




2. New trends in contemporary agriculture

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2.1. Innovation in Agriculture

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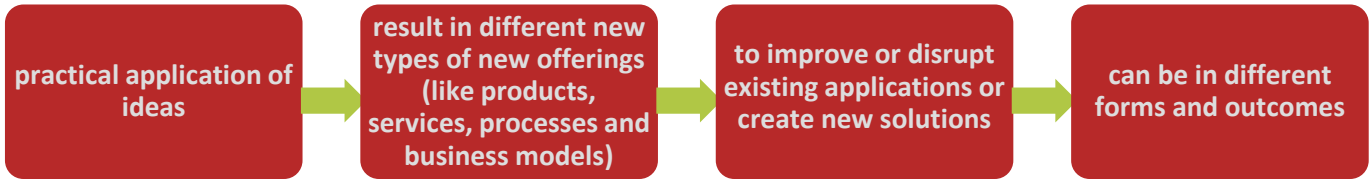
Unit 2. New trends in contemporary agriculture

2.1. Innovation in Agriculture

"Innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, or a new venture started by a lone individual in the family kitchen. It is the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth." – Peter Drucker

Innovation:



Innovations need to overcome obstacles to accessibility, affordability, adaptability, scalability, repeatability and sustainability.

Innovation is a change, a novelty or a process of making changes. Innovation involves not only ingenuity and imagination but even more new processes, technologies and ways of using existing technology. Any new technology or process that does not create a positive change in people's lives does not really qualify as an innovation.

Different Fields of Innovation	
Product and Product Performance Innovations	- developing a new product - improving the performance of an existing product This type of innovation is frequent in the business world.
Technology Innovations	- capturing completely new technologies - using technologies as the basis or trigger for other innovations (For example, the Internet was an innovation in itself, but it also leads to other innovations in various fields)
Business Model Innovations	- innovating an existing business model - developing a new business model The use of different channels, technologies and new markets can drive to new business models for creating, delivering and capturing value for customers.
Organisational Innovations	- managing and sharing resources in a new way - using resources and assets in a completely new way
Process Innovations	- improving efficiency or effectiveness of existing methods - creating a completely new process Possible process innovations include production, delivery or customer interaction.
Marketing / Sales – New Channel Innovations	- designing new methods to capture and retain customers attention - using innovative marketing/sales concepts - using new channels for customer acquisition/sales
Network Innovations	- connecting different groups and stakeholders to create extra value This type of innovation is popular due to the use of ICT services.
Customer Engagement / Retention	- inventing innovative concepts that try to increase the engagement of customers and keep the retention up

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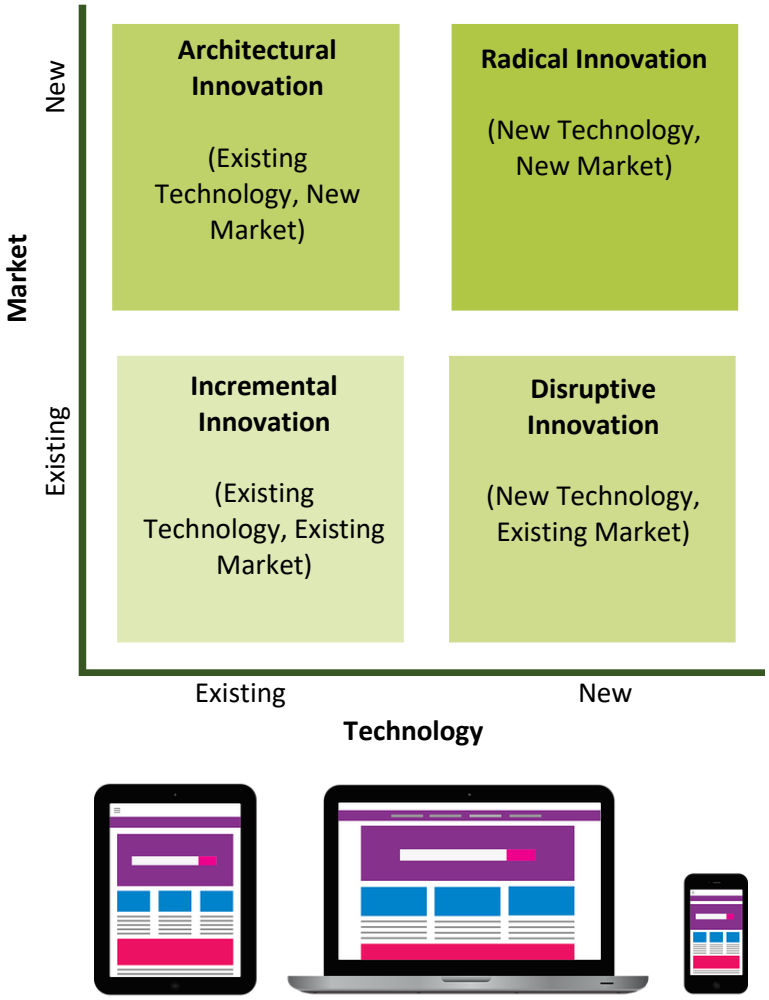
The 4 Types of Innovation

There are various ways in which innovation can affect products, services and processes. We usually distinguish between 4 levels of innovation – Incremental, Disruptive, Architectural and Radical.



1. Incremental Innovation

One of the oft-recurring innovation forms uses existing technologies within the existing market. The aim is to improve an existing offer by adding new features, design changes, etc.

2. Disruptive Innovation

Disruptive innovation is mainly related to the application of new technologies, processes or disruptive business models in existing practices. Sometimes, especially at the beginning, new models seem inferior to existing solutions. But after repetition, they transgress them and take over the market due to efficiency and/or efficacy advantages.

3. Architectural Innovation

Architectural innovations take existing expertise, technology, and skills applying them to a different market. In this way, they can open up new markets and expand the customer base.

4. Radical Innovation

Radical innovation involves the creation of technologies, services and business models that open up entirely new markets. (Most people see innovation this way, but it is the rarest form of them all.)

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Innovating for the future of food and agriculture

Innovation is the central driving force in agriculture to:

- ✓ Transform food systems
- ✓ Lift family farmers out of poverty
- ✓ Help achieve food security

Farmers are more than just food producers, they are guardians of natural resources (soils, water, biodiversity and seeds) and born innovators!

From the beginning of agriculture, farmers have been forced to change, adapt and create new ways of cultivating the land coping with difficult terrains and extreme climatic and weather phenomena. Their survival and livelihoods depended on it, so they found ways to make it work.

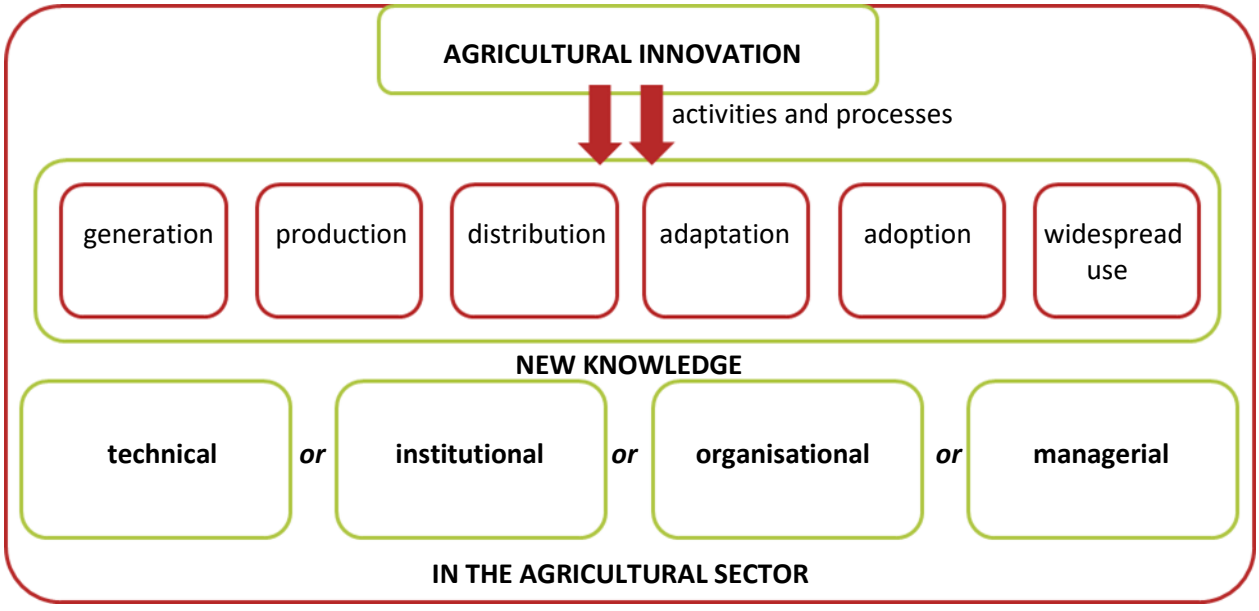
Empowering farmers and investing in innovation is key to achieving food security. This includes:

→ Encouraging innovative and new solutions
→ Recognising the successful innovations that farmers have already used and helping to spread them to other farmers
→ Bring new or existing products, processes or ways of an organisation into use for the first time
→ Creating, developing and implementing a new product, process or service

Innovation can support smallholders and family farmers and increase their productivity and profitability.

Agricultural innovations primarily relate to the need to:

- increase production (of food, fodder, by-products)
- enhance quality (of produce, production process, growing conditions)
- improve market penetration
- bring new products, new processes, and new forms of organisation into use



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Drivers of innovation in agriculture

The drivers interact with each-other affected by market, natural and policy and science and technology factors.

SECTORS	FACTORS THAT STIMULATE INNOVATION
Market	→ Changes in food consumption patterns → Dominating position of food supply chains → International trade, including changes in global demand → Changes in consumer's awareness on issues such as fresh local food, sustainability, food safety, etc. → Price of inputs and labour costs → Changes in supply channels and advances in marketing tools and strategies
Natural / Environment	→ Natural conditions in the area → Availability of natural resources → Environmentally friendly practices → Natural catastrophes
Policies and regulatory frameworks	→ Rules, standards and norms → Taxes and fees → Incentives and subsidies
Science and technology	→ Advances in sciences → Progress ICT-based technologies → Availability of information on market opportunities and prices → Availability of new inputs → Availability of new agricultural practices → Approaches to new storage and conservation technologies and infrastructure

Agricultural Innovations encompasses all dimensions of the production cycle along the entire value chain - from crop, forestry, fishery or livestock production to input and resource management to market access.

In many cases, innovation is about changing how things are done. So, innovation often seeks to solve problems more than creating new technology or product.

We can observe here:

→ Improvements in technologies and practices carried out by farmers themselves
→ Formalised scientific research and development (R&D)
→ Combination of improvements carried out by farmers themselves and formalised scientific R&D

Agricultural Innovations should be viewed as the process whereby individual farmers or agricultural organisations bring new or existing products, processes or ways of an organisation into use for the first time. So, recognising the successful innovations that farmers have already used and helping to spread them to other farmers is of great importance.

Creation, adaptation and application of new technologies and practices		
PRODUCTION Increase agricultural production by optimising yield and/or quality with higher input use efficiency	**PRODUCTION CAPABILITY** Increase the capacity of agricultural production of the soil, water, and air by developing and applying sustainable farming, tools and practices	**MARKET EXPANSION AND DIVERSITY** Increase the diversity of markets and agricultural products to expand the value, utility and reach

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How to encourage innovation in agriculture

Innovation is sometimes a critical area for the survival of agricultural producers, especially local and small-scale farmers. Conversely, coming up with new ideas, putting them into practice, or applying someone else's innovative solutions to existing practices can sometimes be stressful for them. Also, a very influential factor is the structural strength of the social, legal and cultural context in which innovation is introduced.

Innovation always contains a calculated risk that needs to be addressed. Not all attempts to innovate will be successful, and farmers should manage the process to filter out potential fails before they have too much impact on their innovation budget. For this reason, it is useful for the farmers to try to develop a thoughtful process covering some of the tips listed below to better manage it and get a better overview.

TIPS for developing a thoughtful process of introducing innovation on farm

- → Actively encourage members of farm to think innovatively
- → Review existing practices and identify weaknesses that require improvement
- → Examine capabilities and the cost/benefit of making changes
- → Ask customers for feedback/invite customers for feedback rounds
- → Ask stakeholders for feedback
- → Invest in education and training
- → Build cooperation and networking to exchange information, good practices and solutions
- → Actively research on the internet (follow agricultural news, tech news, etc.)
- → Ask / interview experts
- → Foster creativity

Creativity and Innovation

"Creativity is of great importance in supporting entrepreneurship, building skills, improving wellbeing, facilitating freedom of speech and dialogue and ensuring significant growth in the economy and employment."[1]

Creativity and Innovation are closely tied, and in the domain of responsible and sustainable production, this connection is perhaps even more noticeable and stronger. Creativity can be a strategic factor for responsible and sustainable agricultural production. It can be both an enabler and a driver of development.

Creativity enables someone to, for example, look for ways of sustainably managing natural resources, alternatively resolving water issues, new business models, using new technologies effectively, and so on. Thus, creativity and innovation, like business ideas, are increasingly seen as the core and trigger of further societal prosperity and business success.

Cooperation, innovation and network [2]

Most local innovation projects (53%) funded under the agricultural European innovation partnership focus on alternative types of farming, such as

- → organic farming,
- → conservation agriculture,
- → adapting circularity principles to farming,
- → agroecology,
- → bio-based production.

[1] Mróz, A.; Ocetkiewicz, I. Creativity for Sustainability: How Do Polish Teachers Develop Students' Creativity Competence? Analysis of Research Results. Sustainability 2021, 13, 571. https://doi.org/10.3390/su13020571

[2] European Commission: EU rural areas in numbers - Key data for rural areas today, broken down by topic. https://ec.europa.eu/info/strategy/priorities-2019-2024/new-push-european-democracy/long-term-vision-rural-areas/eu-rural-areas-numbers_en

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Supporting economic diversification and short supply chains

According to the European Commission's long-term vision for EU rural areas: "Developing short supply chains, promoting rural tourism and making use of labelling schemes acknowledging the quality and variety of local and traditional food products will have a positive impact on local economies."[3]

Suggestions for further consideration

Suggestions for adult educators:

✔ Incorporate fostering creativity and creative thinking as a point of your work

- to stimulate innovation and achieve optimal and sustainable wellbeing for individuals, families and communities

→ encourage farmers with activities that will contribute to building up their creativity and creative thinking

* Apply the approach to creativity and sustainability from a variety of disciplinary and thematic perspectives as well as from trans-disciplinary and intercultural perspectives

* Promote cross-fertilisation

* Apply Project-Based Learning, Problem-Based Learning, Work-based Learning, Self-Directed Learning

* Using Real-Life Situations in Education

→ Launch initiatives that seek to stimulate, mobilise and exchange creative solutions, tools and approaches in agricultural work (and all walks of life)

→ Initiate actions that will enable farmers to think creatively to have long-term effects on the economy, ecology, environment and community equity

[3] European Commission: A long-term vision for the EU's rural areas - Building the future of rural areas together https://ec.europa.eu/info/strategy/priorities-2019-2024/new-push-european-democracy/long-term-vision-rural-areas_en

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2.2. Water and agri-food sector

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2.2. Water and agri-food sector

Farming accounts for almost 70% of global water withdrawal.

Water is an essential factor in any agricultural production, and water scarcity has a huge impact on food production and food security.

Water scarcity is one of the greatest challenges of our time. How we can address it in agriculture:

→ Use water wisely to grow crops
→ Improve irrigation management
→ Improve livestock management
→ Manage land sustainably
→ Use soil conservation techniques
→ Reduce food loss and waste

Improving water management in agriculture is essential for a sustainable and productive agri-food sector.

Water-saving techniques ensure that water use in agriculture is:

✓ more efficient
✓ more productive
✓ more equitable
✓ more environmentally friendly

Water in Food Systems

A. Water in Agricultural production

Sustainability-minded farmers are looking ahead and using an arsenal of methods to conserve water. Wisely water management is not just about how water is delivered, but also when, how often and how much.

Successful water management involves a careful, honest assessment of available and required water. To availability and needs are reconciled, system design involves taking into account the watershed as a whole and the health of the soil, types of plants and animals on the farm.

a) Arable farming (crops)

Plants require consistent amounts of water to go through their life cycle from seed to harvest. Water use varies greatly from crop to crop. For example, pulses crops have a small water footprint, so only 1 250 litres of water are needed to produce 1kg of lentils. Orchards tend to use more water than annual fruit and vegetable crops due to the years it takes to nurture trees to a fruitful age and have to be watered year-round for only one annual harvest.

Improving land and water management

An integrated approach to soil-water-plant-nutrient management

Soil–plant-water relations entail the physical properties of soil and plants that affect the movement, retention and use of water.

→ Understanding the effects of soil quality and water characteristics on plant production and its management
→ Understanding the relationship between soil, water and plant for sustainable optimal crop production

Soil quality, water quality and synergy between them are highly imperative for optimal crop production.

Two significant physical properties of soil that impact the soil's water and air supply for crop production are soil texture and soil structure.

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Ways Farmers Save Water

Improving water resources management

This should include optimising irrigation scheduling and more efficient irrigation systems, such as drip irrigation. Soil fertility needs to be improved to ensure that crop growth is not constrained by nutritional or physical constraints and every drop of water can be fully utilised for growth. Efficient water uptake by crops can be achieved through demand-based irrigation scheduling that takes into account the water needs of different crops, growth phases, and prevailing environmental conditions.

Water-saving techniques for optimising agricultural practices that support the intensification of crop production and preservation of natural resources:

I. Irrigation management

The most common irrigation systems are flood, overhead, and drip.

Drip Irrigation Systems	- bring water directly to the roots of plants instead of sprinkling water on top - reduction of evaporation that occurs with spray watering systems Timers can be used to schedule irrigation for the colder parts of the day, further reducing water loss. Properly installed, drip irrigation can save up to 80% more water than conventional irrigation and can even contribute to increased crop yields. 
Water Capture and Storage	Many farms rely on municipal water or wells (groundwater), while some have built their own ponds and reservoirs to capture and store rainfall for year-round use. Relying on ponds for all water needs on the farm with proper management can create habitat for local wildlife and help minimise their impact on the surrounding watershed.
Wetlands	The idea is to slow down erosion due to water running off fields by catching and retaining it in marsh-like areas of shallow water lying between cropland and streams, rivers or lakes.
Irrigation Scheduling	To avoid underwatering or overwatering of crops, farmers carefully monitor the weather forecast, information on crop status and field characteristics, soil and plant moisture (current and forecasted crop water demands and plant-soil water availability, i.e., current soil water status) and adjust their irrigation schedule to the current conditions. For example, farms that use flood irrigation in their orchards can water at night to slow evaporation, allowing water to penetrate the soil and replenish the water table. Irrigation scheduling also requires detailed information on the irrigation system (e.g., application efficiency and capacity), and the use of soil moisture monitoring sensors can enable irrigation at the right time.
Dryland Farming and Dry Farming, or cultivating crops with little or no irrigation	Dry farmers do not irrigate, relying on soil moisture to produce their plants. Special tilling practices and careful attention to microclimates are essential. Dry farming tends to improve nutrient-dense and flavorful but produces lower yields than irrigated crops. - encompass the specific set of agricultural techniques, management practices and continuous adaptation to the presence or absence of moisture in a given crop cycle for growing without irrigation - includes the constant assessment of the amount of moisture present or missing for any crop cycle and planning accordingly - requires careful husbandry and aggressive cost management to minimise/offset for losses in bad years - involves the selection of crops and cultivars suitable for dry farming practices (Not all crops are suitable for dry farming!)
Drought-Tolerant Crops	Growing crops that suit the region's climate is another way for farmers to get more crops per drop. Crop types from arid regions are naturally drought-tolerant, and other crop varieties have been selected over time for their low water needs.

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II. Soil conservation practices geared to maintain soil productivity

Different methods of soil conservation help mitigate erosion, prevent earth runoff, keep fertility, avoid degradation, minimise nature pollution and chemicals deposition in water bodies. By applying integrated techniques and practices to avoid degradation, erosion and depletion, soil conservation is vital to land reaps high yields productively, enabling that land is able to do so in the future. Thus, it considerably contributes to the sustainability of the environment and resources.

Tillage has been shown to increase water losses on evaporation, and tilling farmland after each crop disturbs the soil and reduces its ability to retain water.

Conservation Tillage	Conservation tillage uses specialised ploughs or other tools that partially till the soil but leave at least 30% of vegetative crop residue on the surface. As the use of cover crops, such practices help increase water absorption and reduce evaporation, erosion, and compaction. Conservation tillage can stop and even reverse the process of soil degradation, helping to prevent nutrient depletion and protect yield.
No-Till Farming	No-till farming implies leaving the land alone, allowing the remainder of the last crop to decompose into the soil and planting seeds into the crop residues. That enables dead plant matter to decompose and helps the regular renewal of the soil. Additionally, the vegetation accumulates moisture for future crops. Also, fields retain many beneficial organisms like earthworms and others that help feed the soil and retain water better, providing less likely to evaporate water.
Compost and Mulch	Compost or decomposed organic matter is used as fertiliser to improve the structure of the soil, increasing retain more water in the soil during the dry season. Mulch is a material spread on the surface of the soil to conserve moisture. Mulch made from organic materials such as straw or wood chips will break down into compost, further increasing the soil's capacity to retain water. Compost and mulch help farms retain more water in the soil during the dry season. Farmers can also use black plastic mulch as a soil cover to suppress weeds and reduce evaporation.
Cover Crops	Cover crops reduce weeds, increase soil fertility and organic matter, and help prevent erosion and compaction, allowing water to penetrate the soil more easily and improving its water-holding capacity. Farmers also use perennial grass and clover as cover crops in orchards to build healthy soil.
Crop Rotation	Crop rotation implies a change of agro-species instead of planting monoculture during many subsequent seasons. Farmers who apply this method have numerous advantages. Crop rotation helps to improve the structure of soil with different root systems, mitigate the development of pests and add nitrogen to the nitrogen-fixing plants (legumes). Also, it is a good practice for improving productivity and encouraging food diversity. Crop rotation of legumes, cereals and oilseeds benefits the population in terms of nutrient ranges.
Contour Farming	The method suggests planting species along the contour and proves effective on hillsides and slope territories. Rows along the slope provoke soil erosion due to water flows, but rows along the contour restrain it. Furrows and rows of plants prevent rainwater from washing away the soil from the hill into lower-lying areas and help keep the soil healthier. Thus, when farming on a hillside, farmers cultivate and plant along the contour and do not allow the soil to run off the slope.
Strip Cropping	It involves combining high-growing crops with low-growing ones for the sake of wind protection. An example is when corn grows in strips with fodder crops. Additional advantages are organic matters from low crops, and the practice works even better when high-growth crops are intensified on the sides where winds usually blow.
Buffer strips - Stream Buffers	It means planting rows of trees and shrubs on banks of bare water bodies to prevent sedimentation, water leaching and wind gusts that take the soil out of the field and damage the land. Vegetation roots planted along a stream or riverbank help keep the soil in place, fixing the soil to avoid slumping into waterways and erosion.
Grassed Waterways	A grassed waterway is a furrow for water streams covered with grass, as wide strips of grass planted in a field or between a river/creek at the edge of a farm field. It is connected to a ditch, pit or pool to collect water. Grassroots also hold the soil in place, protecting it from water erosion and contributing to soil conservation.

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Going Organic

Organically grown crops use less water than conventionally grown crops. In addition to keeping many toxic pesticides out of watercourses, organic methods help retain moisture in the soil. Healthy soil, rich in organic matter and microbial life, serves as a sponge that delivers moisture to plants. Studies have found that organic fields can recharge groundwater supplies up to 20%.

Step Away from Synthetic Fertilisers and Pesticides	Chemicals used to control weeds and pests are harmful to the environment and undesired in soil conservation. Switching to organic farming and alternative ways of solving problems is highly important in agriculture. Alternatives are various biological and cultivation options that restore soil fertility (such as the use of green and animal manure, compost, crop rotation and other methods of non-chemical control).
Integrated Pest Management	Pests are a big nuisance and a major issue to tackle for farmers. While chemicals and synthetic herbicides leaking to water and the atmosphere poison nature, organic methods contribute to the well-being of the agricultural field and the environment. A conscientious farmer replaces synthetic herbicides with organic ones by establishing biological enemies of pests whenever possible, rotating crops to minimise the increase in pest populations in the same field over the years and using alternative techniques in the complex.

b) Pastoral farming (livestock)

Livestock breeding requires a significant amount of water because it is necessary to feed, clean and maintain the animals. Animal products (especially those that feed on grain rather than growing on pastures) tend to require much more water than plant products due to the water that enters the production of food that animals eat during their lifetimes.

Pasture-raised meat	For pasture-raised meat (especially unirrigated pasture) requires less water than conventional grain-fed meat.
Rotational Grazing	Rotational grazing is a process in which livestock are moved between fields to encourage pasture regrowth. Good grazing management increases water absorption in the fields and decreases water runoff, making pastures more drought-resistant. Increased organic matter in the soil and better fodder cover are also benefits of water-saving rotary grazing. So, farmers practise rotational grazing to keep their pastures and animals healthy.

c) Mixed farming (crops + livestock)

→ Example of a farm that grows apple orchards and lambs

While conventional farms spray their orchard floors with herbicides, this farmer lets weeds, clover and other plants grow wild. This ground cover serves as forage and habitat for bees and beneficial insects (which pollinate the orchards), as well as for feeding lambs that graze in the orchard. They keep down weeds while adding their natural fertiliser and are eventually processed into meat, another of the farm's yields. These apple orchards retain water better than conventional orchards, supporting multiple products without additional irrigation.

B. Water in the food value chain

Water is often used inefficiently in the food value chain. Substantial decisions such as choice of location, technology and suppliers are usually made without taking into account the impacts on water resources, especially when water is not a limiting factor either in quantity and/or price.

Take into account:

→ virtual water used to grow food
→ decisions such as location, technology and suppliers selection and impacts on water resources
→ virtual water in food processing (uses water and often wastes some of the food)

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The water consumed in the production process of an agricultural or industrial product has been called the 'virtual water' contained in the product (Allan, 1998). For example, it requires about 1300 tons (cubic meters) of water to produce a ton of wheat. In addition to the virtual water used to grow food, food processing uses water (and often wastes some of the food). The amount of wastewater associated with the processing of products ranges on average from 6000 litres per ton of tomatoes to 64000 litres per ton of cauliflower.

Food Loss and Waste

Wasted food is equal to wasted water! By wasting food, we also waste the resources that went into its production. Poorly developed systems for handling, storage, packaging, transportation and marketing of agricultural products result in post-harvest losses. Losses due to food wastage are particularly noticeable from harvest, through delivery to food services and in households.

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- task development to work on further elaboration and application of lessons learned in working with rural women

(Proposals for organising and developing a teaching unit)

Water management models for efficient on-farm watering of vegetable crops under open field conditions

The best irrigation technologies for on-farm water application should be combined with irrigation scheduling programs based on knowledge of soil characteristics and water requirements of local crops to reduce water losses due to drainage and minimise the risks of water contamination. It is essential not only to properly determine the water requirements but also to adjust the frequency of irrigation to the soil characteristics and the growth of plant roots.

Here it also is necessary to consider:

- on-farm water management to minimise evaporation water losses

- evaluation of rainfall patterns to determine quantity and quality available for agriculture use

- use of improved crop varieties

- use of improved cropping systems and agronomics, such as conservation tillage

- rethinking crop scheduling

On-farm water productivity can be optimised by employing appropriate irrigation scheduling protocols. Also, new advances in remote sensing, data processing and management technologies offer opportunities to optimise decision-making regarding irrigation regimes.

Proposal for organising and developing a teaching unit:

Review irrigation scheduling tools and water management models for efficient on-farm watering of vegetable crops under open field conditions.

Assess the use of different:

(a) types of irrigation systems

(b) irrigation management methods

Compare by considering their advantages and drawbacks.

Outline recommendations regarding the practical value of available tools and technologies to help growers to optimise irrigation management of vegetable crops in open field conditions.

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Irrigation management of vegetable crops grown in greenhouses

Under greenhouse conditions cropping cycles may differ appreciably from those of outdoor crops.

Here it is necessary to consider irrigation management for greenhouse vegetable crops:

- soil-grown

- free-draining soilless systems

In Europe, most greenhouse vegetable crops are grown in soil.

Both soil-grown and free-draining soilless systems typically have large nitrate (NO_3^-) leaching loss, and irrigation is a major contributing factor to that. Improving the irrigation management of greenhouse vegetable crops could contribute to reducing the appreciable N loss in groundwater and surface water bodies.

Proposal for organising and developing a teaching unit:

Review state-of-the-art methods and tools available or being developed to optimise irrigation management of both soil- and soilless-grown vegetable crops in greenhouses.

Assess the use of different:

(a) types of irrigation systems

(b) irrigation management methods (for soil or soilless production)

Compare by considering their advantages and drawbacks.

Outline recommendations regarding the practical value of available tools and technologies to help growers to optimise irrigation management of vegetable crops grown in greenhouses.

Suggestions for further consideration

Suggested topics for further consideration:

- → Farm-level water management
- → Crop water relations, crop yields and water productivity
- → Irrigation and drainage in cultivated areas
- → Management and strategies to improve water use in agriculture on farm-level
- → Rainwater harvesting and crop water management
- → Use of wastewater and other low-quality waters in agriculture
- → Groundwater management in agriculture and conjunctive use of groundwater and surface water
- → Implications of groundwater and surface water management on nutrient cycling
- → Exploitation and protection of agricultural water resources

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