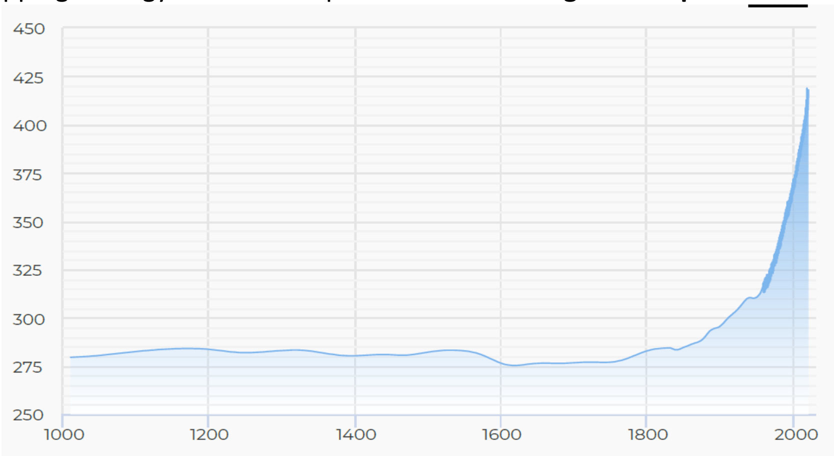
The Earth is a specific and unique place in our solar system where life is possible.
The main reason for this is the appropriate distance of the planet from the sun and our greenhouse effect atmosphere.
Simply put, the greenhouse effect is what makes the earth warm. This effect is of particular importance for planet Earth, because without atmospheric gases that retain heat from the sun, our planet would be a very cold place with an average temperature of -18 degrees Celsius.
The gases that make this possible are called **greenhouse gases**, which essentially retain some of the energy coming from the sun that the earth's surface absorbs and later slowly releases back into the atmosphere.
In order to better understand this process, it is best to compare greenhouse gases to a tent wrapped around the planet that does not allow heat to escape.
The concentration (amount) of these gases in the atmosphere in the last 140 years began to increase rapidly and therefore the temperature began to rise. In other words, "the blanket around our planet is getting thicker and retaining more and more heat."

Picture 1: Gases from fossil fuels
Source: https://unsplash.com/

Why is the concentration (amount) of greenhouse gases in the atmosphere increasing?

The main reason why this is happening is because we are burning more and more fossil fuels (coal, oil and gas) which release huge amounts of carbon dioxide into the atmosphere.
By burning these fuels, carbon dioxide (CO2), the most important gas that causes the greenhouse effect, is released into the atmosphere. One of the basic problems with carbon dioxide is that once it enters the atmosphere it is very difficult to leave it, it is even considered that even though it was released into the atmosphere hundreds of years ago, it is still there.

In the past 140 years, humanity has burned huge amounts of fossil fuels, which were the basic source of providing energy for the development of civilization.
The electricity for our homes, the cars we drive, the appliances we use every day came about as a result of energy from fossil fuels.
In fact, we have burned so many fossil fuels that in just 140 years the concentration of carbon dioxide in the atmosphere has increased by as much as 43%, and the higher its concentration, the greater the possibility of "trapping" energy in the atmosphere and **increasing the temperature.**



Graphics: Concentration of CO2 in the atmosphere from 1010 to the present

How much have the temperatures increased so far?
How much will they grow in the future?

The average surface temperature of our planet has increased by a little more than 1 degree Celsius since 1880. Although it may sound like a little, the consequences are still visible. It is enough to look at the weather in our country.
The summers are getting hotter and the high temperatures persist until the end of October. Winters, on the other hand, are becoming milder and snow is becoming less common.
If this trend of burning fossil fuels continues and if people continue to behave recklessly, the earth will continue to warm and by the end of this century the temperature could increase by about 3.5 degrees Celsius, and further up to over 5 degrees.
Scientists warn that this can be very dangerous and will dramatically change the conditions for life on our planet. That's why we need to do everything to prevent further **warming of the planet.**

Picture 2: Global Warming
Source: https://unsplash.com/

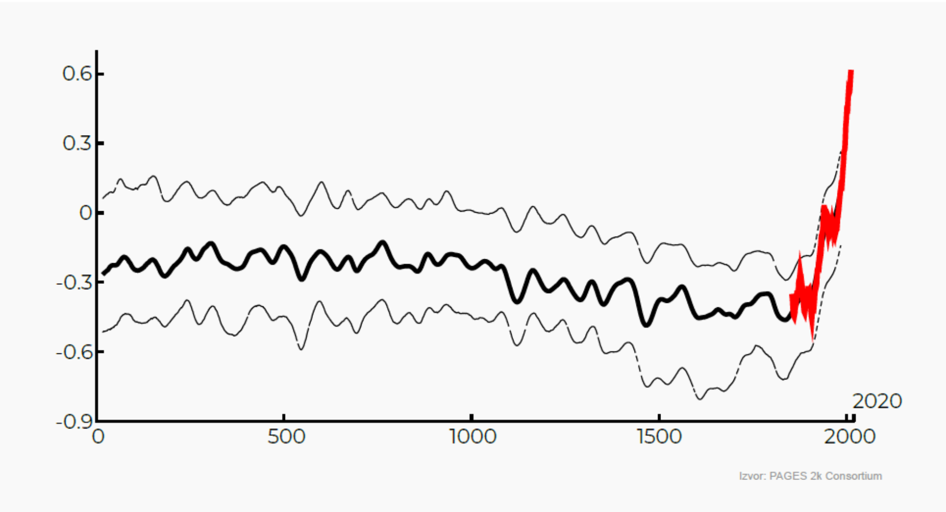
Why should warming by 3.5-5 degrees worry us?

The average temperature of our planet is about 15 degrees Celsius, but it has not always been like that. About 15 thousand years ago there was an ice age on the earth.
Most of Europe and North America were under ice, including all of Scandinavia and most of Great Britain.

The temperature at that time was about 4 degrees Celsius lower than today.

Picture 3: Earth in the Ice Age
Source: https://unsplash.com/

Then, over a period of several thousand years, the world warmed up and conditions were created that enabled our ancestors to build a great civilization, of which we ourselves are a part. If we allow the temperature to rise by 5 degrees, most of our planet will become an inhospitable place for life, and in Macedonia the snow would completely stop falling, even on the mountains.



Graphics: Deviation of the average global temperature in the last 2000 years in relation to the values for the period from 1961 to 1990
Measurements after 1850 are marked in red, while estimates based on intermediate data are shown in black.

According to scientists, any warming of more than 2 degrees can be very dangerous, and **it would be best if we stop at 1.5 degrees**, because anything beyond that brings serious consequences.
Just as an example, if the temperature were to rise by 2 degrees, most of the coral reefs on Earth would be destroyed.
Scientists have been pointing out the problem of heating for a long time. Towards the end of the 9th century, Svante Arrhenius published a paper entitled "Effects of Carbonic Acid in the Air on the Temperature of the Earth's Surface" in which he calculated how much the temperature of our planet would increase if the concentration of carbon dioxide in the air increased.
In 1938, Guy Callendar presented his paper "Artificial Production of Carbon Dioxide and Its Influence on Climate" in which the first published data showed that the burning of fossil fuels by humans was beginning to change the earth's climate.
A lot of time has passed since then. Technological advances and years of research have greatly advanced our understanding of these problems and their possible consequences. So yes, today scientists can predict with great certainty how the climate will change in the future.

What are the possible consequences?

When we talk about the possible consequences of global warming, the first thing we should know is that their weight directly depends on **how long we will continue to burn fossil fuels, that is, how much the temperature of our planet will increase.**
If we manage to stop the warming of the planet by less than 1.5 degrees, most of the possible consequences we are talking about will be prevented.

How is the earth's climate changing?

Increase in temperature
We have already mentioned that our planet is "well on track" to warm by about 3.5 degrees Celsius by the end of this century. But what exactly does that mean? Will it be 23.5 degrees instead of 20 degrees in spring?
Climate is the average weather over a longer period, while current weather conditions are what we see as a weather forecast and are variable.
If the earth were to warm by about 3.5 degrees, it would mean that hellishly hot summers would become a "normal" thing that we would have to live with.
In general, the likelihood of "extreme events" would increase, such as days with very high temperatures or heat waves that would last longer and be more intense.
It would not only affect human health, but also agricultural production, animal health and many other aspects of daily life.
The other seasons would also be warmer, and episodes of extremely high temperatures in autumn and winter would greatly disrupt natural processes and lead to enormous damage.

Melting of polar ice caps and glaciers
Large parts of our planet are covered with ice all year round. North Pole, South Pole, Greenland or high mountain glaciers. All these ice surfaces are very, very important and make up a delicate system on planet Earth.
As the temperature rises, due to an increase in the concentration of greenhouse gases in the atmosphere, the ice cover of the planet decreases.
Huge ice sheets in Antarctica are becoming unstable and there is a real danger of their separation from the Continent, which would mean their irreversible loss and accelerated melting in the coming period.

The Arctic Ocean has been losing its ice for the last 40 years. Scientists predict that there is a huge chance that this ocean will be completely thawed during the summer months of the year in the coming decades.

Picture 4: Consequences of accelerated melting of polar ice caps and glaciers
Source: https://unsplash.com/

The ice is not only melting at the North and South Poles, if the warming is not stopped, the same fate awaits the glaciers of the high mountains, which are also rapidly disappearing.
Many ecological communities depend heavily directly on the water that melts from glaciers, and the changes that occur can cause them serious problems.
In the near future, the rapid melting of glaciers may cause **possible floods and river overflows**, and until they disappear forever, many areas, especially in South America and South Asia, could have a problem with drinking water supplies.

Rising sea and ocean levels

All the ice that melts eventually ends up in the seas and oceans, and this will lead to a rise in the world's sea levels.
There is enough ice in the Antarctic ice sheet alone to raise global sea levels by 60 meters. Fortunately sea levels are not rising that fast. The current estimate is that even under the worst case scenario, sea levels will rise by a little less than 1 meter by 2100.
A huge part of the population lives in coastal cities. As many as three quarters of large cities are located by the sea, and some of the most important cities, such as New York, Shanghai, Melbourne and Tokyo, are directly threatened by the eventual increase in sea levels.

Picture 5: Expected floods from climate change
Source: https://unsplash.com/

Although 1 meter does not sound like a lot, even in such a situation, a large part of the cities will be in serious danger of flooding, and the consequences will be even more dramatic for small island states that are already preparing plans for population relocation.
The sea level is rising not only because of the melting of the ice, but also because of the thermal expansion of the water. As the atmosphere heats up, the seas and oceans also heat up, and as heated bodies have the ability to expand, the heated water occupies a larger area and **the sea level rises**.

Strong tropical storms
The warming of the waters not only leads to a global increase in the level of the seas, but also causes the effect of "propellant fuel" for strong and destructive typhoons and hurricanes.
In recent years, we have witnessed strong storms that have caused human suffering and enormous material damage. Hurricane Dorian, for example, which devastated the Bahamas, left more than 70,000 people homeless, while Cyclone Idai, which hit southeastern Africa, killed more than 1,300 people.
Rising sea levels further increase the effects of storms, because the range of storm surges that cause flooding and human suffering is greater.

Picture 6: Severe storms
Soruce: https://unsplash.com/

Amounts of rain

The climate is a complex system and all the changes described so far will have a huge impact on the **total amount of rain.**

It is still difficult for scientists to give an accurate estimate of how the total amounts of rain will move in different parts of the planet, but one thing they have noticed is that in the future there will be less rain in areas that are already dry, while humid regions will expect more rain.

A warm climate, on the other hand, will also change the way rain falls.

The trend is already being observed that larger amounts of rain fall in a much shorter time. More and more often we receive information that in just a few days amounts of rain have fallen that usually fall in a few months. On the other hand, the periods of time without rain are getting longer.

In the future, such developments will be more frequent.

Picture 7: Flooding

Source: https://unsplash.com/

Increasing acidity (acidification) of the oceans

By burning fossil fuels, humans release huge amounts of carbon dioxide into the atmosphere and thus heat the Earth. However, not all amounts of carbon dioxide remain in the atmosphere, a part ends up in the oceans.

Part of the carbon dioxide from the atmosphere dissolves in the oceans and thus **Carbonic acid** is created.

As huge amounts of this gas are released into the atmosphere every year, in the oceans, in the last 140 years, so much Carbonic acid has been created that **the total acidity of the oceans (ph value) has started to change.**

Acidic waters directly threaten the survival of certain species, which have calcium-carbonate armor around their bodies, because this element dissolves in an acidic environment.

At the same time, such conditions are not suitable for the survival of some species of Plankton, which is a basic source in the food chain in the seas and oceans. A reduced concentration of plankton can seriously disturb the balance in aquatic ecosystems and further threaten the survival of some marine species

Picture 8: Consequences of ocean acidification
Source: https://unsplash.com/

What can we do to prevent this?

All the possible consequences that have been discussed so far sound very dangerous, but the good news is that most of them can still be prevented.

The most important thing we as a civilization can do is to start using renewable energy sources as soon as possible and stop burning fossil fuels IMMEDIATELY.

That means, as soon as possible, we should stop burning, first of all, **COAL**, as a fossil fuel for obtaining electricity, and start producing it from the sun, wind and water.

Picture 9: Renewable energy sources
Source: https://unsplash.com/

Also, as far as transportation is concerned, we need to start using electric vehicles as soon as possible, instead of those that move with the help of internal combustion engines and use engines that run on oil or gasoline.

Of course, let's charge the batteries of electric vehicles with **renewable energy sources**.

Fossil fuels also still find enormous use in industrial production processes. So it is necessary to find new technologies that will enable us to supply the necessary energy for industrial production processes in other, alternative ways.

As we can conclude FOSSIL FUELS are by far the "most important" part of this story, but they are not the only one.

It is also very important to protect and preserve **FORESTS**, because they help us a lot to extract carbon dioxide from the atmosphere. It is no coincidence that it is said that trees and forests are the "lungs" of planet Earth and we should not only preserve them but also intensively restore them.

Picture 10: Dense forests
Source: https://unsplash.com/

We have to find ways to make **more use of arable agricultural land and to produce food in sustainable ways**, and it is especially important to use less meat in our diet in the future because animal husbandry also has a significant impact on the emission of greenhouse gases.
You may have noticed that we have mentioned the words "an hour sooner" in several places in this section of the text.
The reason for this is that the speed of action is too important for these issues and the faster we react, the simpler and easier we will solve the problem that threatens us

How much have we done so far?

Unfortunately, still NOT enough.
If everyone in the world respects the promises and plans to prevent climate change, our planet would warm by 2.8 degrees by the end of this century.
That's a lot more than the 2 degrees Celsius limit that should NOT be exceeded, and even more than the 1.5 degrees that should be our goal, especially if we want to reliably solve the problem.
The problem is that not everyone adheres to the promises made and the plans they have adopted and our main task should be to constantly remind them of that and not let them forget it.
However, much has been done so far!
Ten years ago, the situation looked much worse than it does now, and if the picture today looked like it did then, we would certainly be talking today that by the end of this century the planet would have warmed by more than 4 degrees.
For the last ten years, **CLIMATE CHANGE** and the solutions that are being taken have been the MAIN TOPIC of conversation in most forums, meetings and tribunes all over the world.
In 2015, all countries in the world have agreed that Climate Change is a problem that requires URGENT action, and that is why the Paris Agreement was signed, with which everyone undertakes to do everything in their power to keep the Earth's warming below 2 degrees Celsius.
From all this we can conclude that we are still moving in the right direction, but that we are still not doing it fast enough.

Can we speed things up?

Of course we can! The main reason for this is that the development of technology in recent years is going really fast.
The price of electricity produced from renewable energy sources has been reduced several times, so that in some parts of the world the price of electricity produced from renewable sources is much cheaper than the price of electricity produced from fossil fuels.

This, unfortunately, does not mean that the production of electricity from fossil fuels will be completely overcome and that we can fully rely on alternative ways of production.
There are still many challenges ahead of us in that direction. First of all, in connection with the storage of electricity produced from renewable sources.
However, many things are already known and we know in which direction we need to move until the complete rejection of coal as by far the worst option for electricity generation in the years ahead.
Even the storage of electricity, as the biggest challenge for the production of "clean" energy, is becoming more efficient and cheaper, and it is more than certain that this trend will continue in the future.
The main reason for this is the increasingly rapid development of technology in the production of electric cars.
Electric cars are increasingly conquering the market, so that in the Scandinavian countries they are already dominant compared to conventional cars.
The car giant Tesla is a leading company in this direction. And more and more car manufacturing companies are joining this production trend.

Picture 11: Electric car
Source: https://unsplash.com/

The rapid development of technology should go hand in hand with new policies, such as bans on diesel vehicles, the introduction of high taxes on carbon dioxide emissions and clear deadlines for the complete rejection of coal as an energy source.
So, the development of technology, on the one hand, and restrictive policies, on the other hand, should give clear directions in which direction the world will have to move and ensure even faster and greater progress.
For now, industrial processes are still lagging behind in this "green" direction, and here even more progress is needed in the coming years, so that we could fully respond to the challenge.

CLIMATE CHANGE is a systemic issue and it will be necessary for virtually everyone in the world to agree and take joint and decisive action in order to successfully solve the problem.

But that does not mean that we, as individuals, cannot do anything in this regard. On the contrary.
As we have seen so far, the climate of our planet is not a simple matter at all. To begin with, it is necessary to first educate everyone about the climate change that is happening in order to better understand the problem we are facing.
Once we understand what climate change is, we need to make people around us aware of the problem, so that as many people as possible are aware.
When we succeed in that, all of us together will be able to put pressure on the state to start adopting policies and strategies so that the entire economy turns in the direction of the development of renewable energy sources.

We also need to change our own habits, drive cars less and walk and ride bicycles more. To make our homes energy efficient and to use less energy in daily living.
Let's support companies that are trying to reduce their impact on climate change and thus send a clear signal to everyone that they need to start changing and adapting to new trends.

The most important thing is to understand that each of us can be actively involved in solving this problem together with millions of other people from all over the world.

We should not be just observers, but we should be actively involved in offering solutions that will make some kind of contribution to solving the problem.

- If we are good at writing, we should write about climate change and inform people.
- If you are a lawyer, you should get involved in drafting legal solutions for a "green future".
- If you are artists, offer creative solutions that will reach the general public.
- If you are involved in the economy, offer solutions on how to get renewable energy sources.
- If you are involved in marketing, work on popularizing this topic.
- All scientists, engineers, programmers, can find and offer a million different ways to apply their knowledge and skills in finding solutions to prevent climate change.

We could go on and on, because climate change is a very broad area and really everyone can get involved in their own way and make a significant contribution.

And the best thing is that if we are successful in that, we will not only leave a better place for future generations to live in, but also a better and more developed society.

Picture 12: The Earth
Source: https://pixabay.com/

What is the current situation?

Some scientists believe that it will be inherently difficult, if not impossible, to keep the warming of the planet below 1.5 degrees, which is considered the "comfort zone".
The limit of 2 degrees is still achievable, but in order to achieve it, our efforts in finding new technological solutions and new political solutions that will "hold" the course towards a green transition of the world will have to increase significantly.
We all have a lot of work ahead of us but we hope to succeed in our intentions, we just need a little more help.

Picture 13: The Earth on the palm
Source: https://pixabay.com/

II. MODULE

Social drivers and vulnerabilities

Module 2. Social drivers and vulnerabilities

Climate change and the vulnerability of socio-economic dynamics

In the recent years, we have witnessed the growing need for measures to face the complex challenge of climate change. As our planet's climate continues to change, so does the need for research into the complex interplay between climate variability, land-based livelihood practices, and socio-economic dynamics.

The social consequences of climate change are multifaceted. They touch different dimensions of life, from health and livelihood to demographic factors such as age and gender. With climate change, people face increasing challenges in terms of extreme weather changes, the health effects they bring, lack of food, water and security, migration, forced displacement, loss of cultural identity and other risks.

The social dimensions of human adaptation to agro-climatic change as its social, economic and behavioral aspects are the critical starting point for studying and successfully dealing with the effects of climate change.

Vulnerability is defined as the ability of an individual, household or community to prevent, mitigate and recover from natural hazards, with poor or near-poor households being more vulnerable to natural hazards.

The greater vulnerability of more or less poor households to natural disasters stems primarily from the fact that vulnerable households have relatively few assets and lack access to the necessary capital (Alwang, 2000). Community disaster resilience is closely related to risk in areas affected by natural disasters. A community with better resources, better disaster management, information communication, has less.

Climate change limits livelihood opportunities for women, children and those vulnerable groups without adequate access to employment and public services, increasing their insecurity and worsening their livelihoods.

Farmers' exposure to climate change significantly relates to their need for financial access as an adaptation strategy. The results show that changes in climate and extreme climate events such as land erosion, air pollution, natural disasters, lead to higher insurance costs, especially for health insurance.

Vulnerability as a socio-economic form depends on the socio-economic conditions in which people live, namely:

- employment and working conditions, level of education, health, gender, age;
- access and control over resources/assets such as food, water, shelter, energy, information, social networks, agricultural tools, land, technology, infrastructure, financial capital, etc.;
- access to social protection, public services and institutions;
- rights in the legal sense, human rights, governance, policies;
- cultural and historical factors etc.

The focus on analysis of the social aspects and consequences of climate change on agriculture covers the social drivers of climate change, gender, age and income level.

Assessment of the social dimensions of agriculture

The social dimensions of agricultural practices and policies have an important place due to several important aspects for farmers:

Human well-being: Agriculture is not just about food production, it profoundly affects the well-being of millions of people. Social impact assessment helps ensure that agricultural activities improve human lives by promoting food security, livelihoods and overall quality of life.

Equity and Inclusion: Agriculture is a key source of income and employment for the population, especially in rural areas. By assessing social impact, we can identify disparities and work towards equitable and inclusive agricultural systems that benefit everyone, regardless of gender, age or socio-economic status.

Food security: The social dimension of agriculture is closely related to food security. Assessments help us understand how agricultural practices and policies affect food availability, access and use. This knowledge is of crucial importance in preventing the occurrence of hunger and malnutrition.

Rural Development: Agriculture often serves as the backbone of rural economies. Social impact assessment supports rural development efforts by identifying areas where investment can drive economic growth, infrastructure development and better living conditions.

Dealing with climate changes

Climate resilience: Agriculture is vulnerable to climate change, and social impact assessment can guide the process of creating agricultural adaptation strategies. Understanding how climate-related factors affect farmers and communities is essential to building resilient and sustainable agricultural practices.

Gender equality: Agriculture is a sector where gender differences are often pronounced. Social impact assessment allows us to address gender-specific challenges and promote women's empowerment in agriculture.

Community Well-being: Agriculture does not operate in isolation, but interacts with communities and ecosystems. Assessments help us consider the wider societal context, preserving community well-being and environmental sustainability.

Policy effectiveness: Social impact assessment for relevant institutions that enact agricultural policies and programs with specific objectives, enables evidence-based policy making by assessing whether these policies are achieving their intended results and making the necessary adjustments. Informed decision making: Farmers, policy makers and stakeholders make decisions every day that affect agricultural practices. Social impact assessment provides them with data-driven insights to make informed choices that benefit both individuals and society.

Sustainable Development: Agriculture is a central pillar of sustainable development. Social impact assessments contribute to the achievement of sustainable development goals by promoting ecologically, economically sustainable and socially inclusive agricultural systems.

Assessing the social impact of climate change in agriculture is not academic research aimed at scientific goals, but is a critical tool to ensure that agriculture contributes positively to the well-being of communities, fosters sustainability and helps address global challenges, with particular emphasis on food security, climate change mitigation measures and adaptation.

Social dimensions of the climate changes

Proper social protection contributes to the resistance of rural farmers to the negative pressure of climate change. Social protection allows vulnerable rural households to be protected from the impact of climate shocks by promoting social protection initiatives, because climate change, agriculture and poverty are closely intertwined.

Promoting climate-smart agriculture in correlation with policies and programs for social protection and decent rural employment can solve important issues of climate vulnerability, rural poverty and degradation of modest agricultural assets.

In 2017, 70 percent of the world's extremely poor live in rural areas, 64 percent work in agriculture, and most of them rely on subsistence agriculture as their main source of income.

Globally, poverty rates are three times higher in rural areas than in urban areas, and agricultural workers are four times poorer than workers in other sectors (World Bank, 2016).

Agricultural production relies heavily on these small, often poor farmers. In developing countries, these farmers produce most of the food. In Asia and Africa, for example, 80 percent of food production comes from smallholder agricultural farms (IAASTD, 2016).

The impacts of climate change on agriculture are far greater on the poor, because they are more exposed to hazards. Over 90 percent of the world's poor live in risky climate conditions (Global Humanitarian Assistance, 2015).

These communities have less capacity to manage risk and cope with crises, and as a result, their assets and livelihoods, as well as their entire socioeconomic environment, are more strongly affected by climate shocks (Rentschler, 2013; Hallegatte et al. ., 2016).

As a result of the consequences of adverse climate impacts, small farmers may be forced to resort to unsustainable, environmentally damaging agriculture that quickly depletes their long-term assets. It is believed that due to climate change, by 2030, an additional 35 to 122 million people could fall into the category of "poor" (Hallegate, et al., 2016).

Impact of climate change on social problems

Standard of living

There are more than 200 countries in the world. All countries are very different from each other, with different geographical location, territory, natural environment, climate, population, economy and standard of living. All those countries are affected differently by climate change. They also differ in their capacity to cope with the new climate changes.

Countries are often divided into two large groups according to their level of development: the so-called "developed countries" and "developing countries".

Developed countries are relatively rich countries with favorable living conditions and strong economies, in which industry, services and the financial sector play a major role. People living in these countries have access to good health care and education, fulfilling job opportunities and relatively high incomes. The group of developed countries usually includes the United States, Canada, Australia, New Zealand, European countries, Japan, Singapore, Hong Kong and Israel. Some Eastern European countries, including Russia, with so-called "transition economies" represent a subgroup within the group of developed countries.

Developing countries are still dependent on traditional industries: farming, livestock and mining. They have a lower standard of living, a less developed health system, fewer social programs for the population and fewer opportunities for education and employment.

The group of developing countries is extremely diverse. Here are China, India, South Korea, Turkey, Brazil, Argentina, Mexico and some others, which are quickly catching up with developed countries thanks to the rapid growth of industrial production. Many of the things we use every day – clothes, shoes, dishes, furniture, appliances, toys – are made in these countries, especially China. China is now second only to the United States in the volume of goods and services it produces each year.

On the other hand, there are 47 countries, which are considered the least developed in the world. These include small island states, mountainous landlocked countries, as well as countries with overpopulated territories and unfavorable climatic conditions. These countries are very poor, their economies are weak, and their people and way of life are very vulnerable to natural disasters. Most of them are in Africa and Asia, and the poorest of them are Burundi, Congo, Liberia, Sierra Leone, Malawi, Ethiopia, Tanzania, Bangladesh and Zambia, where people lack food, clean drinking water, hospitals and schools.

The governments of these countries cannot pay welfare benefits or pensions to their citizens, so families there try to have as many children as possible to help their parents run the household, work in the fields and support them in old age.

Also poor sanitation, lack of food and clean water, and lack of clinics and hospitals means that many children die before they grow up, so having many children is a way to ensure that at least some of them survive. About 800 million people (11% of the world's population) now live in the world's poorest countries, but these countries contribute less than 1% to the global economy.

Social inequality

In October 2011, the world population reached 7 billion. The vast majority of the world's people - 5.9 billion, or 84% of the total - live in developing countries and only 16% or 1.1 billion people (the so-called "golden billion") live in developed countries. At the same time, 16% of people living in rich countries consume the lion's share of world production.

So the contribution of people living in developed countries to global greenhouse gas emissions (their so-called "carbon footprint") is much greater than that of people in developing countries, because creating the daily output consumed by people in rich countries requires a huge amount of resources and energy.

For example, it takes 3.5 times more resources to sustain the life of the average American than to sustain the life of the average inhabitant of Earth, and the average American uses 9 times as much as the average Indian. So the golden billion bears more responsibility for the consequences of climate change.

The gap between the quality of life of the world's rich and poor is huge. The average income in the richest 20 countries is 37 times higher than that in the poorest 20. The income of the 500 richest people in the world exceeds the total income of the 416 million poorest people on the planet. Worst of all, the very high birth rate in developing countries means that their population growth rate is 3.5 times higher than that of developed countries.

The population of many of the poorest countries in Africa and Asia could double in less than 40 years. Thus, the number of the poorest people on the planet is increasing.

It would be a mistake to think that poverty is limited to the least developed countries. Rich countries have both backward regions and poor people. In the United States, for example, the number of poor was estimated at 46 million people in 2010, or about 15% of the total population.

In Germany, almost one in seven people, or a total of 11.5 million, live at or below the poverty line. Often, the poorest people in developed countries are people who come from developing countries for better work, as well as people who live in rural areas and declining industrial cities, where mines and factories close because they are unprofitable.

Inequalities in living conditions—the unequal distribution of income and opportunity among people on our planet—represent some of the most pressing social problems in the world today. As the United Nations Development Program's 2013 Human Development Report rightly notes: “Every person has the right to live a fulfilling life according to his or her own values and aspirations.

No one should be condemned to a short life or a life of misery because they happen to be of the 'wrong' class or country, of the 'wrong' ethnic group or race, or of the 'wrong' gender."

Unfortunately, climate change only increases the problem of social inequality and makes the task of overcoming poverty more difficult.

Economy and social categories

The way of life and the economy of the local population largely depends on the natural conditions and the climate, so any change leads to big problems for the economy and society. People in poor countries and regions depend mainly on agriculture for their livelihood, so any drought, flood or hurricane can immediately deprive these people of their only source of income.

Climate change in poor countries has a particularly strong impact on women, who are mainly responsible for raising children, caring for the sick and elderly, feeding their families, growing crops or providing drinking water.

Even in high-income countries, young children, the elderly and people with disabilities may be at particular risk because their health is highly dependent on weather conditions.

Climate migration

Climate change causes tens of millions of people to migrate to avoid the consequences of storms, droughts and floods. According to estimates, by 2010 there were more than 40 million people in the

world who moved from their homes due to reasons related to climate change. According to forecasts, their number may reach 200-250 million by 2050.
In a densely populated agricultural area, with the predicted increase in the water level in these rivers by 2 m, it will lead to flooding of a large area of arable land. Local people who work in these fields will be forced to look for new places to live and work.
Frequent droughts or floods, with particularly serious consequences for agriculture, will force many people from rural areas to move to cities in search of work. Such migration leads to the creation of entire settlements of poor migrants - poor neighborhoods and areas with poor sanitary conditions and a high crime rate.

New conflicts

Climate change can cause serious conflicts between people, especially around questions of land rights, lack of access to water and climate migration.
Particularly exposed to the risk of conflicts related to climate change are regions threatened by long-term droughts, lack of water, rising sea levels, salinization of crops and damage to agricultural crops, lack of access to energy and other factors that can cause political and social crisis, as well as increased migration flows.

International cooperation for providing social assistance

Special programs are needed to help the most vulnerable social groups with the aim of reducing the social risks arising from climate change. These should include:

- training and professional reorientation of people living in rural areas, giving them an alternative profession in agriculture;
- projects for resettlement of inhabitants to endangered regions;
- opening new jobs in poor areas;
- research for the development of new varieties of agricultural crops that are more resistant to drought and
- technique and possibilities for early warning for natural disasters.

However, all these measures require money that poor countries and poor people do not have. Various funds and financial instruments have already been created to help developing countries overcome social problems associated with the negative effects of climate change. The main donors are the governments of developed countries, large companies and international organizations, before the United Nations.
Programs and instruments are needed to target and distribute these funds for a painless recovery and easier management of the effects of climate change.

Gender as a social dimension under the influence of climate change

The meaning of gender in agriculture

We cannot put an end to hunger and poverty without strengthening the equal representation of men and women in the agricultural and food systems. Today, agriculture and food systems face an unprecedented series of challenges. The global population is growing in conditions of new and permanent crises - economic, energy, ecological, food and social.
These crises include conflicts, natural disasters, price volatility, market insecurity, mass migration, health crises and much more, all of which are exacerbated by climate change, the depletion of natural resources, rapid urbanization, changes in food patterns and food systems for life.
Faced with these challenges, it is important to build inclusive, sustainable and resilient agricultural and food systems, so that the agricultural sector can work at full capacity and become more efficient. FAO recognizes that in order to achieve this, we must deal with persistent inequalities that affect the poor

performance of the agricultural sector in many countries. We need to work and strengthen our activities for rural women, men, girls and boys.
Men and women relate to the environment in different ways, and changes in the environment have different effects on their lives. Women play a key role in maintaining communities and managing natural resources, but their contribution is often underestimated and neglected.
Both men and women are involved in agriculture all over the world, although the investments they play change rapidly and differ significantly by region. Gender is shaped by access to productive resources and opportunities, participating in work with many resources, inputs and services - land, profit, labor force, technology, education, extensions and financial services, while, in a broader context, women have less access to them (Quisumbing et al., 2014).
These kinds of differences in securing resources and new financial possibilities shape the agricultural sector, both in small agricultural systems and in larger commercial systems. Thus, in order to understand agriculture, we must understand gender dynamics in agriculture.
Understanding gender in agriculture begins with understanding the differences between "pole" and "gender," terms that can be confusing because they are often used inconsistently and interchangeably.

Pole refers to the innate biological categories of male and female and is a fixed category rooted through biological differences.

On the other hand, gender refers to the social roles and identities associated with what it means to be male or female in a given society or context.

Gender roles can be shaped by ideological, religious, ethnic, economic and cultural factors and are a key determinant of the distribution of responsibilities and resources between men and women (Moser, 1989); Gender roles are socially, not biologically determined, they are fluid and subject to change based on changing norms, resources, policies and contexts.
"Gender" and "women" are often—but incorrectly—used interchangeably. Gender refers to the relationship between men and women, not an exclusive focus on women. Much of the literature and practice on agricultural development has focused on men.
Gender is also equated with poverty, caste, ethnicity, age or life cycle stage, and so on.
Analyzing gender in agriculture also means overcoming the meaning of gender as the head of the household. Gender of the head of household is a misleading indicator of gender because it ignores the majority of women worldwide who live in households defined as male-headed, as well as men who live in female-headed households (Doss, 2018).
Thus, it confuses gender issues with those of household structure; a woman is considered the head of the household only if there is no adult male in it, or there is no adult male contributing economically to the household.
It can also be inappropriate when in multigenerational households one person is defined as the head of the family, even though there are different adults who may have different roles and responsibilities.
In agriculture, gender analysis provides insight into how gendered socially constructed roles and responsibilities shape many decisions in agricultural production, processing, market participation, all the way to consumption and welfare outcomes.

The gender gap in agriculture and its implications in the context of climate change

Responsibilties

In developing countries, women are involved in small-scale agriculture, often in temporary or unpaid activities. The visible increase in women's responsibilities in agriculture is the result of the increasing scale of family farming, which is driven by demographic pressures and land fragmentation.

Job growth in other sectors and significant male migration from rural areas is another factor increasing the workload of women. (Slavchevska et al., 2016)

There is increasing evidence that ignoring the large "gender gap" that persists in agricultural productivity and development in most countries carries significant costs (Ali, 2015; Peterman et al ., 2014; UNWomen, 2015).

The gender gap in agriculture must be addressed to achieve the transition to climate-smart agriculture

It is estimated that closing the gender gap in agriculture would increase total agricultural production in developing countries by 2.5 to 4 percent and reduce the number of hungry people by 12 to 17 percent globally, equivalent to 100 to 150 million people (FAO, 2011).

Evidence also points to the fact that more equal gender relations in households and communities contribute to increased agricultural and rural development, productivity and nutrition (Farnworth et al ., 2013).

Female farmers are as efficient as male farmers, but produce less because they control less land, use fewer inputs, have less access to labor and services. (FAO, 2011).

But when crops traditionally produced by women farmers become commercially profitable, men often take over their production and marketing (Berti et al ., 2004; Doss 2001; Momsen 2010).

Inequality

Although women make up 43 percent of the global agricultural workforce, women own, work and manage smaller and less valuable plots of land than men (FAO, 2011). Limited ownership of their own agricultural land severely limits women's access to credit, thus jeopardizing their capacity to adapt to the negative effects of climate change.

Without formal land ownership, they cannot finance climate-smart agricultural innovations. It also means that women have little access to services that could help facilitate investments in acquiring new technologies, improving their natural resource management practices, and adopting more efficient and productive crop and livestock management, all it could help them deal with the degradation of natural resources and build resilience to climate change (World Bank, 2009).

There is compelling evidence that climate change can reinforce or worsen inequalities. However, it is important to recognize that addressing gender inequalities is not just a matter of 'righting the wrong'. It also represents an important opportunity to tap into previously underutilized and underrecognized abilities, knowledge and talents.

Ensuring equal access of women and men farmers to land and other productive resources can ensure greater gender equality, better food security and increased climate change adaptation and mitigation. It opens up the possibility of a cost-effective and transformative approach to climate-smart agricultural development. For this to become a reality, there is a need for a careful re-evaluation of past and current agricultural practices.

Focusing on gender equality is essential to meeting the goals of climate-smart agriculture, as it will serve to increase agricultural productivity and incomes, build resilience to climate change adaptation, and contribute to climate change mitigation.

Climate education and advisory

The ability to access and use information about weather, climate and early warning of disasters is a critical element of adaptation. Improved access of men and women to climate information is another key aspect of the transition to climate-smart agriculture.

In 2011, out of 97 countries, only 5 percent of education, training and counseling services were aimed at women; and only 15 percent of the staff for education, training and counseling were women. In some cultures, women working in agriculture were practically prohibited from engaging in these trainings (FAO, 2011). In some countries, extension service provider staff may have attitudes that reflect a bias against farmers who lack access to credit and have less education. These educators and advisors tend to target resource-rich farmers, and women, who typically have poorer access to resources, are neglected (Elias et al ., 2015).

Work responsibilities

The gender gap in agriculture is also reflected in the scope of women's work responsibilities. Women are farmers, workers and entrepreneurs. They also spend considerable time ensuring that other members of their household, including children and the elderly, are adequately fed.

Rural women often manage complex households and implement multiple livelihood strategies. Their activities usually include producing crops, raising animals, processing and preparing food, working for wages in agricultural or other rural enterprises, engaging in trade and marketing, caring for family members, and maintaining their homes.

These domestic activities are time-consuming tasks and limit women's opportunities to participate in and benefit from climate-smart agriculture initiatives. Women's disproportionate responsibility for unpaid work traps them in "time poverty".

They do not have time to participate in agricultural development initiatives and other social, economic and political activities, which deprives them of the full enjoyment of their economic and social rights (Action Aid, 2013).

The workload that women undertake must be lightened to enable them and their families to spend their time upgrading for greater productivity. Between 1980 and 2010, the share of women employed in agriculture increased by about 30 percent (SOFA, 2011).

Gender differences and the effects of climate change in Macedonia

Climate change and its negative impacts do not recognize stereotypes and grounds for discrimination (age, gender, ethnicity, religion and other affiliation), but strongly recognize people's climate resilience, which deeply depends on social and economic status and the gender basis of disparity .

National data show that the agricultural sector is the most important in the Macedonian economy, responsible for 16% of the country's GDP and employment for 36% of the workforce.

Agriculture is an important, but not necessarily paid, activity for women across the country. Official statistics for Macedonia indicate that in 2012 women made up 40% of workers in agricultural enterprises.

The available data on education by different agricultural sectors shows that approximately 30% of agronomists are women (SSO, 2014). The percentage of female members of households who work in individual agricultural holdings and employees in business entities is 43% (SSO, 2007).

The degree and type of participation of women in agriculture varies in different regions. In Vardar and Pelagonija, the majority, i.e. 66.7% and 60% of employed women, work in agriculture and take the surplus to the market, while in the Pologsk region (73.7%) and the northeastern region (66.7%) women are engaged in by farming for their livelihood.

Overall, rural women account for up to 38% of those economically active in agriculture, hunting and forestry (including seasonal workers), with an estimated 20% of economically inactive women actually working on family farms on an unpaid basis (CICP, 2012).

Women are engaged in unpaid agricultural activity more than men, and their tasks are planting, harvesting, processing and packaging. Women in Macedonia are responsible for agricultural activities near the house, for feeding and milking livestock. Macedonian women work in the field with men, while Albanian women mainly work near the home, while men work outside the home. Men take on more difficult tasks, such as digging, watering and harvesting. They also operate the agricultural machinery and sell goods in the market. As in most parts of the world (FAO, 2011), women's tasks in agriculture in the Republic of Macedonia are related to manual work and are rarely supported by information and technology.

Women's participation in agriculture in the country is also characterized by a lack of land ownership, little input into decision-making, and a lack of control over their time and labor.

According to FAO, approximately 16% of the country's land is owned by women, but few women are formally registered as farmers. On average, less than 6% of female households own farmland or a house (CIKP, 2012). Women in rural areas have only primary education, while in urban areas they have at least secondary education.

Age as a social dimension under the influence of climate change

Intergenerational dynamics: Climate change may affect intergenerational dynamics in farming families. Bridging the generation gap and encouraging communication and cooperation between different age groups can facilitate the exchange of knowledge and expertise, enabling farming families to adapt more effectively to climate change. Farmer age has a significant impact on the adoption of climate-smart agricultural practices. .

In some cases, older farmers are less likely to adopt certain practices such as measures to improve soil fertility management and crop diversification. The influence of age on acceptance can be attributed to factors such as experience, level of education and difficulty accepting risk.

Older generations may be resistant to change or hesitant to adopt new technologies and practices, while younger generations may bring new perspectives and ideas to address climate-related challenges. It is important that agricultural policy makers and training services consider the age demographics of farmers.

Climate change affects farmers of all ages, but its impact can vary depending on factors such as location, type of agriculture, socio-economic status and access to resources.

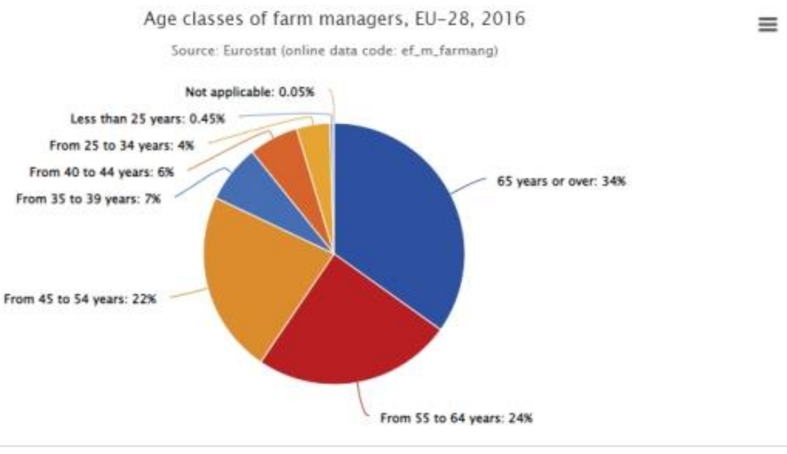
Young farmers: Climate change presents unique challenges and opportunities for young farmers just starting their farming careers. While they may be more open to adopting innovative practices and technologies to adapt to changing climate conditions, they may also face barriers such as limited access to land, capital and resources.

In addition, young farmers lack the experience and established networks that older generations rely on to deal with climate-related risks. Climate change may influence the decisions of young people considering a career in agriculture as they weigh the potential risks and uncertainties associated with agriculture against other livelihood options.

However, it can inspire innovation and entrepreneurship among young farmers, who can develop sustainable farming models and explore niche markets that are resilient to climate change.

Only 11% of all farms in the European Union are managed by farmers under the age of 40. Convincing young people to take up farming is a significant challenge. According to the European Commission, due to the aging of the agricultural population, the EU is stepping up its efforts to encourage young people to engage in agriculture. Young farmers are initially provided with grants to start their own business, support to maintain income and benefits in the form of additional training.

The next generations of European farmers supported in this way are considered to improve the future competitiveness of agriculture in the EU as well as the guaranteed food supplies of Europe in the coming years.



Picture 14: Age representation in agriculture in the EU

However, climate change is wreaking havoc on farming communities that are on the front lines of the climate crisis.

According to the 2022 National Coalition of Young Farmers Report, 73% of young farmers have experienced at least one negative climate impact on their farm in the past year, and 88% percent of them believe that the weather changes that are occurring are forcing them to shift their usual farming activities. and are the result of climate change.

Crops are destroyed or damaged by extreme weather events, growing seasons are disrupted, and there are severe economic losses due to droughts and unsafe conditions from uncontrolled wildfires.

Young farmers are poised to directly mitigate the devastating effects of climate change through agricultural policy reforms, greater representation in decision-making that directly or indirectly affects them, quality education about climate and its impacts, and collaborative and transformative partnerships with peer organizations and allies. .

Gender roles shape the experiences of young people because differences in resources mean that young men and women have different conditions to adapt to and succeed as farmers in the face of climate change. Climate threats to agriculture are prompting rural youth to leave agriculture and find work in cities.

It is essential to develop gender-sensitive policies for young male and female farmers by promoting rural diversification interventions.

The general goal of this measure is to encourage the employment of young male and female farmers by creating new and maintaining existing jobs. This increases the level of economic activity in rural areas, improves the quality of life and reduces rural depopulation, achieves sustainable development of rural areas, thus contributing to a better territorial balance, both economically and socially.

Specific objectives of rural diversification are: ·

- ❖ Maintenance of agricultural activities in rural areas by providing certain services;
- ❖ Developing and promoting rural tourism; ·
- ❖ Developing non-agricultural micro and small enterprises that are based on local resources and that are related to improving the quality of life in rural areas;
- ❖ To preserve and develop traditional craft activities; ·
- ❖ To promote entrepreneurship in rural areas.

Middle-aged farmers: Middle-aged farmers often carry significant responsibilities, such as managing the day-to-day operations of their farms, providing for their families, and planning for the future.

Climate change can disrupt their livelihoods by affecting crop yields, increasing input costs and creating market uncertainties.

These challenges can strain household finances and increase stress levels as middle-aged farmers navigate the complexities of adapting to changing environmental conditions while ensuring the economic viability of their farms.

In addition, middle-aged farmers may also face health risks associated with climate change, such as heat-related illnesses or exposure to air pollutants from wildfires.

Older farmers: The results show that older farmers' knowledge of climate variability and climate change depends on their gender, level of formal education and farming experience.

Older farmers adopt on- and off-farm strategies to cope with climate change and climate variability. The vulnerability of older farmers to climate change requires specific social protection mechanisms, such as a pension scheme.

It should guarantee access to monthly cash transfers that will ease subsistence constraints and ensure well-deserved well-being.

The number of people aged over 60 is projected to increase from 13.6 per cent in 2020 to 24.9 per cent in 2050. By mid-century, one in four people in the region will be aged 60 or over. , while people aged 80 or over will represent one-fifth of all seniors.

This shift in the age structure of the population occurs when climate change increases the frequency and intensity of extreme weather events such as heat waves, tropical cyclones, storms and droughts.

Dependence on natural resources and agricultural sectors, weak institutions, lack of social protection and high levels of poverty among the population make the world very vulnerable to the risks associated with climate change.

However, older people are at greater risk of becoming poor and often lack access to adequate resources and services. With the expected life expectancy of women being higher than that of men. They live in poverty for longer, are more likely to lose their partner, have lower levels of education and need to combine agricultural work with childcare.

This also means that adult women are more likely to be employed in the informal sector and are often paid less than men.

While some seniors can cope with the effects of extreme weather and other risks, others cannot. Older farmers are more susceptible to disease and to the negative impact that climate change may have on the supply of food, water and sanitation, health and social care, housing and transport services.

Vulnerability also depends on associated factors, such as gender, ethnicity and disability. Older people with disabilities are at particular risk from the effects of climate change.

Climate-related hazards pose a danger to the elderly, adding additional stress to their ability to cope with the many challenges they already face. For example, floods caused by climate change cause disruption and recovery problems, concern and anxiety for adult farmers from the risk of recurrence.

These threats can cause stress, which together with pre-existing health impairment, can have a significant impact on well-being without effective coping capacity and adequate social support systems.

Older farmers hardly accept the changes brought by technologies, but they still want to leave the agricultural area and production in good condition as a legacy to the new generations. That leaves an opportunity with the right direction and training to expand the capabilities of the old snake farmers to cope with climate change more easily.

Overall, climate change affects farmers of all ages, presenting both challenges and opportunities for agricultural livelihoods. Solving these challenges requires tailored strategies that take into account the different needs, capacities and experiences of farmers of different age groups, as well as encouraging cooperation and innovation in agricultural communities when designing and implementing climate smart agricultural programs.

Agricultural income and climate change

As air and water temperatures rise globally, the costs of amortizing climate change will increase rapidly. One study suggests that unmitigated global warming could reduce average global incomes by roughly 23% by 2100 and make 77% of countries poorer per capita than they would be without climate change.

The impacts of climate change will disrupt the natural, economic and social systems on which we depend. This disruption will affect global food security, damage infrastructure and jobs, and harm human health.

These impacts are unevenly distributed around the world, with some countries facing much greater risks than others. However, all countries, communities and companies will feel the effects of climate change.

Unfortunately, the impacts of climate change are already here. Global sea levels have risen by 19 cm since the beginning of the twentieth century, increasing the risk of flooding for many coastal cities and communities. Heat waves and droughts are becoming more frequent and intense in many parts of the world, causing damage to human health and more heat-related deaths.

Climate change also affects food security as rainfall and heat patterns change. In Southern Europe and some parts of Africa, Asia and South America, crop yields are declining.

The global food supply is not stable as extreme weather events and habitat degradation disrupt supply chains. This could lead to higher food prices and 183 million more people worldwide to face hunger.

Even just half a degree of warming can make the difference between dangerous climate effects. By limiting global warming to 1.5°C instead of 2°C, for example, 420 million fewer people will be exposed to extreme heat waves and 10 million fewer people will suffer the risk of flooding due to sea level rise.

These risks and impacts are not evenly distributed, so some regions of the planet will feel the effects of climate change more severely than others depending on their location and ability to adapt. However, because both the climate system and our human societies are globally interconnected, the effects of climate change will affect all countries, companies and farming communities in some way.

A 2017 climate change impact research mechanism on farm family finances reveals that climate change has effects on the financial vulnerability of rural households through farmer health, credit availability and agricultural production.

Furthermore, the effect of climate change on the financial vulnerability of households is more pronounced among farmers with a lower level of education.

Physical capital consists of infrastructure and materials needed to support livelihoods.

Human capital refers to individuals' knowledge, health status, etc., to earn a living.

Financial capital refers to the financial resources, which typically include cash, savings, credit, remittances and transfer income, that households or individuals use to achieve their life goals.

First, the high dependence of agricultural production on the natural environment makes agriculture often affected by winds, rainfall, hail, persistent drought, and pests and diseases caused by climate change. These factors affect the physical capital of agricultural households.

Second, disease risk affects the human capital of agricultural households, leading to increased financial vulnerability of rural households. (7.3% increase in annual mortality in rural areas due to increase in average daily temperature per °C.)

Third, climate change may disrupt the operation of rural financial institutions, thereby affecting the financial capital of rural households. It is unclear how climate change affects the financial stability of rural households by affecting the cost of living and thus the financial stability of rural households.

Climate change has significant implications for farming families, especially in terms of their financial income. Here's how climate change affects various financial aspects in farming households:

Health problems: in agricultural households due to an increase in medical costs affect economic productivity and thus reduce the income of rural households.

For example, climate change and weather events may increase the presence of vector-borne diseases in livestock, leading to higher healthcare costs for agricultural households.
Access to credit and loans: climate-related risks can make agricultural activities appear riskier to banks or financial institutions, which can lead to uncertainty in bank lending, which in turn makes banks more cautious in lending, thus reducing credit supply and market liquidity (Berg and Schrader, 2012; Hosono et al., 2016).
For farmers, this means stricter lending criteria and higher interest rates for agricultural loans. Small farmers, who often lack additional and formal credit history, may find it increasingly difficult to access affordable credit to finance their farming operations.
Uncertainty in bank lending causes rural households affected by such a disaster to face more severe financial constraints, and also further increases bank loan default rates, undermining banks' ability to operate, thus creating a vicious cycle.
The reluctance for such lending by banks is more pronounced in developing countries than in developed countries.
Crop Insurance Premiums: This uncertainty in bank lending is caused mainly by post-disaster losses, particularly the loss of uninsured assets. With the increasing frequency and severity of extreme weather events, crop losses are becoming more common.
As a result, farm families may face higher crop insurance premiums to protect their livelihoods. These increased costs can strain household budgets, especially for small farmers with limited financial resources.
Inflation or recession: Physical damage caused by sudden climate disasters such as floods, winds, high temperatures, or long-term climate problems such as sea level rise, changes in precipitation, and acidification of sea and drinking water can directly lead to a decline in the value of agricultural property. This decline in value increases the risk of loan defaults for farmers' households and businesses.
In addition, macroeconomic fluctuations such as inflation or recession caused by these natural disasters can indirectly have a significant negative impact on microfinance, that is, borrowers may not be able to meet their debts, which again leads to the suspension of loan repayments and depletion of banks' liquidity.
Investments in infrastructure: Rising temperatures or changes in precipitation lead to lower river levels, crop failures, delayed planting seasons, lower incomes and reduced yields, higher costs of seeds,

fertilizers and pesticides, and thus significant impacts on the natural assets and resources on which agriculture depends.

In addition, investments in irrigation infrastructure or drought-resistant crop varieties may be necessary, further increasing costs.

Income volatility: Changes in weather events can cause variability in crop yields, leading to income volatility for farming families.

This volatility makes financial planning and budgeting more challenging, as farmers can hardly predict their future income. In times of poor harvests or crop destruction, households may face a financial problem, affecting their ability to meet basic needs and invest in future agricultural activities.

Investments in climate adaptation: To mitigate the impacts of climate change, farming families may need to invest in adaptation strategies such as improved water and irrigation management systems, practices to improve soil quality, and crop diversification.

While these investments can improve resilience to climate-related risks in the long term, they often require upfront capital, which will further impact household finances.

Market volatility: Climate change may disrupt global agricultural markets through changes in supply and demand dynamics, price volatility and trade distortions. Farming families may experience fluctuations in commodity prices, which will affect their income levels and profitability. Market volatility can make it challenging for farmers to make important decisions regarding crop selection, marketing strategies and long-term investments.

Overall, climate change poses significant financial challenges for farming families, including increased input costs, higher insurance premiums, limited access to credit, income volatility, need for climate adaptation investments, market volatility and potential health care costs.

Addressing these challenges requires coordinated efforts by policy makers, financial institutions and agricultural stakeholders to support farmers in building resilience to climate-related risks and ensuring the sustainability of agricultural livelihoods.

III. MODULE

Agricultural technologies

Module 3. Agricultural technologies

Meaning and benefits of agricultural technology application

Modern agricultural business is developing in different directions at the same time. However, its primary focus is using agricultural technologies to increase yields through better planning and smarter management. By promoting more efficient and sustainable farming methods, advanced technology in agriculture is helping farmers thrive in today's agribusiness.
Time-oriented practices such as crop rotation and the application of new agricultural technologies, such as monitoring the productivity of the field with machines and satellite images or special agricultural software, contribute to the sustainability of agriculture.

The modernization of agriculture during the last three decades is progressing progressively, while the development of the IT sector in it is one of the main drivers of this process.

Factors that determine the pace of technological innovation in agriculture are:

- climate change and global warming
- the degradation of the environment
- change in consumer demands
- limited natural resources
- food scraps
- issues related to consumer health and chronic diseases
- growing global population expected to reach 9 billion by 2050

Today, innovations in the food industry are mainly focused on solving the following challenges:

- food scraps
- CO2 emissions
- chemical residues and freezing
- drought
- labor shortage
- better health and sugar consumption
- murky supply chains and distribution inefficiencies
- food safety and provenance
- farm efficiency and profitability
- unsustainable meat production

What is agricultural technology?

Agricultural technology, also known as "agritech", encompasses a wide range of disciplines and devices that improve agricultural production. This includes vehicles, robotics, computers, satellites, drones, mobile devices and software. The use of big data analytics and artificial intelligence (AI) technology in agriculture is also an example of how the agricultural sector is embracing technological advances.
Modern farms and agricultural crops operate very differently than they did a few decades ago, primarily due to advances in technology, including sensors, devices, machinery and information technology. Today's agriculture routinely uses sophisticated technologies such as robots, temperature and moisture sensors, aerial imagery and GPS technology.

These advanced devices and precision agriculture and robotic systems enable businesses to be more profitable, efficient, safer and more environmentally friendly.

The benefits of technology in agriculture

Agricultural technology aims to make work in the field more efficient, easier and more comfortable. Every year there are various new agricultural innovations and occasionally revolutionary and innovative technologies emerge. As agribusiness continues to modernize and grow, it is increasingly crucial for agricultural consultants, food producers and technology managers to be familiar and up-to-date with the latest technology standards.

Water, fertilizers, pesticides and other products are no longer applied "by eye" or evenly across the field by large agricultural producers. The use of advanced agricultural technologies allows precise application of only what is needed in each location, as well as careful adaptation of the treatment to each plant.

The implementation of smart agricultural technology is beneficial for all participants in the agri-food chain. By using it to optimize and automate agricultural operations and field activities, growers and landowners can now save significant amounts of time and effort.

These are just a few examples of how agriculture has benefited from advances in agricultural technology:

- using less water, fertilizers, pesticides and other inputs allows agricultural producers to reduce costs and keep more of their profits;
- by preventing or drastically reducing the amount of chemical runoff into waterways, businesses reduce the impact of agriculture on the environment and take steps towards greater sustainability;
- increasing crop yields while reducing labor inputs;
- facilitating farmers, agronomists or other agricultural workers to communicate and coordinate activities using mobile devices, applications or web-based resources;
- reducing barriers to access to agricultural insurance and financial services, as well as market and technological data;
- mitigating damages that can be caused by pests, natural disasters and bad weather in agriculture with the help of affordable, always-on agricultural monitoring systems;
- increasing farm income through improved product quality and increased quality controls;
- timely recognition of lack of nutrients in plants and notification to the agricultural authorities
- producers for the type and amount of fertilizer and other necessary changes;
- ability to predict potential farm problems through visualization of production patterns and trends derived from analysis of current and historical agricultural data.

By estimating their total yield, agricultural producers can accurately budget for the next growing season and better prepare for emergencies.

Evolution (development) of Agricultural Technology

Technological progress in agriculture is intrinsically linked to the rise of urban centers and commercial exchange. New technological advances have always prevailed in this field.
However, the technological model of agricultural production remained largely subsistence-based and characterized by low productivity until the beginning of the 20th century. This era, known as "Agriculture 1.0", is marked by the invention of the plow and the widespread use of animal drafts.

Agriculture 2.0 began in the late 19th century with the introduction of mechanical machines such as tractors. And later, agricultural technology went through a number of active development cycles as the pace of technological progress increased tremendously.

Agriculture 1.0

In the beginning, people were hunters and gatherers. As early as 6000 years ago, farmers began to grow wheat and domesticate animals. With iron plows, they found they could bring more land to work. For the first time, agricultural technology enabled large-scale, organized food production and storage. It enabled the growth of villages and cities.

Agriculture 2.0

The technology of agriculture was practically unchanged. Oxen pulled ploughs; people worked manually. But in the 18th and 19th centuries, new tools and techniques suddenly transformed the speed and efficiency of farms. Crop rotation, steam power, steel work, drilling technology, seed production and crossbreeding made ploughing, planting and harvesting more efficient and productive.

Agriculture 3.0 or precision agriculture

Between the 1950s and 1970s, industrial chemistry and new opportunities for mechanization contributed to a new wave of agricultural efficiency and productivity. Fertilizers, herbicides and pesticides, crop spraying, tractors, the use of combine harvesters and the development and advent of various veterinary drugs all helped to turn farms into factory farms. With all these benefits, farms produced more food more cheaply and made more profits for landowners.

Precision or smart agriculture evolved here due to the need to monitor and more efficiently manage all inputs into crop production. The pursuit of precision agriculture and its associated agricultural technology has led to the development of new agricultural methods and tools.

The Global Positioning Satellite System (GPS) was the breakthrough technology that made this era of agriculture possible. GPS helps to find deviations in a given area for agricultural production, which allows for more effective use of available resources. This was the main reason why the idea of sustainable agriculture and a number of automation options emerged.

Agriculture 4.0, or connected agriculture

The leap from smart agriculture to connected agriculture is a good example of how quickly the production technology used in agriculture has moved forward at the turn of the century. Technology such as autonomous machines, sensor-equipped robots, augmented reality, Internet of Things (IoT), drones and satellites are part of the new agricultural environment, called Agriculture 4.0

Decision making in the agricultural sector is now based on data that is digitally stored and accessible through digital tools. With the help of this analyzed data, farmers and other major participants in the agricultural industry can make better decisions.

Agriculture 4.0 is born in an era of ubiquitous automation and digital connectivity. All developments in agricultural technology are becoming more and more integrated and networked, in order to optimize all stages of the production process and to strengthen the monitoring, management and control of the business.

It can be described as: "Integrated internal and external connection of agricultural operations", ie communication with external partners, such as suppliers and end users, as well as transmission, processing and analysis of all data.

At the same time, it also includes a number of concepts from which common terms have been created in the IT industry, but which are now also used in the field of agriculture.

Internet of Things (IoT) - a network of physical devices, vehicles, home appliances and other objects with embedded electronics, software, sensors, actuators and connectivity that allow these devices to connect and collect and exchange data

-In the same way that the Internet connects smart cities, the digitization of Agriculture 4.0 collects data through wireless IoT sensors that provide real-time information about the soil and the environment, including moisture, water absorption through the roots, the presence of nitrates, salinity, CO_2 in the

air, temperature and brightness, among other parameters. This technology also facilitates the exchange of information with IoT sensors on, for example, drones and satellites. In other words, they are all interconnected and interact with each other to optimize crops.
Through this wireless network, this data is immediately stored in the cloud computer and can be accessed from anywhere using a smartphone or computer. Furthermore, more experienced farmers who can learn advanced information techniques can share them with third parties, e.g. partners across the value chain.

- **Big Data** - a term that refers to data sets that are too large or too complex for traditional data processing application software to adequately process.

This digital tool facilitates automated analysis of data collected from various types of IoT sensors on crops and from any other sources, including drones and robots. And provides predictive information; data is interpreted and turned into actionable knowledge, enabling digital farmers to make informed crop and marketing decisions and thus gain a competitive advantage. To do that, a large volume of data must be generated quickly.

- **Artificial Intelligence** - intelligence demonstrated by machines, as opposed to the natural intelligence displayed by humans and other animals, as well as practices in IT - collaboration, mobility, open innovation

Digital agriculture applies artificial intelligence to automate and optimize tasks with the help of machines and
management software that processes and evaluates data and makes decisions in real time. One of the main areas of application of AI in this industry is machine vision. With information gathered from images captured by cameras and sensors (on fixed and mobile media), he makes decisions as if he were the digital farmer.

Key technologies and concepts

High-precision positioning systems (such as GPS and Galileo) are the key technology for achieving precision in off-road driving. With Galileo, Europe's global navigation satellite system, baseline accuracy will be obtained much faster and maintained more reliably.
Automated steering systems: enable specific driving tasks to be undertaken such as automatic steering, overhead turning, field edge tracking and row overlap. These technologies reduce human error and are the key to effective site management:
Driving assistance systems show drivers the road to follow in the field using satellite navigation systems such as GPS. This allows for more precise driving, but the farmer still has to steer.
Automated steering systems take full control of the steering wheel, allowing the driver to take their hands off the wheel during row trips and the ability to keep an eye on planters, sprayers or other equipment.
Geomapping: used to produce maps including soil type, nutrient levels etc in layers and assigning that information to a specific location in the field. (see picture on the left)
Sensors and remote sensing: collect data from a distance to assess soil and crop health (moisture, nutrients, compaction, crop diseases). Data sensors can be mounted on moving machines.
Integrated electronic communication between the components in the system, for example between the tractor and the farm office, the tractor and the seller or the sprayer and the sprayer. These systems are still mostly proprietary.
Variable Rate Technology (VRT): the ability to adjust machine parameters to apply, for example, seeds or fertilizers according to exact variations in plant growth or nutrients and soil type.
Blockchain technology
Just as the digitization of the agri-food sector is redesigning the value chain, blockchain technology improves traceability throughout the supply chain by storing all information in an immutable data

registry. Among other benefits, the introduction of this technology in agricultural practice will provide consumers with transparency regarding the origin, date of production and quality of the product. It can also be used to ensure food safety, as it quickly locates the source of the contaminant and sends health alerts for affected products. In short, Agriculture 4.0 delivers the best performance; it produces more with fewer resources, reducing costs in a way that is more sustainable for the planet.

Agriculture 5.0, or digital agriculture

Agriculture Technology 5.0, or simply put, "digital agriculture," refers to the next generation of agricultural methods and tools to maximize crop yields and other agricultural outcomes. One such technology is 5G, which is currently in the process of rapid development and will improve the reach and accessibility of the latest agrotechnical developments worldwide. Just as the industry brought a new an era of social responsibility in production, Agriculture 5.0 seeks to bring higher yields, but with more sustainable agricultural techniques that will be within the reach of every farmer.

Robotics, cloud computing, specialized software, and the Internet of Things are integrated into agricultural machinery using less labor, energy, chemicals, and destructive machinery. And, thanks to indoor and vertical farming techniques, to produce food without any access to conventional farmland.

Compared to previous farming methods, digital farming technology excels in the following aspects:

- efficiency of data collection: how much data can be collected in a certain time or space;
- data accuracy: how close the measurement is to the truth;
- timeliness: how quickly data can be processed into actionable information and reported to end users.

When it comes to weather, pests and diseases, farmers have little or no control. However, with the advent of digital technologies in agriculture, they can reduce the negative impact of these elements. Meanwhile, digital agricultural technologies give farmers the opportunity to greatly increase decision-making efficiency and returns to factors they directly control. Some examples are:

- what types of crops to grow;
- how to rotate crops for best results;
- when and how much water to use for precise irrigation;
- when, how much and what nutrients and plant protection products to apply;
- what type of tillage works best with a given type of soil

Agricultural experts agree that digital agriculture's most valuable tools and technologies in terms of competitive advantage are state-of-the-art farm management software, space-based solutions (especially those that provide high-resolution satellite imagery), proximal sensors, connectivity instruments and data such as and threat prediction algorithms.

Challenges for the development of Agricultural technologies

Demographics

One of the main problems is that we need to produce more from less. According to the UN, the global population is expected to grow from 8 billion in 2022 to 9.7 billion in 2050. This growth means that there is an increased demand for food, while the accompanying urbanization reduces the amount of land available for agriculture.

Plus, per capita food consumption generally increases as a country develops, further increasing demand.

Climate change

Changes in weather patterns are already affecting agriculture around the world. This is widely predicted to worsen, leading to further challenges around maintaining – never mind increasing – production.
Also, climate change will lead to competition for natural resources, such as water, which will make agriculture more difficult.

How to overcome these challenges?

Just as modern technology has massively changed every other aspect of our lives, today's development of intelligent agricultural robots is revolutionizing the industry like never before.
To perform agricultural tasks, agricultural robots must have a blend of intelligent decision-making, precise navigation and excellent dexterity.

Sensors

Sensors play a vital role in many of these processes. For example, sensors are needed to detect hazards that might impede the robot's movement, identify crops that are ready for harvest, and detect when the robot has grabbed a piece of fruit with enough force to pick it.
Sensors likely to be incorporated include touch, azimuth, ultrasound (for spraying), GPS, RGB, LiDAR, moisture and near-infrared spectroscopy (NIRS, for milk quality testing).

Sowing robots

By planting seeds in exactly the right positions and with minimal waste, there can be big production gains for farmers. Robots are being developed that can dig soil, plant seeds, add fertilizer and then water.
FarmDroid is one such seeding robot, which can also weed (see below). It is powered by solar panels and uses GPS to precisely record where the seeds are placed. This data makes it easier to weed between and within the rows later. The manufacturer claims that its solar panels can provide up to 24 hours of CO2-free operation.

Fieldwork robotics

Robots can harvest a range of crops, such as maize, rice and soft fruit. While the delicate nature of some fruits and vegetables has been a limiting factor for the use of robots in the past, improved sensor technology and precise movement mean this is no longer the case.
Field Robotics is developing horizontal and vertical harvesting robots for selective harvesting. Manufacturer Says: Manufacturer Says: “Precise redesign of sensor and holder technology minimizes slippage, significantly reducing harvest time. Using 3D cameras, sensors and machine learning, our robots pick fruit at the perfect level of ripeness, ensuring efficiency and precision.”

Drones

The use of drones in almost every sector of the economy is growing rapidly, but the use of drones in the agricultural industry is booming. According to some reports, the agricultural drone market is expected to grow from a $1.2 billion (USD) industry in 2019 to a $4.8 billion industry in 2024. years. Information collected by drones on farms is often used to better inform agronomic decisions and is part of a system commonly known as "precision farming".
In many areas, the use of drones has already become an essential part of large-scale precision agriculture operations. The data collected from the drone recording fields helps farmers plan their planting and treatments to achieve the best possible yields. Some reports indicate that using precision farming systems can increase yields by as much as 5%, a significant increase in an industry with typically thin profit margins.

Drone for monitoring plant health

One use of drone imagery that has already been demonstrated with great success is monitoring plant health. Drones equipped with special imaging equipment called Normalized Difference Vegetation Index (NDVI) use detailed color information to indicate plant health. This allows farmers to monitor crops as they grow, so any problems can be fixed quickly enough to save the plants. This image simply illustrates how NDVI works.

Drones that use "regular" cameras are also being used to monitor crop health. Many farmers already use satellite imagery to monitor crop growth, density and color, but access to satellite data is expensive and in many cases not as effective as closer drone imagery. Because drones fly close to fields, cloudiness and poor light conditions are less important than when using satellite imagery.

Satellite imagery can offer meter accuracy, but drone imaging is capable of producing accurate image location down to a millimeter. This means that after planting, areas of stand gaps can be noted and replanted as needed, and disease or pest problems can be detected and treated immediately.

Drone for monitoring field conditions

Drone field monitoring is also used to monitor soil health and field conditions. Drones can provide accurate terrain mapping, including elevation information that allows growers to find any irregularities in the terrain.

Having field elevation information is useful for determining drainage patterns and wet/dry areas that allow for more efficient irrigation techniques. Some agricultural drone vendors and service providers also offer soil nitrogen monitoring using advanced sensors. This allows for precise fertilizer application, eliminating weak growing spots and improving soil health for years to come.

Drone for planting and sowing

One of the newer and less widespread uses of drones in agriculture is for planting seeds. Automated drone seeders are mostly used in the forestry industry at the moment, but the potential for wider use is on the horizon. Drone planting means that very hard-to-reach areas can be replanted without endangering workers. They are also able to plant much more efficiently with a team of two operators and ten drones capable of planting 400,000 trees per day.

Spraying of agricultural areas

The use of drones to apply spray treatments is already widespread around the world. Drone sprayers are capable of navigating very hard-to-reach areas, such as steep high-altitude tea fields. Drone sprayers save workers from having to navigate fields with backpack sprayers, which can be hazardous to their health. Drone sprayers deliver very fine spray applications that can be targeted to specific areas to increase efficiency and save on chemical costs.

Currently regulations on drone sprinklers vary widely between countries. In Canada, they are not currently legal because more testing needs to be done to understand the impact of spray drift. Some regulatory proposals recommend that only trained professionals be tasked with flying spray drones, as is the case with Yamaha, which does not sell the spray drones it manufactures but rents out drone spray services complete with licensed operators.

Drone pollination

Some of the newer uses for drones in agriculture are still in testing and development. One of the most publicized (and often invented) uses is pollination drone technology that is capable of pollinating plants without damaging them. The next step is to create autonomous pollination drones that will operate and monitor crop health without constant instructions from operators.

AI drone

Another emerging drone technology also involves machine learning. Improving artificial intelligence (AI) in drones is important to make them more useful to small farmers in developing countries. Current drone technologies are more efficient at tracking familiar crops like corn planted in large monoculture fields.

Drone monitoring programs, as they stand, have difficulty recognizing areas of increased crop diversity, lesser-known products, and grains that look similar throughout their growth stages and are therefore less effective at monitoring crop growth and health. More work is needed to train AI systems to recognize rarer crops and more diverse planting patterns.

Irrigation by drone

New research also creates exciting opportunities for the use of drones in agriculture. As climate change increasingly affects drought conditions, creating more efficient irrigation solutions is vital. Using sensors that use microwaves, drones can capture very accurate information about soil health, including moisture levels, without plants getting in the way. This means that water can be distributed to the field in the most efficient way in an effort to conserve resources.

Safety

Drone security is a key link that is beneficial to farm management. Using drones to monitor remote parts of the farm without having to go there saves valuable time and allows for more frequent monitoring of hard-to-reach areas. Drone cameras can provide an overview of farm operations throughout the day to ensure operations are running smoothly and locate equipment in use.

Security drones can be used to monitor the fence and perimeter of more valuable crops like cannabis, instead of employing more security personnel. Drone cameras are also being used in exciting ways to protect farm animals by locating missing or injured herd animals in distant grazing areas. Observation of remote areas, which used to take hours of walking, can now be completed in minutes.

Conclusion

Drones have already greatly changed the agricultural industry and will continue to grow in the coming years. While the use of drones is becoming increasingly useful for small farmers, there is still a way to go before they become part of every farmer's equipment list, especially in developing countries. Regulations around the use of drones need to be drawn up and revised in many countries, and more research needs to be done on their effectiveness for certain tasks, such as pesticide application and spraying. There are many ways that drones can be useful to farmers, but it is important to understand their limitations and functions before investing in expensive equipment. Drone Deploy, an agricultural drone supplier and programming company, suggests starting small and slowly incorporating drone data into your organization for best results.

Negative impacts of agricultural technology: are there any?

While it is true that modern agriculture has reaped many benefits from technological development in terms of greater efficiency, lower costs and higher yields, there is another side to the coin, which is specifically related to large-scale extensive agriculture. The most significant are its harmful effects on nature.

The primary problems with agricultural technology that have a negative impact on the ecosystem are:

- soil and water pollution from the widespread use of pesticides;
- loss of biodiversity due to the elimination of indigenous species in favor of agricultural crops;
- the release of greenhouse gases, resulting from the clearing of forests to make way for agricultural land and the further overuse of machinery.

All the disadvantages of technology in agriculture are not related to the impact on the environment. Some are related to various aspects of adoption of agricultural technology by growers and their staff, namely:

- farmers who lack the necessary education and practical experience cannot work efficiently with machines and software, making them unable to take advantage of today's advanced agricultural technology;
- the maintenance costs of the machines are really high;
- the use of chemical fertilizers and pesticides can harm the health of farmers and other agricultural workers who work on the land.

As agricultural technologies enable us to meet the food needs of an expanding world population, it is clear that we cannot turn our backs on them. But we can make their negative effects less severe by using and improving precision farming techniques that go hand in hand with ecological practices.
Because these technologies have the potential to reduce or even eliminate the negative impacts of conventional farming methods, they help solve a wide range of environmental problems. In this way, industrial agricultural producers can gain two privileges: increase their competitive advantage and at the same time benefit from global long-term welfare.

IV. MODULE

Impacts on health, food and farm size

Module 4. Impacts on health, food and farm size

Climate has always changed due to natural influences. But it is indisputable that human activities, especially the use of fossil fuels, are the main causes of the increase in global temperatures and precipitation. The method of heating, that is, the use of firewood as a source of thermal energy, is one of the activities by which man disturbs the natural balance.
Of particular concern is the increasingly common unplanned cutting of trees, which reduces the forest stock and makes the process of carbon dioxide absorption and air purification impossible.
The soil becomes porous and susceptible to erosion from rainfall. At the same time, the use of firewood as a way of heating homes in households pollutes the ambient air that we all breathe during the combustion process.
Climate represents the meteorological conditions that prevail in a particular area during a long period of time. In fact, the climate is defined through a statistical analysis of the weather conditions, where the average values of the climate parameters (temperature, precipitation, humidity, atmospheric pressure, wind, etc.) and their variations over a longer period of time, usually the last 30 years, are considered.
Recently, more and more emphasis has been placed on the anthropogenic influence on the climate, that is, the influence that man has on it.

Human with his/hers activities, especially starting from the industrial period of development, begins to release large amounts of various gases into the atmosphere, and some of them (gases causing the greenhouse effect) cause global warming and climate change.

The planet is warming and will continue to warm.

According to global climate scenarios, warming will continue with increasing intensity. Even if the continuous increase in the content of greenhouse gases in the atmosphere stops, the planet will warm by 0.6oC by the end of this century.
Depending on the scenarios for the increase in the concentration of greenhouse gases, the temperature will rise between 2 and 6oC globally by the end of the century. So, how much the planet will warm up in the next period depends exclusively on man and his activity.
Air pollution produces cumulative negative effects on climate change, primarily due to the process of urbanization and extensive energy consumption.

All citizens of the planet earth are affected by the climate changes that are related to the use of energy.

Climate change has an impact on:

- Mortality and serious illness in humans
- Heat stress in cattle
- The yield of cereal crops
- The demand for cooling fluids
- Security of energy supply
- Range and Activities of Disease Transmitting Vectors
- Soil erosion
- The occurrence of floods;
- The occurrence of fires;

- The quality and quantity of water resources;
- The risk of infections and epidemics;
- Coastal erosion and damage to coastal infrastructure;
- Possibilities for moving;
- Conflict risks for safe drinking water**.**

Impact of climate change on health

Man is directly and indirectly exposed to the impacts of climate change. Climate change will cause consequences for human health worldwide, but the severity of these consequences will depend on the region and the ability of the population to prepare, cope with and recover from direct impacts, such as higher temperatures and heat waves. waves, droughts, floods and fires, and from indirect impacts, such as changes in vector-borne infectious disease risks, declines in crop yields, water shortages and population displacement.

Assessing the population's vulnerability to the impacts of climate change on health is the first step towards improving resilience to those impacts. The assessment can serve to identify the most vulnerable groups/individuals of the local population, to identify the biggest weaknesses in the health infrastructure - the differences in access to health services - and the shortcomings in the preparedness to deal with disasters in the region. Vulnerability assessment can help authorities determine the best strategies to improve population adaptation.

What diseases in the region may be affected by projected climate changes in the region, such as changes in temperature and precipitation?
Which population is most exposed to diseases influenced by the climate?
What are the risk factors/circumstances that influence those diseases?
What are the policies, strategies and programs aimed at reducing the impact of climate change on human health?

Data on health in the region were analyzed and linked to data on time variables over a certain period of time. Various statistical methods were used to determine relationships with exposure to weather or climate, taking into account factors that modify the condition and/or in some way influence it, such as current climate conditions, water supplies, food and nutrient production , as well as the socio-economic and health condition of the population.

The impact of climate change on human health will become more pronounced. Extremely high air temperatures, especially among the elderly, are directly related to the number of deaths caused by cardiovascular or respiratory diseases. Extreme weather events can destroy homes, medical facilities, and other essential assets needed for health care.

A large proportion of the population in vulnerable areas may have to relocate, which further increases the risk of infectious disease transmission and may cause additional health consequences. The change in rainfall patterns is expected to affect drinking water supplies, increase the number of floods and droughts, and threaten food supplies. There may be changes in the way water-borne and insect-borne infections spread.

In addition to the rise in temperature, due to the huge amount of energy accumulated on land and in water bodies, primarily the oceans, the atmosphere becomes more dynamic. This changes the variability of the weather conditions, that is, there is a possibility of greater deviations from the average values. Greater variability also brings with it extreme weather conditions (periods of drought, ice, floods...). Extreme phenomena will be even more frequent, more pronounced, stronger and more devastating, above all for highly vulnerable sectors such as agriculture, which are directly connected and conditioned by the climatic conditions themselves. A period awaits us in which the unexpected will become expected. After all, what we knew about 40 years ago as "eternal ice" is now melting, the sea level has risen by more than 20 centimeters, there are periods of drought in Northern Europe, heat shocks in Western Europe, followed by floods and fires everywhere. around us. And here. In recent years we have seen very late spring frosts, extremely intense rainfall that has caused heavy downpours and floods, more frequent occurrence of sunburn in crops, especially those with western exposure, wet summers, dry summers, emergence of new pests and new diseases in agriculture .

Mental health a target of climate change

A new report from the World Health Organization, presented at the Stockholm+50 conference, states that climate change poses a serious risk to people's mental health, which also coincides with a report from the Intergovernmental Panel on Climate Change, in which rapidly growing climate change is identified as a threat towards mental health and psychosocial well-being.

The World Health Organization defines mental health as "a state of well-being in which an individual realizes his potential, can cope with life's stresses, works productively and contributes to his community".

The consequences of climate change on mental health are expressed through stress and clinical disorders, such as anxiety, depression, post-traumatic stress, and suicide.

Other consequences include effects on everyday life, such as the perception and experiences of individuals and communities in trying to understand and respond to the implications of climate change.

The interdependence of climate, biodiversity and human societies, as well as the close relationship between temperature rise, ecosystem health, community well-being and sustainable development, are essential factors in understanding the overall consequences that climate change has on human health.

Instead of the planned reduction of harmful emissions and limitation of warming, which international agreements strive for, the level of carbon dioxide has increased, so they are 149 percent higher compared to pre-industrial levels, while July 3 of the current year has been declared the hottest day in history, taking global average temperature into account.

Harmful air particles cause damage to inflammatory cells in the nervous system, increase the risk of autism, reduce cognitive abilities and cause ADHD, increase the risk of dementia and Parkinson's disease. High temperatures, on the other hand, can cause irritability, as illustrated by a series of laboratory studies in which participants under controlled conditions reacted aggressively to uncomfortably high temperatures. Numerous cross-sectional studies using real-world heat and violence data provide the same evidence. More violent crimes occur in cities and regions with warmer temperatures than in cold regions, even after controlling for other sociocultural factors that drive violence, such as age, race, poverty, and honor culture. Researchers estimated that an increase of 1 degree Celsius in the average annual temperature leads to over 7.5 attacks and murders per 100 thousand citizens. Although prolonged heat waves, especially in populations ill-prepared to manage them, can also cause a large number of deaths, patients with psychiatric disorders are at increased risk due to the intake of drugs that prevent an optimal response to physiological heat stress .

The increase in global temperatures affects the population both in the form of localized disasters, but also through the long-term effects of recurring disasters and their consequences for the well-being, economic stability and infrastructure of the affected region. Extreme weather conditions destroy homes and workplaces and require significant recovery costs, lead to increased disparity in income among the population, and fuel resentment and conflicts that manifest through robberies and revenge, which further contributes to the recruitment of the population and encourages terrorism. In response to physical, economic or political instability caused by an environmental disaster, eco-migrations also occur, which can equally cause hostilities and conflicts due to sharply increased competition for resources in an area and newly created resentment.

Certain groups of people are at greater risk of adverse mental health consequences due to exposure to climate or weather hazards, and they include children, the elderly, women, people with pre-existing mental illnesses, the economically disadvantaged, and the homeless.
Children are more affected than adults and are more likely to have trauma-related symptoms long after the disaster. Disruptions in routines, separation from a caregiver as a result of evacuation or displacement, and parental stress following a disaster put children at risk for mental health consequences, including phobias, sleep disorders, attachment disorders, and lead to problems with emotion regulation, cognition, learning, behavior, language development, and academic performance. Together, this creates predispositions for adverse mental health outcomes in adults.
Children also show a high level of concern about climate change. Extreme heat is associated with an increase in aggressive behavior and domestic violence, and exposure to extreme heat can lead to increased alcohol use to cope with stress.
Approximately half of the world's population currently faces water scarcity due to a combination of climatic and non-climatic factors, droughts, floods and habitat change due to climate change lead to a net reduction in global food supply of approximately 1 percent per 1 degree Celsius of increased medium temperature.
Although starvation related to lack of food is a problem in itself, it creates additional harm because it contributes to aggression on an individual level. Studies have shown that malnutrition precedes antisocial behavior, aggression and violence in adulthood.
Despite the current state of affairs suggesting that the world is on the brink of climate catastrophe, and that current actions and crisis resolution plans are insufficient to prevent intense heat waves, droughts, floods, wildfires, sea-level rise and famine, an analysis of 100 national policies found that almost half did not mention climate change.
A World Health Organization survey conducted in 95 countries in 2021 found that only 9 countries included mental health and psychosocial support in their national health and climate change plans.
A new World Health Organization policy report provides guidance for countries to manage the impact of climate change on mental health, including integrating climate policies with mental health programs and developing community-based approaches to reduce their vulnerability.
In the future, interdisciplinary collaboration between psychologists, climatologists, political scientists and economists could lead to more examples of positive change, such as the improved provision of mental health services in the Philippines after Typhoon Haiyan, or the national project in India, which resulted was the readiness of cities to respond to climate risks and to address mental health and psychosocial needs.

Impact of climate change on food

Unfortunately, food production also releases large amounts of carbon dioxide, methane and other greenhouse gases in a variety of ways, including through deforestation and clearing land for fields and pastures, and then through the digestive processes of livestock. This may sound comical to you, but actually the explanation is very simple.
The beef industry is one of the major contributors to methane emissions. Methane accounts for about half of the total greenhouse gases emitted by this sector. Cows create methane in two main ways: through their digestion and through their waste. They are part of the group of animals called ruminants – exclusively herbivores. They obtain nutrients from plant food by fermenting the grass in their stomach before digesting it, mainly through microbial processes.
All the nutrients that these herbivores whose meat we eat come from plants. After all, all food comes from plants, even animals depend on plants. Hence, we also get our food from plants. Either directly (fruits, vegetables, nuts, legumes, etc.) or indirectly (through animal products).

Plants, which in photosynthesis use energy from sunlight to produce oxygen (O2) and chemical energy stored in glucose (sugar). They are the first link in transforming solar energy into chemical energy. And the human body runs on only one type of energy: chemical energy.
The process called "enteric fermentation" takes place in the rumen - part of the stomach of the herbivores that we consume. The rumen is home to a complex ecosystem of microorganisms. These include bacteria, fungi and protozoa. Some bacteria and protozoa break down sugar and starch from plants. Others break down the cellulose that makes up plant cell walls. Enteric fermentation occurs when bacteria break down complex carbohydrates into simple sugars. The end products of enteric fermentation by bacteria include volatile fatty acids (VFAs) as well as gases: carbon dioxide and methane.
Although carbon dioxide is much more abundant in the atmosphere than methane, methane traps approximately 30 times more heat than carbon dioxide.
Today on Earth there are more than 1.5 billion cattle - a number that would not even be close to today if man had not mixed his hands in natural selection. That is, if we humans would not put meat (and the other products we get from them) in a priority place in our diet, and hence we reproduce and grow these types of animals in enormous numbers.
In the food industry, the causes of climate change include the production and use of manure and manure (cattle manure) for the cultivation of cereals, as well as the use of energy for farm machinery or fuel for fishing boats, which is mostly fossil .
All of this makes food production a major contributor to climate change, even if we didn't include food packaging and delivery. Cheers to companies and food delivery people who choose to use bicycles as a means of transportation or electric vehicles!
Agricultural production takes place mainly outdoors and is very susceptible to weather conditions. At first glance, climate changes bring better conditions for agricultural production, a higher concentration of carbon dioxide should intensify photosynthesis, extend the vegetation season, increased active temperatures should bring opportunities for the cultivation of new, heat-loving crops, etc.
Yields are limited by the factor of production that is at a minimum. So, Macedonian crop production is limited by the lack of water. Due to rising temperatures, evaporation will be more intense in the coming period and crops will require more water for their growth. On the other hand, precipitation will decrease and have an even less favorable schedule. So the current low yields will further decrease. Even with the application of measures for adaptation to climate change, the reduction of yields is certain, primarily due to the low adaptive capacity in the country. Irrigation seems to be the optimal solution, but existing irrigation systems are sized based on an average dry year or a probability rate of 20%. These systems were built according to the climatic conditions of the past, when they could provide enough water in 8 out of 10 years without any problem. With climate change, this probability decreases even more and the systems will be able to meet the needs less and less. Drought is a regular occurrence in our country and producers have experience in dealing with it. As long as they can provide irrigation water.
However, the main expectations are that the amount of water in Macedonia will decrease, and the water needs in all production sectors will grow. Most likely, agriculture will not be able to continue using as much water as it currently consumes (over 70% of water is used in agriculture). All this will lead to water shortages and water conflicts, and agricultural production does not have the economic power to maintain the position of the largest water consumer in the future.
The problem of climate change in agriculture is not only related to water. In Macedonia, in addition to the lack of water, farmers also face:
Extreme weather conditions such as floods, drought, very high temperatures, late spring frosts, excessive insolation;

New diseases and pests characteristic of warmer regions are expanding their range and are already starting to appear in our country, and farmers do not know them and do not know how to deal with them;
The occurrence of heat stress in agricultural crops and the occurrence of sunburn after the fruits are becoming more frequent, which leads to a decrease in yields and their quality;
Cattle farmers are faced with new diseases that seriously affect their farms (blue tongue, nodular skin), which originate from warmer regions and are not characteristic of this region, which is why knowledge about them is limited. A loss in productivity is also suffered due to heat stress in domestic animals, reduced production of forage crops and an increase in the cost of animal nutrition.
Agriculture is the branch of the economy that is most sensitive to climate change. Agricultural production is directly related to climatic conditions, so small variations in temperature or humidity can lead to a drastic reduction in yields. As climate change affects agriculture, today's modern industrial agriculture contributes significantly to global warming, releasing large amounts of greenhouse gases.

Animal husbandry, and beef production in particular, is a major emitter of these gases. Also, the burning and cutting of forests, the conversion of meadows into arable land, the use of artificial fertilizers and pesticides, the burning of field residues, as well as the use of agricultural machinery have a large share in the emission of gases with a greenhouse effect. Industrial farms are particularly large emitters.
Unlike humans and animals, which have the possibility of faster adaptation and migrations due to climate change, such a reaction in plants is very slow. Plants are slow to adapt to changes in climate and when these changes occur at the rate they are happening today, plants are left at the mercy of the forces of nature. Although they have the ability to migrate, such migration is so slow that it is almost invisible to humans. An additional problem arises when climate change introduces new invasive species that, without natural enemies in the environment, are able to destroy large fields of monoculture crops that stretch from Canada to Australia.

Figure 15: Genetically modified food
Source: https://pixabay.com/

Human population growth seemingly requires a steady increase in agricultural production to feed a growing global population. Until now, the need for new arable land was solved by cutting down forests, especially the forests in the tropics, whose biodiversity is the richest. This further contributed to climate change, as vast areas of forests were burned and cut down, and they serve as natural regulators of the amount of carbon dioxide in the atmosphere. When it comes to climate change, the rule applies that everything that is taken is charged many times more expensive. The effects of climate change can be seen in reduced rainfall and every year thousands of hectares of arable land are turned into ever-expanding deserts. Because of climate change, there have been major changes in the rainfall regime, and while the amount of total rain water remains the same, long dry periods or strong flood waves appear more and more often. Such changes in the rainfall regime have already affected the reduction of yields per hectare in certain parts of the world.

Like capitalism itself, climate change does not affect everyone equally: the weak and poor suffer the most, while the rich may even profit initially. The most exposed to the effects of climate change are the countries of the Global South, which due to their geographical position are already bearing the consequences, and even more so due to the lack of money for climate change adaptation measures. In Europe, agriculture is under attack in the southern and eastern countries, which have been further weakened by the imposed austerity measures. Greek agriculture has seen a decrease in yields in the last few years, and agriculture in Spain, Portugal, Italy and other Mediterranean Eastern European countries is also under attack. On the other hand, Finnish agriculture has seen significant gains due to warming, and the situation is similar in other rich countries of the Global North.

Natural calamities, and in fact social disasters, have nothing to do with any higher forces, but can be predicted and can at least be influenced to mitigate them.

Genetically modified seeds are often offered as a solution to changing climate conditions and increasingly vulnerable agriculture. These seeds should be able to survive significantly harsher climates and produce quality fruit. With the use of licensed GMO seeds, farmers lose sovereignty over the seeds and are forced to buy GMO seeds every year from a few large corporations that have a monopoly on GMO products. The use of such seeds leads to a decrease in biodiversity and creates fields with monocultures, which we mentioned are highly vulnerable to invasive species. In addition, the safety of GMO products has not yet been fully proven and in some countries their production and distribution are still prohibited.

In the context of the climate changes that are happening, instead of relying on controversial genetically modified crops and corporations, apart from irrigation subsidies and the like, an urgent update of planning in agriculture is needed, because even today many farmers notice that the species that have succeeded in certain areas now they are looking for relocation to a higher altitude, more northern exposure, fresher land. These are some of the possible ways to at least slightly improve the quality of life of the rural population and save food sovereignty and oppose the GMO industry.

Regardless of the advances and technological innovations introduced in agricultural production, weather remains the most significant factor in food production. The fact is that global warming is affecting agricultural yields and those effects are already visible. In countries that base a large part of their economy on agricultural products, climate change is a reality and its impact on agricultural production is seen in food losses amid droughts, floods and other extreme weather conditions. That is why it is necessary to start as soon as possible with measures to reduce the emissions of gases with the greenhouse effect, but also with adaptation to climate change.

Lack of food

Climate change and extreme weather conditions are part of the reasons for the worldwide growth in the rate of hunger and malnutrition. Fish farms, crops and livestock may be destroyed or become less productive.

As the ocean becomes more acidic, the marine resources that feed billions of people are at risk. Changes in snow and ice cover in many regions of the Arctic have disrupted food supplies from livestock farming, hunting and fishing. The heat causes a decrease in water and therefore in the harvest of the agricultural land, but also in the pastures, which affects the livestock.

Impact of climate change on animal health and welfare

Climate change is a serious problem that can have long-term consequences in almost all spheres of human existence, and especially for the survival of the living world. If earlier it was thought that the European continent would cope with climate change more easily than the rest of the planet, this year 2022 showed that the entire planet is in danger. Namely, we have witnessed that this summer the level of the largest rivers in Europe is at its lowest level in the last 500 years. This will undoubtedly have a major negative impact on the economies of countries that use large rivers to transport their products. However, what is even more important, the satisfaction of water and food needs at the global level is seriously questioned, because the biggest negative effect of climate change is on agriculture.

It is predicted that by the year 2100 the global temperature of the Earth's surface will increase by 1.8-4.0°C. It is expected that this increase in temperature will contribute to a decrease in the number of livestock by more than 20-30%, as well as to the disappearance of some species of animals on the planet, which will undoubtedly have a huge impact on the biodiversity of the planet.

High temperatures and air humidity have a direct and indirect negative impact on the body of animals. The direct impact, first of all, is reflected by the appearance of heat stress. The appearance of heat stress in animals leads to a disturbance of the general state of health and has a negative impact on the secretion of hormones, production, reproduction, the immune system and the biological rhythm of animals. In general, high-producing cows are more sensitive to heat stress than low-producing cows. The negative impact of heat stress on the biological rhythm of animals can be controlled through the level of melatonin in the body. Melatonin treatment is an effective and safe manipulation method in breeding some photoperiod-sensitive animal species, such as sheep, goats and deer. In that way, it is possible to influence the time of food consumption during the day and night, that is, animals eat in the cooler periods of the day.

In addition, animals exposed to heat stress change their behavior in order to reduce the heat load on the body. So, for example, animals look for shade, reduce the amount of food consumed, spend more time standing, especially near drinking fountains or in general to a source of water, increase the respiratory rate, and more.

The indirect impact of high temperatures and air humidity on animals refers to the increase in the occurrence and spread of many infectious diseases, primarily due to the creation of favorable conditions for the development of various vectors - carriers of diseases in animals and humans.

V. MODULE

Mitigation and adaptation measures

Module 5. Mitigation and adaptation measures

Mitigation measures

Mitigation or activities to mitigate climate change in the agricultural sector mean the measures that will contribute to the reduction of greenhouse gas emissions from agricultural production.
Mitigation measures in agricultural production include the application of sustainable examples that will enable:

- increase in vegetative cover,
- improving the ability of the soil to bind carbon in organic form,
- application of moderate amounts of organic fertilizers,
- reducing the use of mineral fertilizers,
- proper waste management,
- use of biogas and others.

More important mitigation measures in agriculture that contribute to the reduction of greenhouse gas emissions are the following:
Weeding of perennial plantations. The purpose of this measure is to prevent or reduce the erosion of soils on sloping terrain, to improve the structure and ability of the soil for infiltration of water from precipitation and irrigation, to increase the content of organic matter in the soil and others.
Replacement of classic tillage with reduced soil tillage. This measure aims to avoid the overturning of the soil, which leads to the destruction of its structure, to reduce the intensity of decomposition.

Picture 16: Reduced tillage
Source: Own photo

Correct management of domestic animal excrement (storage, transport and field application). The aim of this measure is to directly reduce the emission of greenhouse gases.
Adding organic waste to the soil or applying green manure (sideration). The goal is to increase the content of organic matter in the soil and to improve the water-physical properties of the soil.
Application of the cultivation system known as agroforestry. The purpose of this measure is to stop the intensive processes of erosion and soil destruction, but also to bind large amounts of CO_2 from the atmosphere in the above-ground and underground vegetative mass of plants on abandoned lands where the vegetation cover has been degraded.

Measures for adaptation of agriculture to climate change

They mean initiatives and activities for the reduction of natural systems and humans towards the real or expected consequences of climate change. For the correct selection and effective implementation of measures for adaptation to climate change, it is important to know their effect and the conditions in which they will be applied. There are numerous activities that individual farmers can apply in different segments of production (autonomous adaptation).

Measures that contribute to the adaptation of agriculture to climate change include:

- water management measures,
- soil management measures,
- waste management measures,
- selection of varieties,
- installation of safety nets,
- organic farming and others.

Water management measures

Water management measures should ensure water conservation and its efficient use.
The projected shortage of water as a resource is one of the biggest problems expected to arise as a result of climate change, so it is necessary to make adjustments to the ways in which water is used in agriculture.
It is very important in the coming period to examine the possibilities of recycling waste water, collecting rain water and other methods of saving water.
Water-saving measures include the selection of drought-resistant crops, application of irrigation during critical stages of plant growth and development. With these measures, it is necessary to replace old and unsustainable irrigation techniques with new, efficient and economically viable systems.
The use of the "drop by drop" system for irrigation of agricultural crops represents an excellent opportunity to save water (Fig. 2). The use of this irrigation system to cope with climate change compared to other systems has a number of advantages:

- uses very little water,
- eliminates surface evaporation,
- can be used for simultaneous automatic watering, fertilizing and plant protection,
- reduces the possibility of diseases and pests,
- reduces the need for labor and more.

It is necessary to investigate the possibilities of wastewater recycling, rainwater harvesting and other water saving methods. Conservation measures include the selection of crops that are resistant to drought, as well as the application of irrigation at critical stages of plant growth and development. It is necessary to replace the old, unsustainable irrigation techniques (in furrows) with new, efficient and economically viable systems.
Compared to furrow irrigation which has 60% effective utilization of the water used, and the application of artificial rain 75%. The main reasons why the drip system is the most suitable for dealing with climate change is that it uses the least amount of water while eliminating surface evaporation.
Through the drip system, fertilization can be done, as well as some forms of plant protection. This technology is recommended for regions with seasonal droughts.
With overall water savings and labor savings, the costs of agricultural production are reduced. Also, this technology reduces the spread of diseases and pests and thus has an integrated effect on reducing the consequences, as well as easier handling of other aspects of climate change.

Picture 17: Drip system
Source: Own photo

Soil management measures

Soil adaptation measures should be aimed at solving the basic problems caused by climate change such as erosion and reduction of organic matter. Fertile soil is necessary for productive agriculture, so the sustainable management of this natural resource is of particular importance. Producers have numerous opportunities available to them to apply sustainable soil resource management practices.

Soil management measures should address the fundamental problems caused by climate change: soil degradation and increased soil erosion. These measures should enable the creation and retention of soil fertility. Measures for sustainable soil management include:

- **Reduced tillage**. The intensive processing and utilization of the soil, which is used in modern horticultural production, contributes to changing its natural structure, increased erosion, reduction of organic matter and microbiological activity and fertility of the soil. Reduced cultivated soil (protective plowing) as a measure to deal with climate change, should prevent or reduce these harmful impacts and preserve soil fertility. With the reduced processing, one third of the plant residues remain on the field, which enables the reduction of erosive processes and the conservation of moisture in the soil. Reduced processing can also be performed without plowing, whereby plant residues from the previous year are completely left and direct seeding is applied to them. Research shows that this method of processing is appropriate and successful in the production of grain, garden, fruit and grape crops.

Picture 18: Conservation plowing
Source: Own photo

For soil conservation, it is also recommended to eliminate plowing, which implies leaving the plant residues from the previous year and applying direct sowing on them. In addition to prevention of erosion, the pressure from fast-growing weeds is also reduced in this way. Application of these techniques reduces production costs (fuel, depreciation) on the one hand, and on the other hand reduces the consequences of drought due to reduction of erosion and ensuring soil moisture conservation.

- **Mulching** is also another soil management measure, a widely known practice of artificially covering the soil surface. The materials used for mulching can be of organic or inorganic origin. If organic matter is used, it should be applied in thinner layers, otherwise anaerobic processes are created, which release poisons for plants and soil microorganisms.

Of the inorganic materials, the most widespread is the plastic film, which is offered in different thicknesses and different colors. The advantages of applying mulching are multiple:

- the emergence of weeds is prevented
- the soil is protected from drying and hardening, and the capacity for preserving humidity increases
- the biological activity of soil microorganisms is retained and increased
- temperature oscillations are mitigated
- the soil structure is maintained and erosion is prevented, thereby preventing the leaching of nutrients
- saving of irrigation water is ensured

Picture 19: Mulching
Source: Own photos

Cover crops are plant species that are sown between the rows in the plantation in order to reduce problems with erosion, fertility and soil quality, to reduce the pressure from the appearance of weeds, pests, diseases, as well as to maintain biodiversity in agroecosystems. Cover crops can also be sown on empty areas, due to the effect of green manure and enrichment of the soil with organic matter.
The selection of plants should be done carefully. First of all, they should develop well in the climatic conditions suitable for the region, and the plants should not demand too much from the soil and accumulate more biomass in a short time.
It should be emphasized that cover crops use a large amount of moisture and therefore should be applied in wetter areas or under irrigation conditions. The method of application is determined depending on their place in the crop rotation and the way of using the resulting green mass. Therefore, cover crops can be applied throughout the year, as a subsequent main crop of the crop, as a previous crop or by sowing as an annual or biennial, together with the main crop.
Although this measure initially increases irrigation costs, the positive effects are felt over many years.

Picture 20: Cover crops
Source: Own photo

Manure management measures

Improper use of mineral fertilizers, and especially nitrogen fertilizers, has a significant negative impact on increasing climate change. Fertilization should correspond to the nutrient needs of vegetable crops and maintain optimal soil fertility with minimal environmental pollution.

When fertilizing, preference should be given to nitrogen fertilizers that are in the form of ammonium ions, which will contribute to the reduction of greenhouse gas emissions. The use of organic waste is particularly noteworthy, which enriches the soil with organic matter and improves its biological activity and fertility.

The use of organic and mineral fertilizers is an effective way to manage soil fertility and crop production. Fertilization should match the nutrient needs of crops and maintain optimal soil fertility with minimal environmental pollution. Under conditions of climate change, there is a high risk to the availability and utilization of nutrients by plants. Research shows that the use of nitrogen fertilizers in the form of ammonium ions, instead of the often used nitrate forms, has numerous advantages in the development of plants, but also in the reduction of greenhouse gas emissions from agriculture. The application of organic manure is strongly recommended because it enriches the soil with organic matter and, in combination with other techniques, can give strong positive effects in improving its biological activity and quality.

Picture 21: Organic fertilizer
Source: Own photo

Selection of varieties

One of the basic conditions for successful crop production is the correct choice of variety. Apart from the productive and quality properties of the variety, farmers should take into account the biological requirements of the variety and the environmental conditions prevailing in the production region, in order to make a correct assessment of the possibilities for successful production. According to the predicted climate scenarios for our country, it is recommended to choose appropriate varieties that will be resistant to drought or to replace the species with others that have lower requirements in terms of irrigation.

In fruit growing and viticulture, grafting is standard practice. However, numerous advantages of seedling grafting have been established in horticultural production, especially for the production of fruit crops (tomato, pepper, eggplant) due to the introduction of resistance to abiotic and biotic stress. And in this case, it is necessary to choose substrates that will be suitable for the existing environmental conditions and will enable stable growth, development and quality yield of the nursery stock.

In order to achieve high and quality yields, the selection of the substrate in fruit production is essential. The basic requirements in fruit production when choosing the substrate are:

- Resistance to diseases and pests;
- Adaptability to soil and climate conditions;
- Good rooting;
- Longevity;
- Suitability for intensive cultivation systems;
- Ensuring constant and quality fertility.

The agroecological conditions in Macedonia impose the need to use fruit rootstocks that have a high tolerance to soil moisture deficit, that is, they must be resistant to drought.

Installation of safety nets

The application of protective nets in agricultural production, as a relatively new technology, has spread globally in a short time. And in our conditions, their application is more common due to the numerous benefits in plant production. Depending on the needs, nets with different densities are available on the market, which can provide up to 90% shading. Apart from light regulation as a factor, they also provide crop protection from other external influences such as hail, strong winds, strong solar radiation, etc.

Research shows that the use of nets affects the microclimate in the plantations, reducing air temperature and reducing moisture loss. In addition, the nets can provide protection from insects and birds. They are suitable for use in gardening, fruit growing, viticulture, as well as production of flower and spice species.

Research confirms that color also has an impact on the quality of crops, their size, durability, as well as the ripening period, through the management of the solar spectrum, the way of distribution and the intensity of light. The introduction of safety nets is a relatively simple and economically viable investment.

The installation of protective nets in the plantations is a promising, new technology that needs special attention in the future.

Protective nets are a novelty for our producers, while in developed countries, especially for high income crops, it has long become a common practice.

The reasons for installing safety nets are numerous. With them, agricultural producers fight against natural elements such as hail, drought, high light intensity and high temperatures.

The main motivating factor for the installation of the protective nets is the fight against hail, and as a secondary goal is the shading of the plants, thus reducing the sun burns of the fruits and leaf mass, which cause huge financial losses for the producers all over the world.

Protective nets also play a role in changing the microclimate in the plantations. In plantations covered with a net, the relative humidity of the air increases, the light and temperature in the plantation are reduced, thus reducing the conditions for moisture loss through transpiration and evaporation.

Picture 22: Safety nets in viticulture
Source: Own photo

Covering nets are increasingly used in the protection of vineyards. They have a multipurpose function:

- Protection from hail;
- Protection from direct solar radiation;
- Protection from spring frosts.

Nets of different density and color are in use. White nets reduce harmful ultraviolet radiation by 8 to 12%. The yield and quality of the grapes decrease linearly with the increase of shading intensity. In regions where there is a critical number of sunny hours, the use of white nets is recommended.

Picture 23: Netting in fruit growing
Source: Own photo

The network also plays a role in reducing heat radiation from the soil, as a result of which the damage from late spring frosts is reduced. Other benefits associated with the installation of protective nets are a reduction in wind speed, up to 50%, which allows for a more efficient application of protective agents in plantations. It follows from this that in plantations covered with a protective net, the overall environment for the normal development of all processes in the plants is improved.

Organic production

Organic production represents a significant measure for mitigation and adaptation of agriculture to climate change, as it promotes and practices the combination of sustainable examples from practice that should ensure the rational use of natural resources.

Numerous studies show that the emission of greenhouse gases from organic production is lower compared to conventional production. This is due to the application of combined soil protection measures (organic waste, production of leguminous species, crop rotation, mulching, etc.). The non-use of synthetic fertilizers and protective agents also plays a role in the reduction of emissions, because large amounts of energy are consumed during their production.

Nitrogen oxides, which are a big problem in conventional production, are also reduced in this way due to the non-application of mineral nutrition, at the expense of the use of organic fertilizers and additional measures to improve and maintain the fertility of the soil, while achieving large yields. And organic animal production has low greenhouse gas emissions due to the fact that the standards require an adequate number of animals per unit area, and consequently excessive amounts of agricultural waste are not produced.

Animal nutrition is based on reduced protein intake and increased vegetable fiber intake, which facilitate the digestive process. The system of organic production promotes the application and combination of sustainable practices that ensure the rational use of natural resources, which is why it is included in the measures for mitigation and adaptation of agriculture to climate change.

VI. MODULE

Local agricultural practices

Module 6. Local agricultural practices

Soil conditions

Climate change and intensive agriculture will intensify the process of soil degradation. An increase in soil temperature will result in an accelerated decomposition of organic matter in the soil, a decrease in the stability of soil particles and the amount of macropores, a significant increase in evapotranspiration, but also an increase in the water requirement of plants.

Picture 24: Effects of climate change
Source: https://unsplash.com/

Soil management measures should address the fundamental problems caused by climate change: soil degradation and increased soil erosion. Good soil practices include:

- maintaining and improving the organic ingredients in the soil by using the accumulated reserves with an appropriate crop rotation,
- use of organic fertilization,
- pasture management and other land use practices,
- maintenance of the soil cover, and to ensure a suitable environment for soil microorganisms and
- to minimize soil loss from wind and water erosion.

Measures for sustainable soil management include:

- **Reduced tillage**. The intensive processing and utilization of the soil, which is used in modern horticultural production, contributes to changing its natural structure, increased erosion, reduction of organic matter and microbiological activity and fertility of the soil. Reduced tillage (conservative plowing) as a measure to deal with climate change should prevent or reduce these harmful impacts and preserve soil fertility. With the reduced processing, one third of the plant residues remain on the field, which enables the reduction of erosive processes and the conservation of moisture in the soil. Reduced processing can also be performed without the use of plowing, whereby plant residues from the previous year are completely left and direct seeding is applied to them.

- **Mulching**. This is a measure that adds cover to the soil surface. Materials of organic and inorganic origin are used for mulching. Mulching can be used to prevent the emergence of weeds, protect the soil from drying and hardening, increase the capacity of the soil to conserve moisture, retain and increase the biological activity of soil microorganisms, reduce temperature oscillations, prevent erosion and washing. of nutrients and maintenance of soil structure, but also to save irrigation water.

Picture 25: Mulching
Source: Own photo

Water

It is expected that the greatest impact from climate change will be observed through water, as a result of the reduction of the annual amounts of water available for agricultural activities. Under the influence of climate changes, changes in the quantity and quality of available water are expected, and with an increase in temperature, the evaporation of surface water will increase. Climate change will also contribute to the reduction of soil moisture, due to the variability of precipitation and its reduction. The occurrence of intense rain or drought caused by climate change will result in enhanced erosion processes due to the occurrence of floods or fires.

Picture 26: Irrigation
Source: Own photo

Cultivation of agricultural crops on the largest part of the country's territory is impossible without additional irrigation. On the other hand, due to the frequent heavy rains that often coincide with periods of increased humidity, agricultural areas, especially along larger river flows, are often subject to flooding with large economic losses after production. Hence, expansion and rehabilitation of existing and construction of new irrigation systems is a policy priority, especially in terms of the expected negative effects of climate change, which will influence an increase in irrigation needs on the one hand, and a decrease in the available amount of irrigation water. on the other hand.
Water is a scarce and sensitive resource, the use of which is necessary to be realized rationally and efficiently, especially in the context of the increased impact of climate change. Mitigating the negative effects of climate change through adaptation measures is also one of the goals of investments in water management. In that direction, with the support of FAO, it is planned to prepare the "Irrigation and Drainage Strategy of the Republic of North Macedonia", which will define the directions and directions

for development, taking into account the degree of utilization of the systems and the efficient and rational use of irrigation water. in the next ten-year period 2021-2031.
The anticipated shortage of water as a resource is one of the biggest problems expected to arise as a result of climate change, so it is necessary to make adjustments to the ways in which water will be used in agriculture. Water management measures should ensure water conservation and its efficient use.
It is very important in the coming period to examine the possibilities:

- for waste water recycling,
- for rainwater collection and
- other methods for saving water.

Water conservation measures include

1. Selection of crops that are resistant to drought
2. Application of irrigation in the critical stages of plant growth and development.

With these measures, it is necessary to replace old and unsustainable irrigation techniques with new, efficient and economically viable systems. The use of the "drop by drop" system for irrigation of agricultural crops is an excellent opportunity to save water.
Introducing a drip system. Compared to furrow irrigation, which has 60% effective use of water used, and the application of artificial rain 75%, drip systems use as much as 90% of water used. The main reasons why this technology is most suitable for dealing with climate change is that it uses the least amount of water while eliminating surface evaporation. Fertilization can be done with the drip system, as well as some forms of plant protection. This technology is recommended for regions with seasonal droughts, as is the case in our country. Given the possibility to install timers that will automatically carry out the watering, it can be timed at times when there is the lowest demand for water (eg early morning). With overall water savings and labor savings, the costs of agricultural production are reduced. It has also been proven that this technology reduces the spread of diseases and pests and thus has an integrated effect on reducing the consequences, as well as facilitating the handling of other aspects of climate change..

Pictrue 27: Drip system
Source: Own photo

Concentration of CO_2

With climate change, an increase in the concentration of CO_2 is expected, which in turn will contribute to an increase in the photosynthetic activity of plants, and thus accelerated growth and an increase in the yield of vegetable plants. However, this phenomenon can have a positive effect only if other environmental factors are optimized (favorable temperatures, sufficient water, optimal light), which is very difficult to achieve in the conditions of climate change. With climate change, an increase in temperatures is expected.
If this increase is within the optimal limits, it can be expected to have a favorable effect on the growth of vegetable plants and enable the shortening of the vegetation period. However, temperatures higher

than the optimum and heat waves will have a strong negative effect on vegetable plants and will cause a disturbance in certain stages of plant development (overplanning, rejection of flowers), thereby reducing or failing yields.

Selection of varieties

One of the basic conditions for successful crop production is the correct choice of variety. Apart from the productive and quality properties of the variety, farmers should take into account the biological requirements of the variety and the environmental conditions prevailing in the production region, in order to make a correct assessment of the possibilities for successful production.
According to the predicted climate scenarios for our country, it is recommended to choose appropriate varieties that will be resistant to drought or to replace the species with others that have lower requirements in terms of irrigation.
It is recommended to choose suitable varieties that will be resistant to drought or to replace them with others that have lower requirements in terms of irrigation. Varieties should be suitable for existing environmental conditions and enable stable growth, development and quality yield.
Seedling grafting in horticultural production has many advantages because it allows greater resistance to abiotic and biotic stress in plants. In fruit growing and viticulture, grafting is a standard practice.
However, numerous advantages of seedling grafting have been established in horticultural production, especially for the production of fruit crops (tomato, pepper, eggplant) due to the introduction of resistance to abiotic and biotic stress.
And in this case, it is necessary to choose substrates that will be suitable for the existing environmental conditions and will enable stable growth, development and quality yield of the nursery stock.

Installation of safety nets

The application of protective nets in horticulture, more recently in viticulture is a relatively new technology and is expanding very rapidly. The use of the protective net ensures light regulation and protection of crops from other adverse external influences (hail, strong winds, strong solar radiation, etc.), as well as protection from insects and birds.

Crop rotation

Crop rotation refers to the practice of growing a range of plant species on the same land. It is an ancient practice that has been used for thousands of years. Crop rotation has regained global attention to address increasing agro-environmental problems such as soil quality degradation and climate change resulting from short rotation and monoculture cropping.
As an example of the positive effect of crop rotation, when rice was grown in rotation with maize and sweet sorghum in the dry season, a significant reduction in greenhouse gas emissions was observed by 68-78% compared to double rice cropping. Crop rotation is a sustainable approach that increases yield and water use efficiency while reducing soil erosion.

Organic farming

Organic production represents a significant measure for mitigation and adaptation of agriculture to climate change, as it promotes and practices the combination of sustainable examples of practice that should ensure the rational use of natural resources.
In organic horticultural production, efforts are made to reduce soil cultivation, that is, to reduce the movement along the soil surface and the depth of plowing the soil. This is achieved by reduced tillage. Reduced tillage contributes to reducing the possibilities of erosion, more rational consumption of water, reduction of the destruction of structural aggregates, increased efficiency of fuels used for agricultural machinery.

Combined soil protection measures are applied in organic gardening, the use of synthetic fertilizers is prohibited, mineral fertilizers obtained by chemical means are prohibited for use in organic gardening. In organic production, it is allowed to use mineral fertilizers of natural origin only. The mineral fertilizers used in organic gardening are: raw phosphates, wood ash, gypsum, marl, limestone, clay, sulfur and others, which prevent soil pollution and the emission of greenhouse gases.

Numerous studies show that the emission of greenhouse gases from organic production is lower compared to conventional production. This is due to the application of combined soil protection measures (organic waste, production of leguminous species, crop rotation, mulching, etc.). The non-use of synthetic fertilizers and protective agents also plays a role in the reduction of emissions, because large amounts of energy are consumed during their production.

Nitrogen oxides, which are a big problem in conventional production, are also reduced in this way due to the non-application of mineral nutrition, at the expense of the use of organic fertilizers and additional measures to improve and maintain the fertility of the soil, while achieving large yields. And organic animal production has low greenhouse gas emissions due to the fact that the standards require an adequate number of animals per unit area, and consequently excessive amounts of agricultural waste are not produced.

Animal nutrition is based on reduced protein intake and increased vegetable fiber intake, which facilitate the digestive process. The system of organic production promotes the application and combination of sustainable practices that ensure the rational use of natural resources, which is why it is included in the measures for mitigation and adaptation of agriculture to climate change.

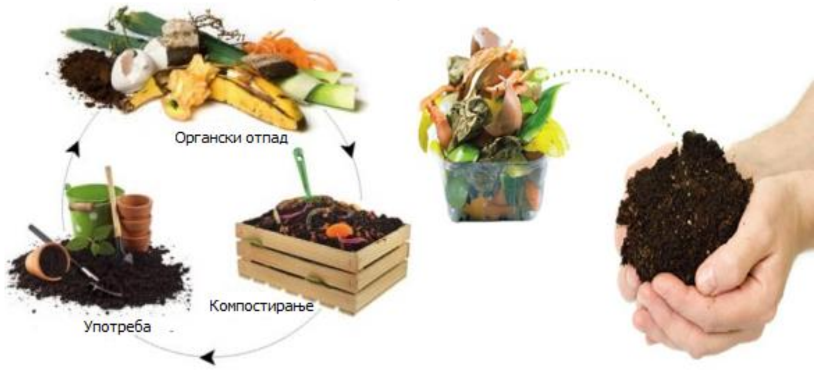
Traditional organic composting

Greenhouse gas emissions caused by fertilizers are the largest source of total greenhouse gas emissions from the agricultural sector. Inorganic nitrogen (N) fertilizers contribute to approximately 75% of the direct emission from agricultural soil. In addition to contributing to greenhouse gas emissions, nitrogen fertilizers reduce soil microbial activity and bacterial diversity.

On the other hand, the use of organic compost is a sustainable and climate-smart approach to increasing soil fertility. The use of composted organic waste to improve soil fertility and productivity is receiving enormous attention worldwide.

Composting is a traditional practice that has been used for centuries. Composting refers to the natural process of rotting or breaking down organic matter by microorganisms under controlled conditions. It is a biochemical process in which microbial degradation of organic waste results in a product known as organic manure or compost. Composting is a sustainable approach to organic waste management. It not only removes waste but also transforms the waste into a nutrient-rich organic product that can be used to improve soil fertility.

Various organic materials are used in the composting process such as straw, crop residues, agro-industry by-products, livestock waste, sewage sludge and kitchen waste.



Picture 28: Composting
Source: Own photo

VII. MODULE

Practical dealing with climate effects

Module 7. Local agricultural practices in conditions of climate change

Measures of mitigation and adaptation to climate change in the agricultural sector

Agriculture is particularly vulnerable to climate change, considering that this production is a "factory under the sky". In agriculture, plant production (agriculture, horticulture, fruit growing, viticulture), as well as animal husbandry and fishing, and through them also food production, is particularly threatened. Irregularity in the supply chain of raw materials for the food industry causes economic and social insecurity.

Concrete measures of adaptation and offered practical solutions for some of them.

Flood adaptation measures	Construction of drainage systems Construction of reservoir lakes and pools Embankment raising Restoration of wetlands Restoration of wetlands Afforestation Agricultural damage insurance
Adaptation measures in fruit growing and viticulture	Use of anti-hail nets Increased intake of manure and other organic fertilizers in the soil for fertility and better water retention Use of irrigation systems Cultivation of the inter-row space in order to reduce water consumption on flat land Introduction of alternative early varieties and table variety Increased monitoring of the occurrence of weeds and diseases
Adaptation measures for extreme weather events	Construction of anti-hail nets/shading nets Cultivation of early varieties Introduction of new varieties/cultures tolerant to high temperatures Introduction of multiple crops in crop rotation Application of high yielding varieties and hybrids Increase in the areas under winter crops Shifting the time of sowing Reducing tillage Introducing a system of wind protection belts, against snow drifts, wind blows and to preserve moisture in the soil
Measures of crop adaptation during drought	Cultivation of crops under irrigation system Increasing water capacities by using water from canals/well/pits reservoirs for water supply Using drainage channels for irrigation introduction of varieties/hybrids resistant to drought and heat Raising nets for shading in order to save water and lower temperatures Elevation of wind protection belts in order to reduce wind erosion, drying lands and ensuring uniformity of irrigation Agricultural insurance against drought damage
Adaptation measures in animal husbandry	Cooling of stables and chicken houses Provision of water for watering the goods Water cooling in fish ponds Provision of alternative food due to reduction of pastures Breeding of aphthochtonous breeds that are easier to adapt Increased veterinary surveillance due to the emergence of new diseases

Agricultural technology

Time and method of tillage

Of all economic branches, agriculture is the most threatened by the negative impact of climate change.

In order to adapt to the new circumstances, FAO experts are particularly committed to the application of conservation agriculture technology.

The basis of this technology is based on the combined application of three principles: **direct sowing** (without classical plowing), **permanent covering of the soil** (with residues from the previous harvest) and **crop rotation**.

Reduced technology is a system of soil cultivation in which 15-30% of plant residues remain on the surface of the land, while in conservation technology (including direct sowing) more than 30% of the soil is covered with plant residues (Nozdrovicki, 2008).

This tillage technology has great potential for farms of all sizes, although its application is of greatest importance to smallholdings and those facing labor shortages.

Table 2. Advantages and disadvantages of conservation systems

Advantages	Disatvantages
Reducing farm costs, saving time, human labor and machinery; Increasing soil fertility by conserving moisture which increases yields, reduces yield variability and enables reliable food production and supply; Soil conservation and erosion protection measures lead to a reduction in soil erosion; Reduction of air pollution resulting from machines used in tillage; Reduction of CO2 emissions in the atmosphere (carbon sequestration) Protection of biodiversity.	Procurement of specialized sowing machines; Short-term problems with pests due to changes in crop cultivation; Acquisition of new management skills; High risk for farmers due to technological uncertainty; Development of adequate technical packages and trainings;

Different forms of conservation or reduced tillage have different effects on soil organic matter accumulation.

In principle, shallower and simpler processing with fewer procedures or when they are completely omitted, contributes to the accumulation of organic matter in the soil, especially in its surface layer.

According to Kovačević (2004), conservation systems of crop production are based on specific changes in cultivation technology, conditioned primarily by the nature of land cultivation.

The essential principle of their functioning is the significant reduction in the number and intensity of processing operations or their complete omission. In doing so, the entire mass of plant remains is retained on the soil surface.

Table 3. Classification of possible soil conservation systems that can be used in organic agriculture (Kovacevic and Oljaca, 2005)

Form of conservation processing	Concept, strategy / tool
Protective processing	machining with a chisel peeling/trimming processing with combined tools - multivator/ultitiler robust dams rotary cultivators
Partial processing	Processing of tapes Processing in the sowing zone Tearing in/between the lines Bank processing
Bank processing	Mound processing Processing of lei
Direct sowing	System of chisel investors A system of knife-edge investors

	A system of rotating investors A system of hoe investors Duck's foot system Inverted T cutting system

RECCOMENDATION:

For soil conservation, the elimination of plowing (no-till) is recommended, which implies leaving the plant residues from the previous year and applying direct sowing on them. In addition to prevention of erosion, the pressure from fast-growing weeds is also reduced in this way.

Application of these techniques reduces production costs (fuel, depreciation) on the one hand, and on the other hand reduces the consequences of drought due to reduction of erosion and ensuring soil moisture conservation. In addition, the biological activity of the soil and its fertility are stimulated.

Time and methods of sowing

By applying a complex of appropriate agrotechnical measures, it is possible to mitigate them, but not to completely exclude the negative effects of drought.

The most important of those ***agrotechnical measures*** are:

- crop rotation,
- processing,
- fertilization,
- mulching,
- variety selection,
- sowing time and planting density,
- weed control and
- construction of agro-protective forest belts.

For each crop grown in a particular habitat, there is an optimal sowing period that is adjusted according to regional and local conditions. The time of sowing changes the rhythm of development, and especially the length of the vegetative phase and the period of formation and filling of the grain, which significantly affects the yield of cultural crops.

In any habitat, the rule applies that crops should be sown as early as possible within the limits of their optimum dates.

Sowing should start with late and end with early genotypes. Sowing at the optimal time is especially important in drought conditions because it ensures better growth and development of the crop and makes better use of the pre-vegetation moisture reserves of the soil.

Intensive cultivars and hybrids should be grown more densely than extensive genotypes under drought conditions.

Growing corn in a denser assembly leads to a reduction in yield by 30-50%, and on sandy soils with poor water retention, it can suffer completely. The same is the case with other trench crops, while sunflower suffers less from the effects of drought in dry years.

Rainfall amounts during the growing season can meet the water needs of plants with a frequency of 10-30%.

That is why it is necessary to know the pre-vegetation moisture reserves in the soil up to two meters deep when planning the assembly of cultivated plants. That water can be used by deep-rooted crops during the growing season.

Based on that, it is possible to plan the optimal density of the assembly for certain varieties and hybrids. But in extremely dry years there is a drastic decrease in yield.
Since the frequency of dry years in our country is higher than average and wet years, the number of plants for small grains and fodder crops should be 10-20% less than recommended. (Molnar, 2001).

In dry conditions, the depth at which certain crops are planted is of particular importance because they dry the soil to a moisture level of permanent wilting.

Crops with a shorter growing season such as winter fodder mixtures, peas, stubble grains can dry the soil up to 100-120 cm; corn up to 180 cm, and sugar beet and alfalfa above 200 cm.
The difference in water content available to plants can exceed 130 mm, which corresponds to the amount of irrigation water in moderately dry years. These differences in the content of pre-vegetation water reserves occur only on soils with a favorable water regime.
On light sandy soils with low water-holding capacity, the influence of pre-crops on spring water content is negligible because water quickly sinks into the deeper layers.

In dry years, crops with a higher proportion of short grain and other early crops are more favorable. This also confirms a more favorable pre-harvest value of crops that leave the field earlier.

RECCOMENDATION :

- ***To change the usual practice of crop rotation in order to make the best use of the available amounts of moisture in the soil;***
- ***To match sowing days with temperature patterns and rainfall patterns;***
- ***To use crop varieties that are more adapted to the new weather conditions;***
- ***To plant hedges or smaller agroforestry belts that reduce the loss of moisture from the soil, contribute to increasing the relative humidity of the air, and at the same time can serve as protection from the wind, which significantly accelerates the drying of the soil.***
- ***Application of accurate and up-to-date data on climate risks for agricultural producers, at the sector level and the support that farmers would receive through advisory services and training, as key adaptation measures.***
- ***Some changes in phenology as a result of mid-year weather changes can already be observed in Europe. For example. in southern France apricots and peaches bloom one to three weeks earlier. In Germany, the sowing of corn and sugar beet is already ten days earlier than usual, and in the south of France 20 days earlier.***

Such changes in the agricultural calendar indicate the fact that farmers will have to independently adapt to new changed weather conditions.
As weather changes intensify, farmers will have to introduce completely new varieties of crops, with new specific cultivation methods.

Drought resistant crops and varieties

The effects of climate change can be mitigated by selecting drought-resistant crops and varieties. However, the question arises as to which crops and varieties are drought resistant. There are several groups and types of such crops and varieties.

Plant species originating from the southern region usually have a higher tolerance to higher temperatures. For example, plants from warmer climates that can be grown here are: sweet potato, soybean, sesame, sorghum, tobacco, cassava and others.

Maize varieties with strong rooting, upright leaf, large panicle and deep seeded kernel are known to have greater tolerance to stress and drought.

Recommendations for new varieties possessing genes for drought resistance are made by scientific institutes dealing with plant breeding and providing agricultural advisory services.

Some domestic (indigenous) or old varieties and populations of plants have special forms of adaptation to local production conditions, including pathogens and climate variability, i.e. the occurrence of high temperatures and drought.

These varieties are often not for sale, but are maintained "od farm" through seed exchanges between farmers.

For example, there are old and domestic varieties of onions, legumes (green beans, beans, broad beans), cabbage, pumpkins, melons and watermelons, and vegetables (peppers, tomatoes). Most of these varieties can be found in the plant gene bank today.

In general, growing drought-resistant varieties does not mean that a high yield will be obtained as when growing non-resistant crops under conditions of intensive agricultural production (with irrigation).

However, drought-resistant varieties do better when there is no irrigation and give a stable yield when the external conditions vary, especially when the air and soil are dry.

RECCOMENDATION:

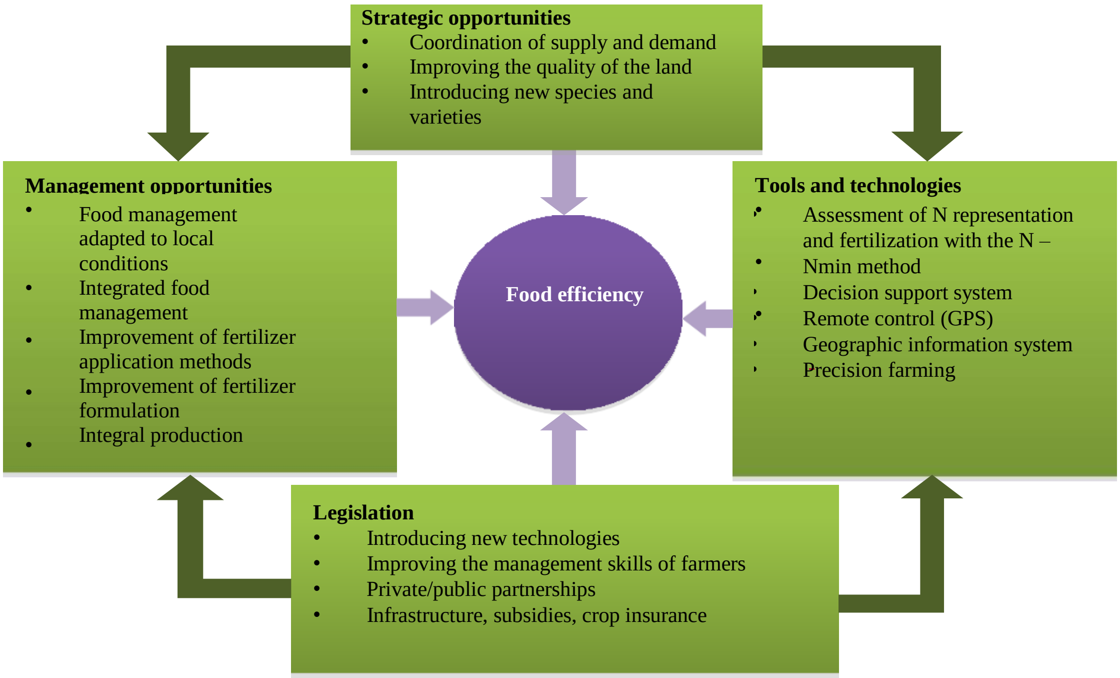
- ***To make a selection of suitable varieties that will be resistant to drought or to replace the species with others that have lower requirements in terms of irrigation.***
- ***In fruit growing and viticulture, grafting is standard practice.***
- ***When planting, it is necessary to introduce materials, such as hydrogel and zeolite.***
- ***In horticultural production, numerous advantages of seedling grafting have been determined, especially for the production of fruit crops (tomato, pepper, eggplant) due to the introduction of resistance to abiotic and biotic stress.***
- ***It is necessary to choose substrates that will be suitable for the existing environmental conditions and will enable stable growth, development and quality yield of the nursery stock.***

Fertilizers and fertilization

Fertilizers (mineral and organic) have a great influence on the yield of cultural plants and the quality of soil, water and air. In the wake of climate change, the importance of timely and appropriate application of fertilizers is even greater. On the one hand, fertilizers (nitrogen, mineral and stable manure) are responsible for the emission of nitrogen oxides from the soil and methane from the stables.

On the other hand, plants will better adapt to the changed distribution of precipitation, changed humidity and temperature conditions, if the correct selection of fertilizer, its form, the amount of nutrients, as well as the time and method of application, is carried out.

The application of the fertilizer should be in accordance with the local conditions, adapted to the production system, the type and quality of the land, available content of nutrients, plant species, varieties and varieties. Since nitrogen (N) has the greatest impact on plant yield, but also negative impacts on greenhouse gas emissions, N use efficiency is a significant aspect of fertilizer application in order to mitigate climate change and adapt production to the resulting changes.



Graphics. Approaches to improve the efficiency and use of nitrogen (N)

RECCOMENDATION:

- ***Application of organic fertilizers (stable, green manure) and plowing of the harvest residues will make it possible to increase/maintain the content of organic soil substances; to maintain/increase soil water capacity and reduce the risk of soil erosion and compaction, and thus denitrification and emission of nitrogen oxides.***
- ***Fertilizing with stable manure should be adapted to local conditions - different properties of the soil, climatic and weather conditions. The collection, preservation and care of stable litter is key to its quality. Better control of the waste management system in order to reduce the release of methane into the atmosphere.***
- ***Recycling of organic waste and application of compost and mulch will allow return/accumulation of organic substances in the soil and reduction of evapotranspiration.***
- ***Including leguminous crops in the crop rotation will reduce the need for N - mineral fertilizers, the production of which consumes natural gas and emits CO2 and nitrogen oxides.***
- ***Perennial legumes should not be fertilized with N-fertilizers. Crops coming into the plot where there was a perennial leguminous crop should not be fertilized with N-fertilizers in the first year. After annual leguminous crops can be fertilized with N-fertilizers based on the Nmin method.***
- ***Fertilizing with N fertilizers based on the Nmin method, it is necessary to adapt to weather conditions.***

- ***Fertilization recommendations based on crop needs, soil fertility control and plant material analysis should be adjusted according to weather conditions.***

Picture 29: Composting
Source: Own photo

Mulching

Mulching is covering the surface with various organic substances. Mulch has multiple effects:

- prevents erosion;
- conserves moisture;
- reduces the appearance of weeds;
- during hot days it reduces the soil temperature;
- increases the activity of soil flora and fauna;
- increases the content of humus and nutrients;
- improves the absorption of nutrients;
- helps in the distribution of the root system in the shallower soil layers, etc.

All these positive aspects of mulching the row surface in fruit orchards allow better growth and yield of fruit plants.
As a mulch material it can be used, e.g. sawdust, especially from coniferous plants, in a layer of 8-10 cm.
Mulch material should be replenished every year but with smaller amounts. The simplest and cheapest way of mulching the surface of the row is by placing straw in a layer of 15 cm. Over time, thatch rots and needs to be replaced every year. In this way, the soil is constantly enriched with organic matter. The disadvantage of straw as a mulch material is that it is light and can be blown by the wind, leaving the soil bare and weeds growing on it.
Peat is quite effective as a mulch material, but it is quite expensive and requires the allocation of a large amount of financial resources for its application. Different synthetic mulch materials can be used to cover the surface in the row, which can be used to successfully control weeds in the plantations. For this purpose, polyethylene film, polypropylene fabric, polyacrylic fabric, jute, wool or linen textiles, etc. can be used.
Geotextile is very effective in mulching the surface. It lasts a long time, if care is taken not to damage it, it can last for ten years, it has a good permeability of water from precipitation, it does not allow the growth of weeds at all, it has a good conservation of moisture, the fallen fruits remain clean. The only drawback is its high price.
Black film can be used to cover the surface in the row, but it is very difficult to place between the stems of the fruit trees, it does not let the water from the precipitation into the zone of the root

system around the stem, it is easily lifted by the wind, it is easily damaged. Due to these shortcomings, it cannot be recommended for mass application in orchards. The negative sides of mulching are: the possibility of rodents inhabiting the bark of the ground part of the trunk and roots, which is why the mulch around the trunk should be removed in the fall, and a large number of insects overwinter under and in the mulch material.

Cover crops

These are plant species that are sown between the rows in the plantation. Their purpose is to reduce erosion problems; fertility and soil quality; to reduce the occurrence of weeds, pests and diseases; to maintain biodiversity in agroecosystems (Lu et al. 2000).

Cover crops can also be sown on empty areas, due to the effect of green manure and enrichment of the soil with organic matter. The selection of plants should be done carefully. First of all, they should develop well in the climatic conditions suitable for the region, and the plants should not demand too much from the soil and accumulate more biomass in a short time. It should be emphasized that cover crops use a large amount of moisture and therefore should be applied in wetter areas or under irrigation conditions. The method of application is determined depending on their place in the crop rotation and the way of using the resulting green mass. Therefore, cover crops can be applied throughout the year, as a subsequent main crop of the crop, as a previous crop or by sowing as an annual or biennial, together with the main crop.

Although this measure initially increases irrigation costs, the positive effects are felt over many years.

Safety nets

Fruit production is closely related to numerous climatic conditions that operate in a certain space and time. Life functions of plants take place correctly only in certain amplitudes of each climatic factor.

Deviation from the optimal limits of each factor causes certain disturbances in the processes of fruit trees, which negatively affects the vegetative growth, fertility, quality of the fruits, and finally, the profitability of their cultivation. Often the occurrence of a single hailstorm, heat wave or strong wind can be enough to compromise or destroy the entire crop in plantations of any agricultural crop. Due to the specificities of long-term plantations, the action of these natural elements

Picture 30: Fruits damaged by hail and high insolation

Source: Own photo

Raising intensive plantations is an expensive investment, and during further cultivation all risks that may compromise production should be eliminated or minimized. Therefore, the need to introduce new alternative technologies and methods in the cultivation of plantations is imposed. One of those methods is the installation of safety nets.

Hail protective and UV protective nets and how to install them

Safety nets are a novelty for our producers, while in developed countries, especially for high income crops, it has long been a common practice. The main reason for installing protective nets is to combat hail. A secondary objective is the shading of the plants, which reduces the sunburn of the fruits and leaf mass, due to which the producers suffer huge financial losses. Protective nets also play a role in changing the microclimate in the plantations. In plantations covered with a net, the relative humidity of the air increases, the light and temperature in the plantation are reduced, thus reducing the conditions for moisture loss through transpiration and evaporation. The network also plays a role in reducing heat radiation from the soil, as a result of which damage from late spring frosts is reduced.

With the installation of the protective nets, the wind speed is reduced by up to 50%, which enables a more efficient application of protective agents in the plantations. It follows from this that in plantations that are not covered with a protective net, the overall environment for the normal development of all processes in the plants is improved.

By placing the nets in the plantations, the illumination of the leaf surface is reduced. Light is one of the basic factors necessary for plant life. That's why any unprofessional installation of protective nets can cause negative effects from excessive shading. Vegetative growth will reduce the quality of the fruits (decrease in size, weaker color and lower content of dry matter).

Current knowledge shows that the color and density of the net have an impact on the vegetative growth of the plants, the yield and the quality of the fruits, which is why the selection of an appropriate net is of particular importance. A wide range of safety nets is available on the market, both in terms of the dimensions of the openings and the color of the net itself. The openings of the nets should be adjusted according to the size of the grains of the city. The choice of mesh density depends on the crop as well as the insolation conditions in the respective region. In our production regions, nets that transmit light of 80-85 % are suitable. The color of the net has significance in the shading of the plantations. Therefore, depending on the intensity of the light, the appropriate color of the nets is chosen. At the same time, in brighter conditions, networks with a darker color are placed, which provides greater shading, and vice versa, in regions with less light, networks with a lighter color are better, which has a greater reflection of light.

For the proper functioning of protective nets, the support structure to which the net is attached is of particular importance. Pillars of different materials (metal, concrete or wood) are used for construction, which are usually placed at a height of 3.8 m for fruit plantations. The supporting structure should be 4.5 m long and 8x8 cm or 7x8 cm thick. The posts are driven into the soil at a depth of 70 cm, and they will be 3.8 m high above the ground. Anchor posts measuring 10x12 cm are placed at the ends of the row.

The support structure, i.e. the poles, are usually placed at a distance of 10 m and wires will be placed on them to which the seedlings will be tied. For better attachment of the net, metal ropes, wires and other elements are used, with which a good connection of the net is ensured by the wind.

The net must be placed obliquely towards the interrow so that the grains of the city can fall into the space where there are no plants. If the network is not well stretched and slanted, the city stays on it and the weight can tear it. The posts for the net serve simultaneously as a trellis support structure. The best and easiest way to set up the construction for the net is before raising the plantation. The overall installation of the system is quite complex and it is best to hire professionals who have experience and equipment to easily, quickly and simply perform all operations for setting up the network. In our conditions, the protective nets should be installed at the beginning of April to enable protection from late spring frosts. The nets are collected and attached to the metal ropes in the autumn period when the risk of hail has passed, but before snow falls that can damage them. Taking into account the high investments in raising intensive plantations, the expected results of their cultivation and the risks arising from climate change

During dry and sunny periods, the net becomes electrostatically charged and attracts dust particles. This dust that remains on the grid reduces the excessive light intensity during the summer period. With the first autumn rains, the dust falls from the nets, which thus return to their original state.

The correct balance between shade and light intensity promotes a balanced photosynthesis process that allows plants to absorb nutrients and develop plant tissues.

Picture 31: A diagonally placed and well-tensioned net
Source: Own photo

Water resources and irrigation

On Earth, 97% is salt water and only 3% is fresh water. Just over two-thirds of that water is frozen in glaciers and polar ice caps. The remaining, thawed portion of fresh water is found mainly as groundwater, and only a small portion is present above ground or in the air. Water supply is mainly based on the use of underground water and springs (80-90%), a smaller percentage is from rivers (10-20%) and only about 1% from natural lakes and artificial reservoirs.

Watering. Irrigation is the controlled application of water, artificially, for agricultural purposes. It is a measure in plant production by which, through special man-made systems, water is added to the soil to meet the plants' water needs when they do not have enough water from rainfall. When irrigating, water should always be used efficiently, applying only the required amount for the crop plants and in a dose that a certain soil can infiltrate to a certain depth.

Infiltration of water into the root zone of plants should be without runoff. How much water will be added to one irrigation and how often it will be watered depends on: soil type, mechanical (textured) composition of the soil and its structure, density of the crop and the need of plants for water.

Sandy soils and sandy loams absorb water quickly, so they need to be irrigated more often with smaller amounts of water to prevent water losses outside the plant roots. On the other hand, clay soils absorb water slowly, so water runs off if it is added too quickly during irrigation. In them, water must be added alternately, giving time to the land to absorb the previously added water, before adding next amount which is known as "cyclic" / "pulse" irrigation.

There are several divisions of land irrigation methods. They are usually divided into:

a) surface, with which the water is brought to its surface and
b) subsurface, with which water is brought to the root zone of plants below the surface of the soil by capillary means.

In surface irrigation, water can be brought to the surface of the soil by gravity or under pressure. Surface irrigation, which brings water by gravity, is carried out by the following methods: furrows (infiltration into furrows), overflow and immersion. If the water during surface irrigation is brought under pressure, then it is by sprinkling; "drop by drop" or with micro-sprayers.

If the water is brought under the surface of the earth, then it is called subsurface irrigation and it can be done with open channels and under pressure.

Each of the above irrigation methods and methods has certain advantages and disadvantages, and the choice of the appropriate method depends on:

- Size, shape and slope of the plot
- The type and mechanical-physical properties of the soil,
- The nature, quality and availability of water to supply the irrigation system,
- The type of plants grown
- Initial costs and availability of funds, and
- Priorities and previous experience of farmers with irrigation

In the context of climate change, drought adaptation is one of the most important tasks.

Therefore, the management of water resources is of particular importance. In arid areas, but not only, there is a great need to collect water through micro and macro reservoirs, supply canals or waterways, water supply networks, and through wells, dams, cisterns, etc.

Reservoirs (artificial lakes) are formed by dividing river flows in valleys. Reservoirs are used to store water in times of abundance and which can be used in times of water scarcity (as a source of water for irrigation when there is a dry period and when there is not enough water for the needs of cultivated plants), but and for other needs. When building reservoirs, it is important to take care of the design of dams and foundations, with appropriate buildings and equipment (overflows, outfalls, hydromechanical equipment) that allow: realization of the accumulation and retention (retention) of water, capture of water for irrigation and others different purposes, diversion of water flow (if necessary), and division and management of water.

Artificially dug canals for providing irrigation water (waterways) are the most well-known way of using water in small and water-poor agricultural areas. In this way, farmers are given access to irrigation water, which creates better conditions for agricultural production. There are several names for channels: groove, gutter, gap. Such canals are a social rural good. Through canals or waterways, water can be brought from one area to another and in this way ensure the distribution of water in different ways.

A pit or cistern is a water reservoir in arid regions. The former construction technology was complex. First, a hole was dug in the ground. The wall had to be made of hard stone. The plaster was made from red earth. It was built with it, and later smoothed from the inside. The pits were closed from the top, and an opening called a shaft (shaft) was left in the middle. Rainwater is collected from the surrounding, landscaped area called. The water is reached with a bucket tied to a rope. Today, with the discovery of new construction materials, the construction of the pit has become faster and easier.

RECCOMENDATION:

- ***Economical use of water in periods when plants need it most***
- ***Using drip irrigation techniques***
- ***Application of the concept of accumulating water through micro and macro reservoirs, and through wells, pits or cisterns, (should be more and more popular and introduced in the context of the development of the rural area and its sustainability).***
- ***Maintenance of existing and construction of new reservoirs***
- ***Regular maintenance and cleaning of the drainage channel network***
- ***Maintenance of drainage systems***
- ***Reuse of treated wastewater***
- ***Prevention of backfilling of drainage channels due to the formation of artificial passages more accessible to the plots.***

Picture 32: Water reservoir in arid regions
Source: Own photo

Picture 33: Rainwater harvesting in a modern way
Source: Own photo

Practical management of climate effects in agriculture

Practical handling of climate effects in fruit and viticulture production

The changed climatic effects in viticulture and fruit production affect in different ways. We will single out the most important ones:

- Change in the proper acclimatization of the varieties (irregular flowering and dissatisfaction with the required amount of low temperatures);
- Earlier flowering of fruit plants and increased risk of late spring frosts;
- Extremely high temperatures cause problems in differentiating flower buds (double flowers), pollination and fertilization of flowers;
- High temperatures and lack of moisture cause disturbances in physiological processes;
- High insolation and temperature cause scorching of the leaves and damage to the fruits;
- Changes in the distribution of existing diseases and pests and the emergence of new crop hazards;
- They reduce the quality of the fruits;
- Occurrence of soil diseases and pests as a result of heavy rainfall and higher temperatures;
- Increased risk of erosion;
- Strong winds and storms cause uprooting of fruit trees, breaking of branches and pushing of fruits;
- The seeds of the city make wounds in the organs of the plants, for the healing of which the plants consume huge amounts of nutrients. In addition, these wounds often represent openings for infection by various diseases and pests.

Picture 34: Fruit damage caused by high temperatures
Source: Own photo

Adaptive measures should be designed for easy and simple application and preferably not require large financial investments.

There are a number of adaptation measures, but we will cover the most important ones:

- Selection of substrates, varieties and fruit species, resistant to climate changes
- Adequate preparation of the surface before raising plantations
- New planting technology, in which the planting depth and use of water-retaining substances will be adapted;
- Adequate maintenance of the surface in the plantations
- Application of appropriate ways of pruning the fruit trees and formation of appropriate types of crowns
- Application of mulching in the rows
- Installation of protective UV and anti-chest nets
- Application of appropriate ways of pruning the fruit trees and formation of appropriate types of crowns
- Selection of substrates, varieties and fruit species, resistant to climate changes
- Adequate preparation of the surface before raising plantations

Selection of suitable fruit species, varieties and rootstocks

1. **Selection of fruit species** - The selection of fruit species, when planting fruit plantations, should be based on the natural conditions in the given region, while the new climate changes and the need to adapt the fruit plants to them must not be neglected.

RECCOMENDATION:

In the western region of our country, apple, autumn and winter varieties of pear, sour cherry, cherry, and in certain micro-regions hazelnut, walnut and strawberry fruit species are recommended for planting.

In the central region, warm-loving fruit species such as peach, apricot, almond, summer and autumn varieties of pear, early varieties of cherries and strawberries, sour cherries are recommended.

In the Gevgelija-Valandovo area, subtropical fruit species are recommended - fig, pomegranate, Japanese apple, actinidia, etc. In some micro-regions, apples can also be grown with success, but only early summer or early autumn varieties or varieties with long vegetation.

In the eastern region, apples, plums, cherries, aronia, raspberries are recommended, and in certain micro-regions, hazelnuts and walnuts. In arid regions, it is necessary to give preference to crops that ripen early before the beginning of summer, and to avoid late-ripening crops.

2. Selection of varieties when raising fruit plantations -. The variety is a very important and often a key factor in creating more profit from plantation cultivation. Seen from the perspective of climate changes (in addition to biological, production and quality traits), when choosing varieties, their requirements for specific environmental conditions should also be taken into account. Some fruit varieties give excellent results in some environmental conditions, but completely different yields in regions with other conditions.

RECCOMENDATION:

In arid regions where there is a shortage of irrigation water, it is recommended to plant early fruit varieties that are harvested before the summer drought occurs.
Unlike fruit-bearing fruit trees, fruitless fruit trees tolerate drought more easily. In more southern regions, early maturing varieties should also be planted. This is important because early ripening

in these warmer conditions ensures fruits that reach the market at a time when there is no competition from other regions.
In areas exposed to the wind, it is recommended to grow varieties with stronger stems that hold the fruits firmly to the branches.
In regions where late spring frosts occur more often, it is necessary to avoid varieties with early flowering because they are more sensitive to low temperatures. But it is not a rule, because varietal characteristics for resistance to low temperatures should also be taken into account.
In rainy regions, it is recommended to grow cherry varieties that are resistant to skin cracking.

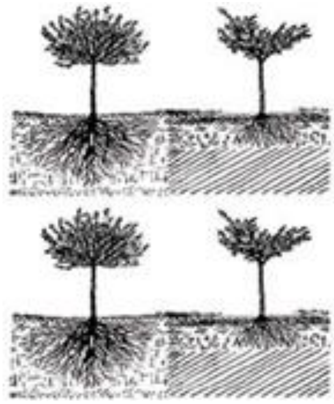
3. Choice of substrates when raising fruit plantations - Choosing a suitable substrate is a difficult and critical decision when raising fruit plantations. Biological properties of the substrate should interact with the specific pedoclimatic conditions in the given region as well as with the planned cultivation technology. The biological characteristics of the variety will come to full expression with the correct selection of the substrate in the specific pedoclimatic conditions and the application of appropriate cultivation technology. Each substrate in given situations has its own advantages and disadvantages and there is no ideal one. That is why it is important to choose a substrate that, under suitable climatic conditions, will show the least negativity. Each substrate has its own specific characteristics related to various aspects such as: lushness, rooting, adaptability to climatic and soil conditions, tolerance to low temperatures, resistance to diseases and pests and others. In modern fruit growing, preference is given to lushness.
Lushness - although in modern fruit growing, when raising fruit plantations, low-growing substrates are used because they have many advantages (they enable the raising of dense plantations, the fruit trees are lower and easy to manage, they have regular and high yields per unit area, they give quality fruits from more lush substrates and more economical and profitable production), however, they also have disadvantages (poorly developed and shallowly placed root system). Because of this, poorly lush substrates are in principle much more sensitive to a lack of moisture in the surface layers of the soil. Thus, the dilemma arises as to whether to always and in all conditions apply weakly lush substrates or to choose more lush substrates with a more developed root system, and to control the lushness and fertility of the fruit trees by applying other measures.
In addition to lushness, the following characteristics are taken into account:

- adaptability to environmental conditions, especially pH,
- tolerance of drought or excess moisture in the soil,
- high temperature resistance, disease and pest resistance etc.

<u>RECCOMENDATION:</u>

- ***On carbonate soils with a high pH, peaches should be grafted onto almonds or peach x almond hybrids;***
- ***Pears of wild pear and gorse; cherry trees are grafted on frosts and sour cherries in drier areas should also be grafted on frosts.***

Deep preparation of the surface before raising the plantations
Plants with a better and more deeply developed root system can also draw water and nutrients from the deeper soil layers, where there is usually more moisture in the dry part of the vegetation period.



Picture 35: Schematic representation of the influence of soil loosening on the development of fruit plants
Source: (Stanković 1990)

Depending on the climate and soil conditions, the type of fruit, the substrate, the cultivation system, etc., the preparation of the surface for raising a fruit plantation can be done in several ways, namely: deep plowing, semi-rugging, rutting, undermining, rippering, digging holes etc.

RECCOMENDATION:

- ***Deep plowing at 35 – 45 cm - is performed before raising strawberry fruit plantations, which have a shallow root system and are grown in semi-humid areas or with irrigation;***
- ***Semi-cultivation at a depth of 50-60 cm - applied to plantations under irrigation conditions and intensive plantations on vegetative substrates, for light, permeable, alluvial soils;***
- ***Rigging at a depth of 70-90 cm - recommended for plantations that are not irrigated, in order to enable deep penetration of the root system and the greatest possible accumulation and conservation of natural moisture. Rigging is also recommended in cases where the impervious layer needs to be destroyed, to enable water permeability, aeration, development and functioning of the root system;***
- ***Undermining with blasting machines at a depth of 50-70 cm. The soil is just plowed (no turning). It is recommended for lighter soils, soils with a shallower humus horizon lying on rocks, stones, etc.***
- ***Digging holes is justified when raising rare plants with a planting distance of 8-10 m. The diameter of the hole should be at least 120 cm, and the depth 60-70 cm. On heavier soils, the diameter of the hole should be 150 cm. On light, alluvial, permeable soils, smaller holes can be dug, with a diameter of 80-100 cm and a depth of 60 cm.***

Adaptive planting technology

From a scientific point of view, and also in practice, the opinion is accepted that the seedlings should be planted at a depth up to the root neck, just as they were in the nursery. However, there are cases when it can be planted shallower or deeper than usual. In our arid regions, where there is a lack of moisture in the surface layers of the soil, there is a need for deeper planting of the seedlings. The advantage of this method is that the root, even during planting, is placed at a greater soil depth, where it continues to grow and spread in the deeper layers. A root thus developed and spread has the power to use water and nutrients from a larger volume of soil. For the application of this technique, it is necessary to graft the seedlings in the nursery higher than the standard grafting, ie 30 cm above the soil. When planting, the seedlings are placed at a depth of 50 cm, so that the junction between the substrate and the seedling should be above the ground.

Use of water-retaining substances (hydrogel, zeolite, zeophyte, etc.)

In the fight against drought in agricultural production, materials are often used that have the ability to absorb air moisture and retain water in the zone of the root system of plants and do not allow its loss through evaporation. This moisture further becomes available to the plants during the period when there is not enough water in the soil for the root hairs to absorb. A larger number of this type of materials are available on the market, but hydrogel and zeolite (zeophyte) are more widely used. **Hydrogel** is an organic polymer of starch with different granule sizes. It has a great power of absorbing moisture. In the world, it is mostly used in arid and semi-arid regions. It is introduced into the soil before planting the plants. In fruit growing, it is used before planting the seedlings by applying 15-20 g of the granules in the hole or in the furrow per planting site. The ability to retain moisture preserves it for up to 4 years after application and for that entire period contributes to a better use of moisture from the soil. **Zeophyte** (zeophyte) is a silicate mineral of natural origin that is produced by grinding natural rocks. It is produced in the form of granules or powder with particle sizes of 0-3 mm. It mostly contains silicon dioxide and aluminum dioxide in its composition. A larger percentage also contains iron, calcium, magnesium, sodium and potassium, and to a lesser extent there is manganese, phosphorus, titanium, etc. It has the ability to absorb moisture up to 43%. Added to the soil, along with the moisture, it retains some of the nutrients that the root system can use in the dry period. Zeophyte in fruit growing can be applied during the planting of seedlings, that is, by adding 0.5-1 kg to the hole or furrow per planting site.

Picture 36: Application of hydrogel (left) and zeophyte (right) during planting of seedlings

Source: Own photo

Use of water-retaining measures The area in the plantations can be maintained in different ways, but each of the ways that will be chosen must ensure the growth and fertility of the plants in conditions of economic profitability.

1. Barren black fallow - means occasional tillage and prevention of weeds throughout the year, through deep autumn, shallow summer plowing and several summer cultivations.

Positive sides:

- Destruction of weeds is carried out
- Nitrates increase (favorable conditions are created for nitrogen fixers)
- There is a greater accumulation of moisture in the soil

Negative sides:

- The humus is lost
- Soil structure deteriorates
- Erosion occurs on sloping terrains

RECCOMENDATION:

- ***this is a unique, effective way of soil maintenance in young plantations, and in arid regions, without enough water for irrigation***

Weeding of the surfaces

The weeding of the surface in the plantations can be done with natural grasses or by sowing seeds of individual types of grasses or grass mixtures. Grasses are used, several species such as: meadowsweet (Poa trivialis), English ryegrass (Lolium perrene), Italian ryegrass (Lolium italicum), fescue (Festuca sp.) and others. Of the legumes, white and red clover, etc. are used.

RECCOMENDATION:

- ***it is recommended in areas with an amount of precipitation over 800 mm per year, properly distributed during the vegetation or in plantations where there is enough water for irrigation.***

Formation of alternative crowns and methods of pruning of plants

Climate change and harmful sun rays cause damage to fruit trees. In the absence of additional protection from strong insolation, there is a need to introduce new, modified principles in the formation and pruning of fruit plants.

Picture 37: Damage to apple from strong insolation
Source: Own photo

RECCOMENDATIONS:

- ***Formation of wider, more closed and more shaded crowns;***
- ***When applying summer pruning, moderate removal of shoots should be practiced;***
- ***during the winter pruning of the plants, it is possible to apply the so-called short and long pruning in apples, pears, peaches, some varieties of plums;***
- ***Application of short pruning in peaches;***
- ***Placing the rows of the fruit plantation in the direction of the blowing wind in order to reduce the negative effect of the wind;***
- ***Installation of protective nets at the beginning of April to enable protection from late spring frosts;***
- ***The protective nets are collected and attached to the metal ropes in the autumn period when the risk of hail has passed, but before snow falls that can damage them.***

Adaptation measures specific to viticulture

RECCOMENDATIONS:

- ***Increasing the number of meteorological stations in these regions.***

- ***Timely notification of vine producers about weather conditions (ice, hail, high temperatures).***
- ***Availability of information of public interest to individual farmers.***
- ***Training of individual farmers on climate change and adaptation measures.***
- ***Recommendations for choosing varieties that are easier to adapt or tolerate climate changes.***
- ***Applied technique, the T-system of pruning (placement of native shoots at an angle of 45o, which allows shading of the bunches)***
- ***Reduction of transpiration in grapevines with new technologies and modernization of production.***
- ***Increased use of nitrogen fertilizers to extend grapevine phenophases and later harvest.***
- ***The dislocation of vines in colder places, at higher altitudes or in coastal areas (lower temperatures, higher rainfall and lower irrigation costs)***

Practical management of climate effects in agriculture and horticulture

The basis for mitigating the consequences of climate change in agriculture and gardening is the application of appropriate agrotechnical measures. These include crop rotation, tillage, tillage, variety (hybrid) selection, seeding, plant nutrition, weed and pest control, irrigation, drainage and harvesting.

Table: Measures of adaptation in agriculture and horticulture

Good horticulture practice	Adaptation measures
Crop rotation	Choosing an adequate starter Avoiding monoculture
Tillage of the soil	Plowing of the harvest residues Timely basic processing Good pre-sowing preparation Inter-row cultivation
Undermining	Undermining
Selection of varieties	Procurement of certified seed material Selection of modern varieties adapted to the climatic conditions Diversified assortment
Sowing	Seed inoculation as needed Timely sowing at an adequate depth Regulation of sowing density according to climate conditions
Nutrition of plants	Soil analysis Optimal basic fertilization Optimum initial fertilization and feeding
Weed and pest control	A combination of agrotechnical, biological and chemical measures to control weeds, bacteria, viruses, insects and other pests
Irrigation and drainage	Irrigation according to the needs of the plants with the required irrigation rate Regular maintenance of channels and drainage systems
Harvest	Timely and correct harvest

Alternative agrotechnical measures - With the development of agriculture, a whole range of alternative agricultural technologies seem to mitigate the consequences of climatic fluctuations in agriculture: soil conservation, mulching, cultivation of cover and joint crops, agroforestry and others. Measures that have proven useful in certain countries of the world are being tested in our conditions, on our countries, cultures and varieties. Numerous alternative adaptation measures are beginning to find their place in horticultural production and are increasingly prevalent on arable land.

Many of these measures have found application in organic agriculture, which in an ecologically sustainable way, using natural processes and substances, contributes to reducing the use of non-renewable energy sources and the emission of harmful gases into the atmosphere and is an effective strategy for mitigating climate change. In recent years, various variants of reduced processing have been applied, which leaves part of the harvest residues on the unprocessed surface layer of the soil, which conserves moisture and increases microbiological processes.

Adaptation measures that are specific to HORTICULTURE

RECCOMENDATIONS:

- ***Elimination of the harmful effect of wind and insolation by growing vegetable crops between plant backgrounds (corn, sorghum, sunflower, winter cereals, tall grass, clover, fodder pea)***
- ***Technique with curtains to be used when growing tomatoes, cucumbers, watermelons, melons, peppers, green beans, eggplants, cauliflower, salads***
- ***Application of biodegradable paper mulch***
- ***Covering the greenhouses with nets - nets***
- ***It is recommended to use less irrigation water than needed to reach the PVK: 100% of the PVK should be irrigated in summer when no rain is expected or for crops under greenhouses, and 80% of the PVK should be irrigated in the months when rainfall is expected. Proper watering only adds to the difference between TM and PVC.Правилното наводнување, само ја надополнува разликата помеѓу ТМ и ПВК.***

Dictionary of professional terms

Agrotechnics: application of technical means during land cultivation
Packaging: packaging material
Animal manure: burnt barn rubbish
Bactericide: an agent that destroys bacteria
Harrowing: tilling the soil with a "harrow"
Biomass: mass of living organic matter
Harvesting: gathering parts of plants
Vegetation: plants, plant life
Rolling: additional tillage using a roller
Garden: a place where flowers, vegetables, etc. are grown.
Drainage: drying of land using channels and pipes; honey removal of fluid or pus from a wound using a special tube (drain)
Disinfection: a procedure to destroy the largest number of unwanted microorganisms
Disinsection: a set of processes undertaken to control insects
Rodentization: a set of processes undertaken to control rodents
Discing: additional tillage with a disc cultivator
Fertilization: addition of mineral and organic substances in order to enrich soil fertility
Fertilizer: mineral and organic substances intended for fertilization
Evaporation: evaporation from the soil
Grain: common name for annual plants whose grainy fruit is used in food
Harvest: gathering the grain
Grain: A small fruit or seed
Protected space: any space in which plants can be grown when external conditions do not allow it
Balancedness: evenness
Insecticide: A means of killing insects
Burns: tissue damage caused by high temperature
Core: interior
Compost: organic fertilizer
Cotyledon: the stem from which the plant germinates
Tuber: A modified stem or root in some plants
Root (root system): underground part of a plant
Legumes: plants with fruits in the form of legumes (beans, peas, lentils, soybeans, chickpeas and others)
Monoculture: cultivation of one crop
Reclamation: improvement of soil fertility
Legume: the fruit of the leguminous crops
Metabolism: a system (complex process) of several biochemical processes that appropriately transform the energy obtained from food, in order to meet certain needs for the normal functioning of all life functions
Microorganism (microbe): any living organism that is not visible to the human eye
Nodia (node or nodule): the part of the stem at the level of leaf separation
Nectar: A sweet liquid secreted by the glands of flowering plants
Greenhouse: a glazed and heated room for growing plants

Dung: organic waste obtained from the urine of animals and the water with which the barn is washed
Plowing: plowing fertile soil with a plow, plow or tractor in order to saturate the land and prepare it for sowing.
Chaff: straws and husks when winnowing the grain
Weed: A self-sprouting plant, harmful to farmers
pH value: a measure of the activity of hydrogen ions (H+) in a solution
Soil: loose layer on the surface of the earth
Crop rotation: changing crops over time and space
Made easy: changing crops by space
Crop rotation: changing crops by time
Pesticides: a large group of poisonous substances (toxins) that are used in agriculture to protect agricultural crops
Pigment: A substance in organisms that colors tissues
Parenchyma: substance of organs
Fruit: a reproductive organ in plants that is formed from the carpel after fertilization
Carpel: the reproductive organ in the flower of a plant
Rudimentary: stunted
Regenerate: renews
Cultivation: deep tillage
Regeneration: process of restoration and growth of lost parts of the body
Starch: plant polysaccharide
Symbiosis: living together
Successive: gradually
Drought: dry weather, weather without precipitation
Frost: a type of precipitation in the form of thin ice crystals
Selection: selection of purebred animals or varietal plants
Seed: A reproductive plant organ present in seed plants
Sideration (green manuring): cultivation of leguminous plants and their plowing in order to increase soil fertility
Frostbite: tissue damage from low temperatures
Transpiration: evaporation of water from plants
Peat: accumulation of partially decomposed vegetation or organic matter
Grass: a family of monocotyledonous plants included in the family Poaceae
Fallow: plowed and left unsown field to lie like that for a year.
Fungicides: agents for destroying plant diseases caused by fungi
Phenophase: phase of changes in the annual cycle of plant development
Food: Any substance used to provide nutritional support to the body
Herbicides: various chemical compounds, mostly of organic origin, intended to destroy plants
Horticulture: the culture of growing garden plants
Humus: A mixture of organic compounds produced by decaying vegetable and animal remains
Flower: generative organ of angiosperms whose function is sexual or asexual reproduction
Barn litter: obtained from the droppings of a domestic animal

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