ENHANCEMENTS IN THE QUALITY OF EDUCATION AND TRAINING IN SOUTH EASTERN EUROPE

ENVIRONMENTAL ASPECTS OF AGRICULTURAL TECHNICIAN

- Compilation of texts -

ERI SEE Education Reform Initiative of South Eastern Europe

EQET SEE

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Introduction

The compilation of texts Environmental Aspects of Agricultural Technician was developed within the project "Enhancements in the Quality of Education and Training in South Eastern Europe - EQET SEE". It was commissioned by the Education Reform Initiative of South Eastern Europe - ERI SEE Secretariat, as the project coordinator towards supporting the implementation of the regionally developed Agricultural technician of traditional and organic cultivation qualification standard and agricultural technician national curricula.

In accordance with the guidelines published by the donor behind the EQET SEE project, the Austrian Development Agency, this document aims to provide additional support to teachers who will implement the agricultural technician program at the national level.

More about the EQET SEE project is available on the project website: https://eqet.erisee.org/.

I Environmental facts and figures: climate change, GHG emissions, global warming

Global warming has already caused widespread, rapid and intensifying changes. Some changes are unprecedented in thousands or even millions of years. Climate change is more than simply the world getting hotter – we are experiencing widespread changes across the atmosphere, land, ocean and ice regions.

Climate facts

- The average temperature of the Earth's surface between 2011 and 2020 was 1.1ºC warmer than the average temperature in the late 19th century (before the industrial revolution) and warmer than at any time in the last 125,000 years.
- Each of the last four decades has been warmer than any previous decade since 1850. The world is warming faster than at any time in at least the last two thousand years.
- The levels of greenhouse gases in the air are continuing to rise because of our emissions. Carbon dioxide concentrations are at their highest in at least the last 2 million years. Methane and nitrous oxide concentrations are at their highest in at least 800,000 years.

Land

- Rainfall over the land has increased since the 1950s. In the tropical regions, it is raining more during wet seasons and raining less during dry seasons.
- Many plant species and animal species have moved closer to the poles and to higher elevations, to follow the shifts in climate zones.
- For some Northern Hemisphere plant species, the growing season has become longer (up to 14 days longer since the 1950s) and, overall, the surface of the land has become greener since the early 1980s. ('IPCC, 2021, p.4')

Climate change and climate variability are projected to have a substantial effect on agricultural production, both regarding crop yields and the locations where different crops can be grown. The crop season has lengthened and is projected to increase further due to an earlier onset of growth in spring, and a longer growing season in autumn. This would allow a northward expansion of warm-season crops to areas that were not previously suitable. While irrigation is an effective adaptation option for agriculture, the ability to adapt using irrigation will be increasingly limited by water availability. ('European Commission, https://climate.ec.europa.eu/climate-change/consequences-climate-change_en')

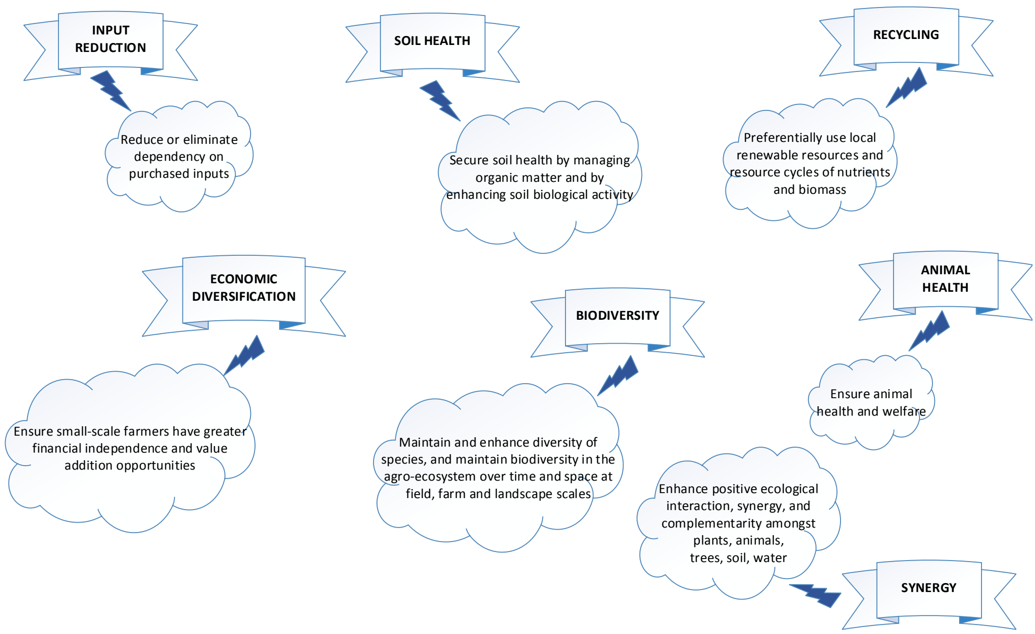
CLIMATE-SMART AGRICULTURE:

- **Reduce energy and water consumption;**
- **Reduce emissions, pollution and waste;**
- **Protect or restore biodiversity and ecosystems;**
- **Enhance climate resilience.**

II Agriculture and environment - theoretical aspects

A key challenge for the agriculture sector is to feed the population, while at the same time reducing the environmental impact and preserving natural resources for future generations. Agriculture can have significant impacts on the environment. While negative impacts are serious, and can include pollution and degradation of soil, water, and air, agriculture can also positively impact the environment, for instance by trapping greenhouse gases within crops and soils, or mitigating flood risks through the adoption of certain farming practices.

2.1 Principles of agroecosystem



(Source: Adapted from "13 Principles of Agroecology", https://www.agroecology-europe.org/the-13-principles-of-agroecology/)
Wezel A. et. al. (2020), p. 9

III Measures and recommendations - advice for practical teaching

3.1 Practical advice in planning agriculture

Site selection and management

When planning and managing the farm activities, be aware of the site history (previous land use), properly take into account the site specificities (such as topography, neighboring activities, ecological and social conditions).

Recommended practice:

- When planning a new building for lodging or milking, or a new pasture or crop area for feed, the production site should be checked against any pollution risk and protected against those through adequate measures when necessary.
- An evaluation should be undertaken for new agricultural sites (e.g. pastures or new crop area for feed), taking into account the prior use of land, availability and quality of water resources, pest disease and weed levels and the potential impact of the production on adjacent populations, crops and the natural environment. In particular, the production site should avoid the destruction of forests. ('SAI Platform, 2009, p.4')

Planting material

Consider the farm's structure &local situation when choosing planting material.

Recommended practice:

- Resistance or tolerance to commercially important pests and diseases, adapted to local conditions and meet customers specified requirements
- Varieties are planted at the optimal time of the season.
- Invasive species should not be planted. ('SAI Platform, 2009, p.4-5')

Animal health

Use all chemicals and veterinary medicines as prescribed to prevent occurrence of chemical residues in milk.

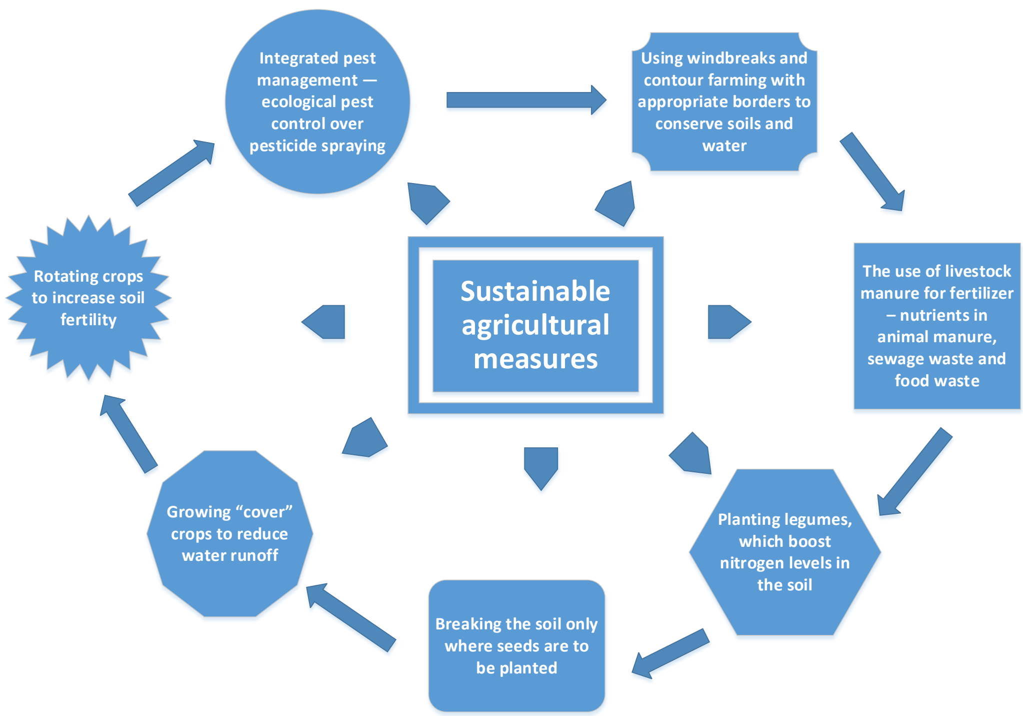
Recommended practice:

- Use chemicals according to directions, calculate dosages carefully and observe withholding periods.
- Only use veterinary medicines as prescribed by veterinarians and observe withhold periods.
- Store chemicals and veterinary medicines securely, respect expiry date and dispose of them responsibly ('SAI Platform, 2009, p.8')

3.2 Measures for sustainable agriculture - material for discussion

By implementing sustainable agricultural measures farmers can more than double their yields and raise their incomes by adopting resource-conserving practices.

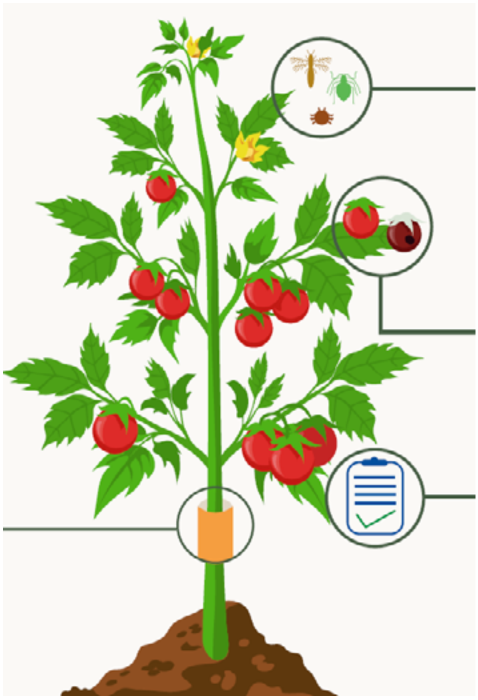
Actions for sustainable agriculture include:



Source: IRISH AID Key Sheet, p.5

3.3 Reducing pesticides with integrated pest management (IPM) - theoretical aspects

1. PREVENT:
Practice good hygiene, and place physical barriers to exclude pests. Use crop rotation, resistant plants, high quality seeds, fertilization and proper drainage for strong crops.



2. IDENTIFY/MONITOR:
Monitor the field and identify pests, set up early diagnosis systems, get advice from qualified professionals

3. EVALUATE:
Assess whether identified pests are causing damage, and whether there is a need to act. Consider first non-chemical controls. Chemical pesticides as last resort.

4. CONTROL:
Verify effectiveness of control actions. Learn and adapt for the future

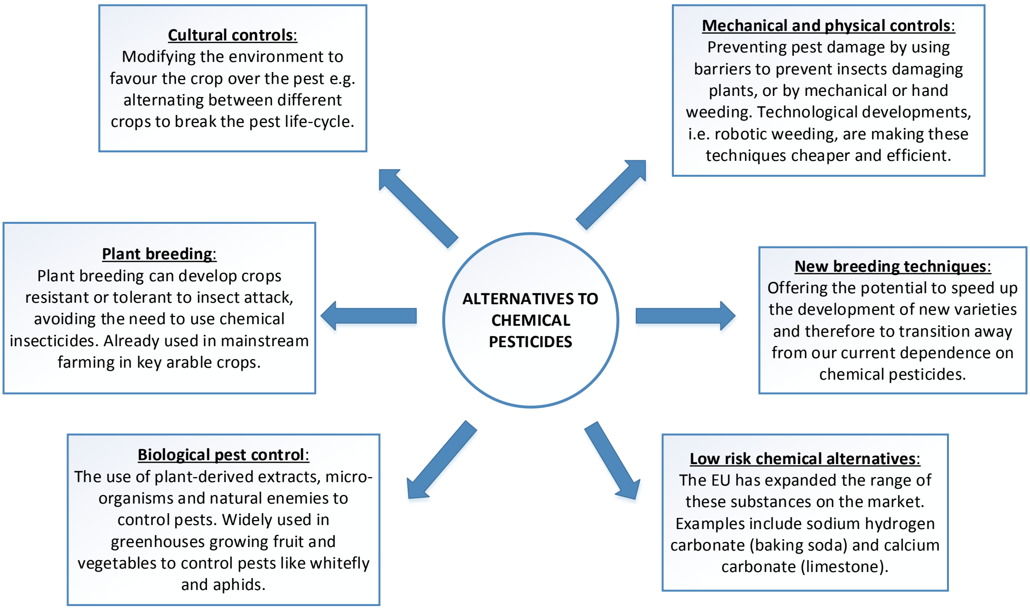
(Source: 'European Commission, 2022, p.1')

ENVIRONMENTAL CRITERIA FOR ORGANIC FARMS*:

- **Demonstrate the use of compost for soil.**
- **Demonstrate agricultural production using soil, not hydroponics or rock wool cultivation.**
- **Demonstrate no use of banned agriculture chemicals from the specific period of years before sowing or planting.**
- **Demonstrate avoidance, reduction and management in the use of agriculture chemicals.**
- **Demonstrate avoidance, reduction and management of fertilizer.**

**in compliance with ISO 14030-3:2022 Environmental performance evaluation — Green debt instruments — Part 3: Taxonomy*

3.4 Alternatives to chemical pesticides - material for discussion



(Source: European Commission, 2022, p.2)

IV Personal protective equipment in agriculture

4.1 PPE as prevention of infections from animals

Using personal protective equipment (PPE) for farming and agriculture jobs routinely prevents significant illness and even fatalities. Those dangers are largely due to contact with animal-acquired infections, chemicals used in conjunction with crops, and respiratory-related risks. That's why agriculture PPE in farming or agricultural work should never be considered optional.

The wide range of health risks to hard-working people in the agricultural sector cannot be ignored. These common health threats are but a cross-section of the known and emerging diseases that surround farm workers.

Given how animal-acquired infections easily transfer to humans, agriculture PPE in farming must include the following items:

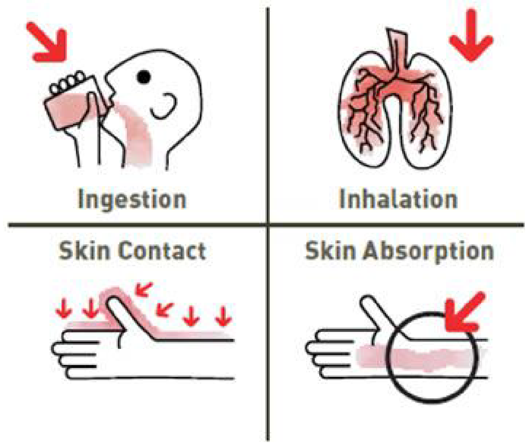
- Coveralls with Secure Wrists, Ankles, and Necklines
- Googles, Face Shields & Other Eye Protection
- One-Piece Disposable Clothing with a Hood
- Disposable Protective Gloves and Footwear Coverings
- Disposable Face Masks

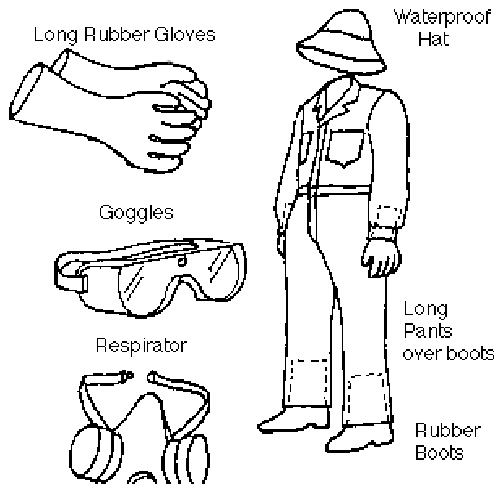
It's essential that the agriculture PPE in farming stockpiles remain primarily disposable. Disposable protective clothing helps decrease the spread of bioburdens, harsh chemicals, and other biohazards that can spread to others throughout laundering or the transport to a laundering facility.

4.2 PPE for farming and agriculture pesticide contact

In too many cases, field workers and seasonal harvesting teams enter fields with common street clothing. This labor-intensive work tends to prompt people to shed layers and results in skin contact with chemical agents. When workers wipe their brows or touch their mouths, a transfer sometimes occurs. It's also not uncommon for these agents to seep through pores or infiltrate cuts and abrasions. Given the rigorous type of work farm hands undertake, the following PPE would be advisable.

- Lightweight, Breathable Outer Wear
- Flexible Gloves and Footwear Coverings
- PPE that Resists Chemical Seepage
- Breathable Face Masks & Eye Protection





Pesticide exposure **PPE for hazardous pesticides**

(Source: 'vegIMPACT Report 2, 2014, p.19')

V Recommendations for Environmental and Sustainable Agriculture - useful practices

SOIL (UNIT 9; LO 9.6)	Recommendations
○ Maintain good soil fertility and prevent damage to the environment, soil erosion and pollution.	✓ Fertilization should be adequate, taking into account soil resources, crop nutrient requirements, climatic conditions and surface, groundwater and contamination risks. ✓ Use a nutrient budget to determine fertilizer requirements. ✓ Adequate stocking rate in pasture should be sought. ✓ Avoid standing animals in pastures when soils become water logged

WATER (UNIT 9; LO 9.6)	Recommendations
○ Properly manage and optimize water use ○ Properly manage the use of inputs and release of wastewater in surrounding water sources	✓ The amount of water drawn from the environment should be minimized. The release of polluted water into the eco-system must be prevented. ✓ Proper use of water for irrigation as well as careful and adequate use of inputs should be made to preserve the volume and quality of water reserves and courses. ✓ Comply with industry standards and meet the requirements of national legislation regards to environmental effects (e.g. knowledge of quantity of manure or effluents, correct storage and spreading). ✓ Manage pastures to avoid effluent runoff by spreading farm manures in accordance to local conditions.

BIODIVERSITY (UNIT 9; LO 9.6)	Recommendations
○ Maintain or enhance biological diversity on the farm	✓ For example, dairy farming practices should preserve and improve the habitat for animal and plant species as well as biodiversity on and around the farm.

AIR	Recommendations
○ Preserve or improve the air quality	✓ Odours emanating from the dairy herd and of the effluent storage should be minimized.

CLIMATE CHANGE	Recommendations

○ Minimize adverse impacts on the global environment and climate change.	✓On the basis of established mechanisms and available inputs, estimate and monitor greenhouse gas emissions (like methane, nitrous oxide, carbon dioxide) of the dairy herd and of manure storage as well as from other on-farm practices and off-farm inputs. ✓Mitigate and minimize these greenhouse gas emissions.

ENERGY (UNIT 9; LO 9.7)	Recommendations
○ Properly chose and use energy resources.	✓Continually seek to optimize energy use. ✓Energy assessment should be performed in order to identify areas for minimizing the relative use of non-renewable resources and maximizing the relative use of renewable energies. ✓Wherever possible, the farm should strive to reduce the use of non-renewable sources of energy and increase the use of renewable sources of energy.

WASTE (UNIT 9; LO 9.5)	Recommendations
○ Use crop by-products as much as possible on the farm ○ Properly handle, and if possible recycle waste generated by the farm	✓The farm shall continuously reduce, reuse and recycle the quantity of waste and by-products of the harvest and processing that it generates. ✓In particular, organic crop debris may be composted on the farm and reused for soil conditioning where there is no risk of disease carry-over. ✓Ensure that animal and human wastes are stored and managed to minimize the risk of environmental pollution. ✓Manage farm wastes properly and optimize their agronomic value (recycling etc). ✓Ensure proper treatment of human and animal waste from dairy farm in order not to contaminate pasture or feed.

('SAI Platform, 2009, p.14-15')

VI examples, best practices - material for discussion

6.1 Example of organic certified farm

Herdade do Freixo do Meio is an organic certified farm of 440 ha located in the Alentejo region in the south of Portugal. The region of Alentejo in Portugal is generally classified as an area highly vulnerable to climate change and at high risk of desertification, due to its aridity index and extension of soils with lowquality, combined with the climate scenarios that project, for this region, a decrease in precipitation levels, an increase in the frequency, duration and intensity of droughts and an increase in temperatures. The measures implemented by Herdade do Freixo do Meio aim to reduce its water needs, reduce desertification and soil erosion, and increase resilience to climate change and climate extremes while sustaining an economically viable agroforestry system.

The farm has implemented a wide number of measures aimed at reducing water needs, increasing resilience to droughts, diversifying crop products and increasing awareness of sustainability and climate change adaptation.

Measures to improve water retention and reduce water needs:

- creation of small dams;
- drip irrigation (to reduce water consumption) with organic fertilizer (farmer made organic liquid fertilizer rich in bacteria which requires training on hygienic handling, introduced in drip irrigation);
- use of renewable energy for water pumping to reduce irrigation costs;
- mulching, i.e. use of straw, leaves, shredded wood, other natural fibers or even compost to cover soil and prevent evaporation;
- tilling on contour lines and no tilling in steep areas, aiming to prevent soil erosion and increase soil water retention;
- keyline design of terrain, trees and crops — this practice increases water infiltration and soil water retention, preventing erosion, increasing pasture productivity and water availability over a larger area, and increasing the depth of roots and the carbon sink;
- increasing soil organic matter to improve soil water retention;
- cultivating the soil with swales and boomerang shapes to increase soil water retention;
- planting trees and crops in areas with particular microclimates within the farm (e.g. northwest slopes have higher levels of humidity).

6.2 ICTs and Agriculture

ICTs in rural development appear to be most widely and relevantly used for information dissemination and gathering. For example, India and China have several programmes and projects that apply ICTs for purposes that use data for comparisons or towards policy decisions.

In India, the Jal-Chitra software is being used to create an interactive water map of villages to enable communities to keep records of the water available from each water source, record water quality testing, list maintenance work done and required, estimate water demand, generate future monthly water budgets (based on past records) and show the community needs met through rainwater harvesting systems. China is carrying out similar water-mapping exercises in several villages.

In the Philippines, the Manila Observatory has partnered with a mobile phone service provider, SMART, to provide telemetric rain gauges and phones to farmers in disaster-prone areas. Local farmers read the rain gauges and phone in information to the observatory. The observatory can also use the phones to issue early storm warnings to fisher folk and farmers.

From Brazil to France:
Conservation Agriculture moves from the South to the North

Although no-tillage techniques had been developed and practiced in France since the 1990s, it was only very recently that the more sustainable approach of conservation agriculture started being practiced in the country. Inspired by the experiences of Brazilian agriculture in decreasing production costs and labor requirements, a group of French farmers applied conservation agriculture techniques to field crops. The practice started to spread through informal networks formed by these farmers, which helped share information on factors of production and cropping practices. The learning process, initially firmly focused on equipment and soil, gradually shifted to the use of cover crops. There has been a general drift away from no tillage practices towards conservation agriculture through the construction of socio-technical networks combining a number of objectives and stakeholders, associated with technical, agronomic and environmental questions, through multiple clusters.

Scotland's TIBRE Project

Some years ago, Scottish Natural Heritage took up the challenge of environmental sustainability and set up a project, TIBRE (Targeted Inputs for a Better Rural Environment), to investigate the range of technological options that could encourage intensive farming systems to become more environmentally sustainable without undermining their economic competitiveness. The TIBRE project was therefore set up to directly enable farmers to contribute to the environmental sustainability of Scottish agriculture, while at the same time continuing to contribute to its agricultural sustainability. Policy-makers felt this could be achieved through the uptake of technological innovations in the areas of chemical technology, biotechnology, engineering and information technology.

The rationale for the project was:

- ✓ Withdrawal of financial support to farmers under the EU's Common Agricultural Policy could lead to greater reliance on cheaper and more environmentally-damaging technology
- ✓ It will become progressively harder for expensive, new and more environmentally-sustainable technology to get a toe-hold in a market dominated by these cheaper technologies
- ✓ Industry is less likely to spend money on new green technologies under these market conditions
- ✓ Policies designed to reduce surplus production, such as set-asides, are likely to be reversed once EU prices approach those of the world market
- ✓ The use of productive land for alternative, non-food crops will increase pressure to intensify food production on remaining land
- ✓ A return to a situation of maximum food production is likely to be damaging for the environment with the current generation of technological inputs

6.3 Example of Natural Farming

Organic farming is growing around 12% per year. However, just 1.1% of the land is certified for organic farming worldwide.

Tatkim, a small State in India, initiated a strategy called "one state at a time", declared 100% organic cultivation, and became the first State in India to follow organic farming methods. The State government has made a policy to transition from chemical-based to chemical and pesticide-free land. It also banned selling fertilizers and pesticides within the State. The Program of natural farming involved: 1) soil protection, i.e. minimal use of chemical fertilizers, 2) environmental protection, i.e. substitute to pesticides, 3) promotion of statewide natural farming initiatives. (Hong P. et. al., 2022, p.7)

6.4 Example of Individual Scale Natural Farming

The Kopi Taluk in India is comprised of 60 villages. One-third of the population is engaged in agriculture, with significant production of paddy, coconut, sugarcane, banana, turmeric, and tobacco. All of the farmers from this place slowly transitioned from natural farming to fertilizer-based farms over the decades. Extensive use of pesticides and fertilizers spoiled the health of the soil and that natural nutrition contents diminished over time. There was a high dependency on machinery and equipment (e.g., tractors) which increased their cost.

One farmer decided to expand his farming land from 4 to 12 acres and doubled his income by following practices such as human harvesting and moving from mono-crop to multi-crop. The approach was to change the farming strategy and strengthen the soil condition.

The waste from the cattle, goat, and poultry sheds is designed to go into a urine and dung pit from which, by gravity, it enters an artificial lake where it gets diluted. Fish grow in the lake and enrich it with their waste. Only water from this lake is used for irrigation.

No manual labor is required to ensure nutrient-rich irrigation water to the farm. Now, farming practices are low cost of production, low level of labor requirement, low water requirement, no chemical inputs, no pesticide or insecticide, and higher yield. Multi-cropping and intercropping are the most critical features on his farm. A study in China has proven that intercropping increased the per unit area yield and substantially lowered pest and disease occurrence. (Hong P. et. al., 2022, p.8-9)

6.5 Example of extensive and intensive farm – business case

This approach was developed in a specific dairy landscape, however, the methodology is replicable and scalable to others. The farm data was split into two typologies: extensive (lower or equal than 17000 kg Fat and Protein Corrected Milk (FPCM) per hectare) and intensive (higher than 17000 kg FPCM per hectare).

In this dairy landscape, there were gaps (in at least one of the typologies) for: ammonia emissions, chemical (pesticide, herbicide, fungicide) inputs, nitrogen soil surplus, percentage of own (or local) protein production, and percentage of natural habitat. For both farm typologies they have reached the goal of 60% permanent grassland. We examined pathways to improve the business case for farmers that want to close the gap on any farm level targets not being met (see Table 1).

KPI	AVOID/REDUCE					RESTORE/REGENERATE			
	1 Soil management	2 IMP*/no spray	3 Organic Inputs	4 Manure management	5 Flowering grass	6 Natural land	7 Woody biomass	8 Riparian areas	9 High impact grazing
Chemical inputs		✓				✓		✓	
Nitrogen soil surplus			✓			✓	✓	✓	✓
Ammonia emissions			✓	✓					✓
% Natural Habitat					✓	✓		✓	
% Permanent Grassland					✓	✓	✓		✓
Landscape diversity (green/blue)						✓		✓	
Landscape fragmentation					✓	✓		✓	✓
Species composition change	✓	✓	✓		✓	✓		✓	✓
% Own (or local) protein production					✓	✓	✓		✓

Table 1: The Action Targets and Farm Level Key Performance Indicators (KPIs) associated through scientific evidence are mapped for the avoid/reduce and restore/regenerate categories. Action targets are prioritizing first actions that avoid and reduce impacts, then actions that restore and regenerate, and all the while prioritizing transformative actions.

(Source: 'WWF-France, 2022, p.12')

Annex I:
Pros and cons on greening approaches in farming system innovations

Farming system innovations approaches to greening	PROS		CONS
	Enhancing positive effects	Reducing Negative effects	
1. Integrated Pest Management	- Increases Agricultural Productivity - Conserves natural resources	- Reduces environmental degradation	- Complex system of measures - Requires farmers" skills to be built up and the cooperation of all farmers in an area to be completely effective
2. Organic Production Systems	- Improves/maintains soil quality - Improves water quality by reducing runoff from pesticide use - Improves quality of food - Increases biodiversity	- Reduces the use of pesticides and thus their harmful effects on the environment - Decreases fossil fuel emissions - Reduces nitrate leaching	- Costs are still higher than traditional farming methods
3. Conservation Agriculture/ Crop Rotation	- Increases soil protection through the permanent maintenance of plant cover - Increases soil fertility - Increases farm profitability by decreasing working time - Increases biodiversity	- Reduces erosion, soil disturbance - Reduces pollutants	- More difficult to practice on organic farms - Risk of failure because of the difficulty of learning new techniques - Cost of learning can be high - In some cases can increase dependence on pesticides (particularly herbicides)

4. Water Management Systems	- Improves soil and water quality	- Reduces use of an increasingly scarce resource, water	- Costs for complex water management systems are high - For water management systems to work efficiently, it requires the cooperation of other actors in agriculture (fertilizer producers, seed producers, etc.)
5. Natural Resource Management	- Improves biodiversity - Increases carbon sequestration - Improves water infiltration - Improves soil productivity and rehabilitates the land	- Decreases the loss of forests - Reduces herbicide use - Reduces use of fire to manage pasture - Reduces fossil fuel dependence	- Costs for paying for a system like REDD are still being debated
6. Urban/ Peri-Urban Agriculture	- Increases employment opportunities in urban areas - Improves air quality in cities, making them more „green"	- Reduces carbon footprint of agriculture - Reduces temperatures - Reduces intensification and the risks associated with it (soil degradation, erosion, loss of nutrients, etc.) in rural areas	- Increased competition for land and water resources in urban areas - Risks of diseases and contaminants if pesticides are used
Source: 'OECD Synthesis Report, 2011, p. 46-48'			

ANNEX II:
Guidelines for eco-agriculture – key actions and effects

Ensuring ecosystem compatible drainage of agricultural land will help to reduce the impacts of floods on fields, reduce waterlogging, increase infiltration and reduce runoff (and hence erosion), and improve soil structure or promote contour ploughing. **(UNIT 1; LO 1.1)**

Effects:

- optimized drainage decreases soil compaction and erosion, and therefore loss of carbon, and nitrogen runoff leaching. It contributes to lower nitrous oxide (N2O) emissions in welldrained crops
- it is essential that drainage systems are designed in a way that avoids negative impacts on waterdependent ecosystems. Modifying existing drainage systems can help to ensure the correct water levels needed for agricultural crop production while enabling more natural water flow during times when drainage is not needed as much

Rainwater harvesting increases the resilience of a farm to water scarcity and droughts

Storage systems require taking land out of production. But, the construction and maintenance of rainwater harvesting and storage systems incurs significant costs for farmers (in terms of labour and machinery). **(UNIT 1; LO 1.1); (UNIT 3; LO 3.5)**

Effects:

- improved rainwater harvesting and storage can result in energy savings. For rainfed crops, rainwater harvesting increases production per unit of area and inputs.
- the use of rainwater in agricultural production has the potential to lessen the pressures on surface and groundwater abstraction.

Precision farming encompasses a set of technologies (e.g. global positioning system tools, use of drones) aimed at the management of spatial and temporal variability of the field by optimizing yield and input applications, for example fuel, fertilizers, pesticides and water. **(UNIT 1; LO 1.1)**

Effects:

- significant reductions in GHG emissions can be achieved thanks to a decrease in nitrogen fertilizer application, fertilizer production and fuel consumption
- Sitespecific and efficient fertilizer and pesticide application might decrease the risk of ground- and surface water contamination
- Precision weeding can also replace pesticides, preventing the development of pesticide resistance in various weeds

High nature value (HNV) farmland, with its emphasis on extensive management practices (i.e. low inputs, minimum tillage, low livestock stocking levels and landscape elements), can conserve soils and offers similar benefits, such as reduced tillage, cover crops and improved grazing management.

Effects:

- the reliance on organic fertilizers promotes organic carbon storage in soils. However, more land is required to produce similar outputs, which could lead to higher GHG emissions per kilogram of meat or milk produced
- HNV farming practices generate high levels of soil organic matter, which enhances water storage capacity and increases resilience to droughts and floods.

Modifying crop calendars can help farmers to take advantage of better early season moisture conditions and a prolonged growing season, and help minimize drought risk periods during grain filling. Moreover, later planting can also be useful for making more effective use of rainfall and stored soil moisture. The cost of this measure is negligible.

Effects:

- soil carbon storage can be increased thanks to higher yields and large amounts of crop residues when modified crop calendars are used.
- adjusting cultivation timing (or modifying crop calendars) to the new climatic regimes ensures food provisioning services. The changes may have impacts on farms' aboveground biodiversity as well as their soil biodiversity.

Cover crops can significantly reduce the risk of soil degradation, which can be exacerbated by climate change effects, such as an increased risk of intense precipitation and strong wind events, especially during winter. The use of native crop species should be chosen whenever possible (as they are more adapted to local conditions and therefore more resilient). When linked with precision farming, cover crops reduce the need for fertilization, as well as increasing organic matter in the soil and ensuring less destruction of the structure by compaction and an increase in the microbiome.

Effects:

- Cover crops can improve soil properties (physical, chemical and biological), sequestration of soil organic carbon and nitrogen retention (reduction of nitrate leaching), aboveground biomass nitrogen and nutrient cycling.
- the measure contributes to suppression of weeds, improvement of wildlife habitats and diversity, potential provision of both forage for livestock and feedstock for cellulosic biofuel production, and increased crop yields in regions with abundant precipitation.

Use of adapted crops could reduce the impact of droughts and water scarcity.

In such cases, shifting to different crops to better attune to the new climate conditions may be the best adaptation option. The cost of implementing this measure is likely to depend on the price of the seed of the adapted crops and whether farmers will need to make large investments as a result of significant structural changes to the farm's production (e.g. a new type of machinery).

Effects:

- Crops with deep root systems (such as maize, wheat, barley) can also accelerate atmospheric carbon sequestration.
- adapted crops are likely to have some effects on biodiversity and ecosystem services
- A switch from annual to perennial energy crops can lead to changes in various ecosystem services, including provisioning of producers' income, provisioning of energy, water quality regulation (related to phosphorus loading) belowground carbon sequestration, annual N2O emissions, abundance of pollinators and potential for biocontrol.

No tillage or minimum tillage induces changes in the soil structure and in the location of soil organic matter and crop residues. **(UNIT 4; LO 4.1)**

This results in changes in biological, chemical and physical soil properties, including soil climate (soil temperature and soil water content). Costs are likely to vary between farms (size and production system/ structure), localities and countries. Provided that yields are equivalent, no tillage is more economical than the conventional tillage for large farms.

Effects:

- the combination of all these modifications has an important impact on carbon and nitrate transformation in soil and leads to a more intact soil structure. Such soils are more resilient to soil erosion by wind and water. No or minimum tillage increases soil organic carbon and reduces energy consumption by agricultural machinery.
- no or minimum tillage enhances soil drainage and improves food supplies for insects, birds and small mammals, thanks to more availability of crop residues and weed seeds. No or minimum tillage also improves ecosystem services, such as water regulation, carbon storage, soil stability, protection of surface soils from erosion, enhanced water infiltration, increased soil fertility through enhanced nitrogen stocks (in the long term), improved soil, water and air quality, and reduced soil erosion and fuel use. No tillage can lead to an increased need for either pesticides or alternative pest control (e.g. integrated pest control management).

Crop diversification and rotation spreads the risk of losing an entire year's production, as different crops respond differently to weather and climate.

A crop system based on a long crop rotation provides more resilience to climate change.

Effects:

- Including a rotation with leguminous crops reduces nitrogen fertilizer needs, field operations and N2O emissions. Crop diversification and rotation delivers efficient nutrient cycling and soil quality improvement.
- crop diversification and rotation conserve the biodiversity.
- It also increases water holding capacity in surface soil, improves control of weeds, diseases and arthropod pests, improves pollination services, and reduces erosion and water requirements and nitrogen and other fossil fuelintensive inputs.

Field margins can slow down the movement of water from soil to watercourses and reduce water and wind erosion.

Field margins are usually a lowcost solution for reducing the impacts of extreme weather events, as they include only the cost of establishment, and there is no maintenance cost, assuming that shelterbelts are left uncut.

Effects:

- field margins (e.g. shelterbelts and hedges) increase carbon storage through retention of sediment from agricultural runoff and through capture and sequestration in biomass. Field margins can also reduce N2O emissions by capturing NO3 before it reaches surface water or groundwater
- field margins support various fauna, reduce soil erosion, enhance water retention, ensure biodiversity at the landscape level and support farmland birds.
- The vegetative composition of the field margins should consider both biodiversity and pest control benefits.

Sustainable production in greenhouses combats the likely increase in temperature and water stress periods during the crop growing season

Effects:

- sustainable horticulture production in greenhouses would be based on renewable energy sources, that is, geothermal energy at low temperatures, photovoltaic solar energy and solid biomass.
- In addition, efficiency increases could be achieved with the current technology
- a closed greenhouse system that captures water could reduce pressures on water ecosystem services, soil ecosystem services and soil biodiversity.

Measures addressing viniculture include the use of protective and monitoring equipment, such as thermal screening and thermometers, that will allow better temperature control. **(UNIT 2; LO 2.1; 2.2)**

Investment in thermal screens would provide shade from direct sunlight and prevent mineral deterioration in fruit (see Box 5.8). For adaptation, the systems have been developed to manipulate the temperatures of vines. These include a chamberfree system in which air can be heated or cooled and then blown across grape bunches to get a 10 °C difference in temperature. Minichambers combined with shade cloths and reflective foils have also been used to manipulate the temperature and irradiance. By applying polyethylene sleeves to cover cordons and canes and installing hail protection nets led to increases of maximum temperatures by 58 °C (for earlier and later growing potential) and decrease minimum temperatures by 12 °C (during higher temperatures). Installation of new technology or equipment would require substantial investment and maintenance costs

Effects:

- healthy vineyards would require fewer inputs and would maintain soil properties (i.e. avoiding erosion and enhancing carbon sequestration); therefore, upstream and infield emissions would be reduced, in comparison with crops affected by water or heat stress.
- improved fertilizer applications and spraying could reduce pressures on water ecosystem services, soil ecosystem services and soil biodiversity.

Breeding livestock for greater tolerance coupled with improved animal health can positively impact productivity and reduce grazing pressure on grassland **(UNIT 6; LO 6.1; 6.2)**

More efficient use of grainbased feeds and feeding, through leastcost ration formulation, diversification of species distribution, selective breeding for improved feed conversion efficiency, and incorporation of crop residues and processing byproducts, are some of the approaches that can be incorporated into agricultural and livestock projects.

Effects:

- using improved livestock genetics to increase productivity directly reduces the emissions intensity of livestock systems.
- breeding livestock for greater tolerance and productivity to reduce grazing pressure may have beneficial impacts on climateregulating services (through carbon sequestration), as well as on water and soil ecosystem services and aboveground and soil biodiversity.

Improving pasture and grazing management can help to reduce soil degradation, wind and water erosion, increase biomass on grassland and improve animal health.

Effects:

- improved grazing management, fertilization, sowing legumes and improved grass species and conversion from cultivation all tend to lead to increased soil carbon.
- Improving pasture quality, especially in less developed regions, improves animal productivity and reduces the proportion of energy lost as methane (CH4).
- CH4 emissions could potentially be reduced by introducing more concentrates in feed, normally replacing forage; animal health implications should be considered when introducing concentrate feed.
- improved pasture and grazing management, including improved grasslands and pastures with reduced grazing pressure, may have beneficial impacts on climateregulating services (through carbon sequestration), as well as on water and soil ecosystem services and aboveground and soil biodiversity.

Improvement of animal rearing conditions (shading and sprinklers, ventilation systems) improves conditions for livestock production **(UNIT 6; LO 6.5)**

The investment in and maintenance of new technology for animal housing, i.e new cooling systems, can be high; however, the cost of planting trees for shading can be lower and have benefits for biodiversity.

Effects:

- improving animal rearing conditions leads to reduced CH4 emissions, since emissions decrease with reductions in temperature
- increased animal health and welfare improves the efficiency of feed use and feed intake, which probably leads to lower emissions per unit of production.
- In particular, in dairy systems, CH4 and N2O emissions decrease with increasing productivity, while CO2 emissions increase but on a smaller scale.
- soil and water ecosystem services and farm biodiversity benefit from improving animal rearing conditions through the indirect effects of planting trees for shading.

Preventing outbreaks of existing or new diseases focuses on addressing livestock diseases induced by climate change, including measures to prevent diseases in animals previously not exposed to certain diseases. **(UNIT 6; LO 6.3)**

Such measures include improving disease surveillance and response, increasing the capacity to forecast climatesensitive diseases and improving animal health services. In addition, farmers could focus on breeding species that are naturally more resistant to disease and climate change impacts.

Effects:

- using improved livestock genetics to increase productivity directly reduces the emissions intensity of livestock systems.
- breeding livestock for greater tolerance and productivity to reduce grazing pressure may have beneficial impacts on climate regulating services (through carbon sequestration), as well as on water and soil ecosystem services and aboveground and soil biodiversity.

Diversification of farm income activities can serve as an important farm risk management strategy

Mixed production systems on farms can increase land productivity and efficiency in terms of use of water and other resources, protect against soil erosion and lead to enhanced nutrient use efficiency.

Effects:

- mixed production systems, such as agroforestry, agropastoral and agrosilvopastoral systems, doublecropping systems and mixed croplivestock systems can address carbon sequestration objectives.
- Integrating feedstock production with conversion, typically producing animal feed, can reduce demand for cultivated feed, such as soybeans and maize, and can also reduce grazing requirements. In addition, agricultural and forestry residues can be used for energy production.
- mixed production systems can increase land productivity and efficiency in the use of water and other resources and protect against soil erosion.

(Source: 'EEA Report No 04/2019, p.78-84')

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