O1.3 Study on transfer possibilities of teaching methods

BREATH
LEARN TO DO FROM THE NATURE

Study on Agriculture

IAMB
Institute for Applied
Mycology and Biotechnology

Katarina ČESNIK

Co-funded by the
Erasmus+ Programme
of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Introduction

Imagine a world without adjectives, where traditional agriculture, small-scale agriculture, mechanised agriculture, intensive agriculture, commercial agriculture and industrial agriculture all become simply agriculture. The disappearance of adjectives would be catastrophic for our ability to describe and analyse agriculture, as well as for efforts to advocate for change within agriculture.

Agriculture and food systems undoubtedly face a variety of serious challenges, from climate change and various forms of environmental degradation, through to the health and welfare of livestock, agricultural workers and farmers. To address these a number of strategies (sustainable intensification, climate-smart agriculture, agroecology), are actively promoted, along with specific combinations of practices including conservation agriculture, organic agriculture and regenerative agriculture (Sumberg & Giller, 2022).

Food system demands have increased exponentially in recent decades and are estimated to continue growing as global populations increase and economic affluence expands. However, the very foundation of a productive system — healthy lands and soils and clean water supply — is already under immense pressure. In fact, by the most credible estimates, up to 52% of global agricultural lands are now moderately to severely degraded, with millions of hectares per year degrading to the point they are abandoned by the land manager (Nkonya et al., 2013).

On a global scale, agriculture was very successful in meeting a growing demand for food during the latter half of the 20th century. Yields per hectare of staple crops such as wheat and rice increased dramatically, food prices declined, the rate of increase in food production generally exceeded the rate of population growth, and chronic hunger diminished. This boost in food production was due mainly to scientific advances and technological innovations, including the development of new plant varieties, the use of fertilizers and pesticides, and the growth of extensive infrastructure for irrigation. Now, in the first decade of the 21st century, our system of global food production must grapple with a sobering fact as it attempts to feed a world population that continues to grow: the techniques, innovations, practices, and policies that have allowed increases in productivity have also undermined the basis for that productivity. They have overdrawn and degraded the natural resources upon which agriculture depends — soil, water resources, and natural genetic diversity (Stephen R. Gliessman, 2006). These pressures have resulted in the global agriculture sector driving more biodiversity loss, destruction of natural habitat, soil degradation and depletion of natural resources around the world than any other industry (Iseman, T & Miralles-Wilhelm, F, 2021).

It is not only the natural ecosystems that are in danger but farmers also. Based on data, agriculture has the highest rates of mortality in any industry. Suicide among farmers is now a universal phenomenon. Studies across the globe have identified farming as one of the most dangerous industries (Behere & Bhise, 2009). Furthermore, we have shifted from a high level of

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

direct marketing to a very sophisticated processing and market structure, both at home and abroad. System is highly specialized. The food-processing sector has in recent years come to represent a larger proportion of the total agricultural industry than farming itself (Butz, Earl, 1972).

As we can see, the agricultural sector is in need of change. The question is: where will this change be found? Will it be through the adoption of alternative practices rooted in traditional agriculture, or through the reconstruction of conventional agriculture to become more climate-smart with the utilization of new technologies? Who will navigate the path that agriculture will continue to follow: profit-driven motives or the three pillars of sustainability - economic, social, and environmental sustainability?

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Current pressing issue in agriculture

Soil degradation

Every year, according to the Food and Agriculture Organization of the United Nations, between 5 and 7 million ha of valuable agricultural land are lost to soil degradation. Other estimates run as high as 10 million ha per year (e.g., World Congress on Conservation Agriculture, 2001). Degradation of soil can involve salting, waterlogging, compaction, contamination by pesticides, decline in the quality of soil structure, loss of fertility, and erosion by wind and water. Although all these forms of soil degradation are severe problems, erosion is the most widespread. Worldwide, 25,000 million tons of topsoil is washed away annually (Loftas et al., 1995).

Overuse of water

Agriculture irrigation accounts for 70% of water use worldwide. Intensive groundwater pumping for irrigation depletes aquifers and can lead to negative environmental externalities, causing significant economic impact on the sector and beyond. In addition, agriculture remains a major source of water pollution; agricultural fertiliser run-off, pesticide use and livestock effluents all contribute to the pollution of waterways and groundwater (OECD, n.d.).

Pollution of the environment

More water pollution comes from agriculture than from any other single source. Agricultural pollutants include pesticides, herbicides, other agrochemicals, fertilizer, animal wastes, and salts (Stephen R. Gliessman, 2006).

Loss of genetic diversity

Throughout most of the history of agriculture, humans have increased the genetic diversity of crop plants and livestock worldwide. We have been able to do this both by selecting for a variety of specific and often locally adapted traits through selective breeding, and by continually recruiting wild species and their genes into the pool of domesticated organisms. In the last 100 years or so, however, the overall genetic diversity of domesticated plants and animals has declined. Many varieties of plants and breeds of animals have become extinct, and a great many others are heading in that direction. About 75% of the genetic diversity that existed in crop plants in 1900 has been lost (Stephen R. Gliessman, 2006). On Earth 36 percent of mammals are humans and just 4 percent are wild animals. As for birds, 70 percent are farmed, and a mere 30 percent are wild (Bar-On et al., 2018).

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Loss of local control over agricultural production

Accompanying the concentration of agriculture into large-scale monocultural systems and factory farms has been a dramatic decline in the number of farms and farmers, especially in developed countries where mechanization and high levels of external inputs are the norm.
Besides encouraging an exodus from rural areas, large-scale commodity-oriented farming tends to wrest control of food production from rural communities. This trend is disturbing because local control and placebased knowledge and connection are crucial to the kind of management required for sustainable production (Stephen R. Gliessman, 2006).

Global inequality

At the beginning of the 21st century, the world reached a dubious milestone: the number of overweight people (about 1.1 billion) grew roughly equal to the number of underweight people (Gardner, G. & B. Halweil, 2000). The largest 1% of farms operate more than 70% of the world's farmland and are integrated into the corporate food system, while over 80% are smallholdings of less than two hectares that are generally excluded from global food chains (Uneven Ground, 2020).
Although inequality has always existed between countries and between groups within countries, the modernization of agriculture has tended to accentuate this inequality because its benefits are not evenly distributed. Those with more land and resources have had better access to the new technologies (Stephen R. Gliessman, 2006).

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Sustainable agriculture

Overall, all authors agree on the occurrence of three approaches to the concept of sustainable agriculture: environmental, economic and social approaches. In other words, agricultural systems are considered sustainable if they sustain themselves over a long period, that is, if they are economically viable, environmentally safe and socially fair. Beyond this ideological definition, the practical issue is to build operational solutions to reach global goals. This is a challenging task because the stakeholders do not agree on the criteria to measure the sustainability of a farming system, and on how to balance those criteria.(Lichtfouse et al., 2009)

While conventional agriculture is driven almost solely by productivity and profit, sustainable agriculture integrates biological, chemical, physical, ecological, economic and social sciences in a comprehensive way to develop new farming practices that are safe and do not degrade our environment.(Lichtfouse et al., 2009)

Conventional versus Alternative Agriculture

Presenting the multitude of practices employed in contemporary agriculture is a complex task. To provide a starting point, we will first delve into the two primary agricultural paradigms: conventional versus alternative agriculture.

The competing paradigms can be synthesized into six major dimensions: 1) centralization vs. decentralization, 2) dependence vs. independence, 3) competition vs. community, 4) domination of nature vs. harmony with nature, 5) specialization vs. diversity, and 6) exploitation vs. restraint. ((Beus & Dunlap, 1990).

Conventional and alternative agriculture refer to different paradigms or approaches to farming. Conventional agriculture represents the dominant and mainstream model of agriculture, characterized by large-scale operations, heavy reliance on synthetic inputs, monoculture, and mechanization. It aligns with intensive agricultural practices in terms of maximizing production within a limited area. Alternative agriculture encompasses various approaches that deviate from the conventional model, emphasizing ecological sustainability, reduced chemical inputs, biodiversity conservation, and holistic farming systems.

Alternative agriculture encompasses practices like organic farming, permaculture, agroecology, regenerative agriculture, and precision agriculture.

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Conventional

Conventional (often referred to as industrial) agriculture is the most common typology in developed countries. It is often seen as a natural outgrowth of Norman Borlaug's "Green Revolution". This system is large scale, dependent on inputs (synthetic fertilizers and agroprotectants) and highly mechanized (Durham & Mizik, 2021).

Conventional agriculture is built around two related goals: the maximization of production and the maximization of profit. In pursuit of these goals, a host of practices have been developed without regard for their unintended, long-term consequences and without consideration of the ecological dynamics of agroecosystems. Seven basic practices — intensive tillage, monoculture, irrigation, application of inorganic fertilizer, chemical pest control, genetic manipulation of domesticated plants and animals, and "factory farming" of animals — form the backbone of modern industrial agriculture. Each is used for its individual contribution to productivity, but as a whole, the practices form a system in which each depends on the others and reinforces the necessity of using all in concert. These practices are also integrated into a framework with its own particular logic. Food production is treated like an industrial process in which plants and animals assume the role of miniature factories: their output is maximized by supplying the appropriate inputs, their productive efficiency is increased by manipulation of their genes, and the environments in which they exist are as rigidly controlled as possible.(Stephen R. Gliessman, 2006).

The practices of conventional agriculture are intensive tillage, application of synthetic fertiliters, irrigation, chemical pest and weed control, manipulation of plant and animal genomes and factory farming of animal. All tend to compromise future productivity in favor of high productivity in the present (Stephen R. Gliessman, 2006).

In addition to using a large share of the world's fresh water, conventional agriculture has an impact on regional and global hydrological patterns and the aquatic, riparian, and marine ecosystems dependent on them. First, by drawing such large quantities of water from natural reservoirs on land, agriculture has caused a massive transfer of water from the continents to the oceans. A 1994 study concluded that this transfer of water involves about 190 billion m3 of water annually and has raised sea level by an estimated 1.1 cm (Sahagian, D. L. et al., 1994).

Second, where irrigation is practiced on a large scale, agriculture brings about changes in hydrology and microclimate. Water is transferred from natural watercourses to fields and the soil below them, and increased evaporation changes humidity levels and may affect rainfall patterns. These changes in turn significantly impact natural ecosystems and wildlife.

Third, the dams, aqueducts, and other infrastructure created to make irrigation possible have dramatically altered many of the world's rivers, causing enormous ecological damage(Stephen R. Gliessman, 2006)

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Alternative agriculture

Organic agriculture

For most of its history, organic agriculture has been given short shrift. If they paid attention at all, conventional agricultural institutions treated it as an antiquated, unscientific way to farm — suitable, perhaps, for gardeners, but not a serious means of commercial food production. Anyone who advocated for organic farming was derided; it was professional suicide for an agronomist or soil scientist to do so (Kuepper, 2010).

Nowadays, organic agriculture is practiced in almost all countries of the world, and its share of agricultural land and farms is growing, reaching a certified area of more than 30 million hectares globally. However, despite this growth and the increased research, policy, media, and public attention, only a small share of the total agricultural land is under organic agriculture (e.g. 4% in Europe; Eurostat, 2007). FIBL scientists in Central Europe conducted a 21-year study of the agronomic and ecological performance of organic, and conventional farming systems. They found crop yields to be 20% lower in the organic systems, although input of fertilizer and energy was reduced by 31—53% and pesticide input by 98%. Researchers concluded that the enhanced soil fertility and higher biodiversity found in organic plots rendered these systems less dependent on external inputs (Altieri & Nicholls, 2012).

It is important to note, that organic food is often (mistakenly) considered to be "chemical-free", which is popular for certain consumer demographics. Synthetic chemicals are generally prohibited, though naturally derived pesticides and fertilizers may still be utilized (Durham & Mizik, 2021).

While organic farming undeniably exhibits greater environmental friendliness and fosters knowledge reintegration into the farm, as farmers are compelled to relocalize their understanding of the production process, enabling them to regain their status as "knowing agents," it is crucial to acknowledge the presence of potential pitfalls within this practice.

Organic farming systems managed as monocultures that are in turn dependent on external biological and/or botanical (i.e. organic) inputs. This 'input substitution' approach essentially follows the same paradigm of conventional farming: that is, overcoming the limiting factor but this time with biological or organic inputs. Many of these "alternative inputs" have become commodified, therefore farmers continue to be dependent on input suppliers, cooperative or corporate (Rosset and Altieri 1997).

Agroecologists argue that organic farming systems that do not challenge the monoculture nature of plantations and rely on external inputs as well as on foreign and expensive certification seals, or fair-trade systems destined only for agro-export, offer little to small farmers who in turn become dependent on external inputs and foreign and volatile markets. By keeping farmers dependent on an input substitution approach, organic agriculture's fine-tuning of input use does little to move

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

farmers toward the productive redesign of agricultural ecosystems that would move them away from dependence on external inputs (Altieri & Nicholls, 2012).

The role and future of organic agriculture will be determined by its ability to be or become economically competitive with conventional agriculture. This depends on productivity of organic agriculture, demand for its products, and on the extent to which consumer prices reflect costs of externalities associated with both production orientations, including costs of environmental and health externalities. This factor therefore also has a strong policy component. Second, competing claims on land and competition over other resources needed for food, feed, the bio-based economy and nature conservation play an essential role. Third, the relationship between the type of agriculture and biodiversity is relevant. Feeding the world with organic agriculture may require more land than with conventional agriculture and hence the area of natural and semi-natural ecosystems may be lower, whereas the quality of biodiversity on and around agricultural land may be higher. Fourth, as global food security has become a primary concern (Godfray et al., 2010), the productivity of organic agriculture and thus the contribution that it can make to feeding the world is an important factor.(De Ponti et al., 2012)

Agroecology: Ecological Processes in Sustainable Agriculture

At the heart of agroecology is a fundamentally different way of thinking based on a different set of values from industrial farming. While industrial methods see food as something to be manufactured from a set of raw materials, agroecology understands agriculture as an ecological system based on cyclic, symbiotic relationships. While industrial agriculture seeks to maximize yield measured in narrow, short-term, quantitative terms, agroecology seeks to maximize sustainable productivity for the long term, taking into account qualitative aspects such as nutritional quality, biodiversity, and working conditions. These values implicit in agroecology become more explicit when one considers permaculture (Hathaway, 2016).

Agroecology values the local, empirical knowledge of farmers, the sharing of this knowledge, and its application to the common goal of sustainability. Ecological methods and principles form the foundation of agroecology. They are essential for determining (1) if a particular agricultural practice, input, or management decision is sustainable, and (2) the ecological basis for the functioning of the chosen management strategy over the long term (Stephen R. Gliessman, 2006).

There are many variants of agroecological systems that can include, organic agriculture, permaculture, natural farming, and biodynamic methods. Often, agroecologists dialogically integrate autochthonous traditions to create a new synthesis of knowledge and practices using participatory approaches.
While agroecological practices are more labor-intensive than industrial farming methods—particularly during the initial implementation stage—agroecology creates an efficient system that naturally resists plagues and pests (for example, by using polycultures) and which also creates better working conditions for farm laborers by introducing shade trees and eliminating the need for chemical pesticides. Rather than relying on external capital, chemical inputs, or even labor,

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

agroecological systems "rely on the efficiency of biological processes such as photosynthesis, nitrogen fixation, solubilisation of soil phosphorus, and the enhancement of biological activity above and below ground." Therefore, "the 'inputs' of the system are the natural processes themselves, this is why agroecology is referred to as an 'agriculture of processes' (Lichtfouse et al., 2009).

In Asia, the use of one particular agroecological method called the System of Rice Intensification (SRI) has increased rice yields by 20– 30 % (and up to 50 % in some cases) while reducing water
usage by 50 % and seed usage by 90 %, often with the use of no chemical inputs. Moving to the kind of integrated polyculture system usually employed in agroecology increases yields by an average of 20 to 60 % over monocrop systems (Hathaway, 2016).

It is evident that agroecological methods can play a significant role in addressing key ecological problems, particularly climate change and water shortages, while still producing sufficient food for all. Indeed, agroecological systems are more resilient to major weather events and may actually ensure a more secure food supply than industrial methods in a world threatened by growing water and energy shortages. Simultaneously, agroecological practices embody values and ways of thinking that, over
time, may encourage genuinely ecological dispositions and worldviews that enable practitioners to approach problems and discern actions from a perspective that systematically promotes sustainability and social justice (Hathaway, 2016).

Permaculture

The term "permaculture" (a portmanteau word derived from permanent agriculture or culture) was coined by Bill Mollison and David Holmgren in the mid-1970s, to describe an "integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man." According to Holmgren, "A more current definition of permaculture, which reflects the expansion of focus implicit in Permaculture One, is 'Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs.' People and their buildings and the ways they organise themselves are central to permaculture. Thus the permaculture vision of permanent (sustainable) agriculture has evolved to one of permanent (sustainable) culture." Broadly, permaculture may be classified (insofar as such an holistic entity may be) as a branch of ecological design and ecological engineering which aims to develop sustainable human settlements and self-maintained agricultural systems modelled from natural ecosystems (Rhodes, 2012).

Permaculture attempts to create sustainable designs that mimic patterns found in natural ecosystems, drawing particularly on whole systems thinking which focuses— not so much on individual elements—but on the relationship between them and the way they interact to form a functional,

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

integrated whole (Peeters B, 2012). In one sense, permaculture is broader than agroecology since it may be understood as both a movement and philosophy promoting design principles that can be applied beyond agriculture. The overall aim of these design principles is to develop closed-loop, symbiotic, self-sustaining human habitats and production systems that do not result in ecological degradation or social injustice (Veteto JR & Lockyer J, 2008).

Permaculture also provides a simple ethical framework guiding all its designs summarized in three simple points (Hathaway, 2016):

1. Care for Earth: including the nurture of soil, forests, and water; working with nature; and preventing damage to ecosystems.
2. Care for people: including looking after one's self, kin, and community; working with others; assisting those without to access healthy food and clean water; and designing sustainable systems that produce life's necessities.
3. Fair share: including setting limits on consumption and reproduction; redistributing surplus production to those in need; building economic lifeboats; and modifying lifestyles.

Permaculture then provides a set of twelve principles that create a framework for design while allowing for a wide range of methods applied in specific contexts (Hathaway, 2016)

1. Observe and interact: design begins with prolonged and thoughtful observation of place.
2. Catch and store energy, nutrients, and water: collect energy and water while they are abundant and store them for times of need.
3. Obtain a yield: ensure that the system can produce necessities in the most self-reliant manner possible.
4. Apply self-regulation and accept feedback: create appropriate negative feedback loops to maintain a healthy system balance.
5. Use and value renewable resources like sunlight and rainwater; employ processes that regenerate soil; avoid external inputs.
6. Produce no waste: recycle all wastes as useful resources.
7. Design from patterns to details: use nature's patterns as templates for effective design.
8. Integrate rather than segregate: design with synergistic relationships in mind (such as mutually beneficial polycultures rather than monocultures).
9. Use small and slow solutions: start small, experiment, and use local resources. Smaller, simpler solutions are easier to maintain than larger, more complex ones.
10. Use and value diversity: diversity increases resilience, making the system less vulnerable to failures.
11. Use edges and value the marginal: the interface between different zones is often the most interesting and creative place.
12. Creatively use and respond to change: all ecological systems have an evolutionary dimension. Observe changes taking place and intervene carefully at the right time and place.

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

In some cases, well-designed permaculture systems have been shown to produce yields comparable to or even higher than conventional agricultural methods. However, permaculture often focuses on local and small-scale production, which may not achieve the same level of output as large-scale industrial farming. Instead, permaculture systems prioritize resilience, self-sufficiency, and the ability to meet the needs of local communities.

Traditional agriculture

Traditional agricultural landscapes refer to the landscapes with preserved traditional sustainable agricultural practices and conserved biodiversity. They are appreciated for their aesthetic, natural, cultural, historical and socio-economic values (Lieskovský et al., 2015). Traditional farming landscape occurs in regions where farming practices either remain same or change comparatively little over a long period of time (Fischer et al. 2012).
Besides mitigating climate change, traditional agriculture is also helpful for human health safety, natural resource management, energy conservation and socio-ecological integrity. Climate smart traditional agricultural practices agroforestry, intercropping, crop rotation, cover cropping, traditional organic composting and integrated crop-animal farming can be adopted as the model practices for climate-smart approach in agriculture (Singh & Singh, 2017).

Climate smart agriculture (CSA)

New technologies are rapidly transforming the agricultural landscape, revolutionizing various aspects of farming practices, crop cultivation, livestock management, and overall agricultural productivity. These technological advancements offer innovative solutions to address key challenges faced by the agricultural sector, including the need to increase yields, optimize resource utilization, minimize environmental impact, and enhance overall efficiency. Here are some notable examples of new technologies in agriculture:

1. **Precision Agriculture** involves the use of advanced tools like GPS, remote sensing, and geographic information systems (GIS) to collect and analyze data on soil conditions, crop health, and weather patterns. This data enables farmers to make precise decisions regarding irrigation, fertilizer application, and pest management. By optimizing resource allocation through targeted interventions, precision agriculture can increase yields while reducing environmental impact (Gebbers & Adamchuk, 2010).

2. **Vertical farming systems** are a type of agriculture where crops, such as herbs and leafy greens, are grown indoors in vertically stacked layers instead of in horizontal rows in the ground, like traditional (open field and glasshouse) agriculture methods. This system is optimised through the use of technology such as LED lighting, closed-loop water recycling, and total climate control (Andrew Lloyd, 2023). Vertical farming enables year-round production in urban areas. It conserves land, reduces water usage, and eliminates the need for pesticides or herbicides. This technology has the potential to enhance food security, especially in densely populated regions.

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

3. **Smart greenhouses** help create the tightly controlled environment necessary for vertical farming, which conserves space, expands the grow season and produces higher crop yield in places that would otherwise not be suitable for growing plants. The containment of crops also helps eliminate the conflict between farmers and native species (Ben Lutkevich, n.d.).

4. With the introduction of **Industrial IoT in Agriculture**, far more advanced sensors are being utilized. The sensors are now connected to the cloud via cellular/satellite network. Which lets us to know the real-time data from the sensors, making decision making effective. The applications of IoT in the agriculture industry has helped the farmers to monitor the water tank levels in real-time which makes the irrigation process more efficient. Internet of Things in Agriculture has come up as a second wave of green revolution.

5. **Biotechnology and Genetic Engineering**. Biotechnology is the application of scientific techniques to modify and improve plants, animals, and microorganisms to enhance their value. Agricultural biotechnology is the area of biotechnology involving applications to agriculture. Current genetic engineering techniques allow segments of DNA that code genes for a specific characteristic to be selected and individually recombined in the new organism. Once the code of the gene that determines the desirable trait is identified, it can be selected and transferred. Similarly, genes that code for unwanted traits can be removed. Through this technology, changes in a desirable variety may be achieved more rapidly than with traditional breeding techniques (Ania Wieczorek, 2003). Important question regarding the application of biotechnology in agriculture and genetic engineering is who is benefiting from this ? Are the farmers and growing popultaion really in the focus here or is yet another way to make profit ? Research agandas are dominate by commercial interest, the uneven distribution of benefits, especially for poor farmers. The poorest are actually the ones who lose, as biotechnology exacerbrates trands towards industrialization of agriculture, erodes the diversity of agroecosystems, and undermines the rights of farmers. (Altieri, 2004)

Many farmers have benefited from CSA but there is limited evidence that CSA adoption has enabled significant numbers of very poor farmers to escape poverty, even though it is the poor who are most impacted by climate change. Indeed, in rain-fed agriculture, which is particularly vulnerable to climate change, there are farmers for whom agricultural-based livelihoods are so precarious that even 'climate-proofing' their agricultural systems will not contribute to poverty reduction, let alone significant improvements in food security. For these farmers, continuing in agriculture represents little more than a persistence of poverty. CSA is most likely to be a pathway from poverty for those farmers who are able to increase farm size and/or have access to markets in order to capitalize on new agricultural technologies and practices. Designing and implementing CSA interventions that are equitable and inclusive means recognizing people's differing access to CSA opportunities, and addressing the differential impacts of these interventions on existing poverty levels and inequalities. A particularly challenging proposition is encouraging different actors to work together to overcome deeply entrenched power imbalances

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

that stymie gender and social equity. This applies to society in general, extending beyond the communities of scientists and small-scale farming populations involved in CSA intervention (Hellin & Fisher, 2019).

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Conclusion

In this study discussion, it is important to note that numerous other agricultural practices exist, beyond the scope of our coverage. However, these practices can generally be categorized within the frameworks mentioned earlier. A key observation emerges: just as in other domains, agriculture is not a one-size-fits-all endeavor. The suitability of a particular practice for a given region depends on a multitude of parameters and factors that must be carefully considered.

When searching for best practices it is important to preserving the long-term productivity of the world's agricultural land while changing consumption and land use patterns to more equitably benefit everyone, from farmers to consumers. Preserving the productivity of agricultural land over the long term requires sustainable food production. Sustainability is achieved through alternative agricultural practices informed by in-depth knowledge of the ecological processes occurring in farm fields and the larger contexts of which they are a part. From this foundation we can move towards the social and economic changes that promote the sustainability of all sectors of the food system.(Stephen R. Gliessman, 2006).

The forecast for agricultural production is to maintain a high level of food production due to the projected population increase. However, it is imperative to explore alternative systems that can assist us in achieving this goal.

We would argue that the most important question is not whether we can produce enough food to meet the growing demand, rather it is important to consider whether the food we produce will reach those who need it.That is why, when seeking solutions, we should not focus solely on production of enough food but also the location and distribution. According to the Food and Agriculture Organization of the United Nations (FAO), it is estimated that approximately one-third of the food produced for human consumption is lost or wasted globally every year. This corresponds to roughly 1.3 billion metric tons of food. It's important to note that food waste occurs throughout the entire food supply chain, including production, post-harvest handling, processing, distribution, and consumption. Food waste can happen due to various factors, such as inefficient agricultural practices, inadequate storage and transportation, lack of infrastructure, market dynamics, consumer behavior, and food loss in households and food service establishments.

Armed with this knowledge, we should redirect our efforts away from increasing food production and further industrializing agriculture. Instead, we ought to reevaluate our consumer habits and challenge the notion of constant accessibility. By supporting local farmers and embracing alternative agricultural methods, we can foster shorter distribution lines and reduce food losses.

In a nutshell, agriculture should teach us how to work with nature and empower people to grow their own food, thus enabling them to become stewards of the land.

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

References

Altieri, M. A. (2004). *Genetic Engineering in Agriculture: The Myths, Environmental Risks, and Alternatives*. Food First Books.

Altieri, M. A., & Nicholls, C. I. (2012). Agroecology Scaling Up for Food Sovereignty and Resiliency. In E. Lichtfouse (Ed.), *Sustainable Agriculture Reviews* (Vol. 11, pp. 1–29). Springer Netherlands. https://doi.org/10.1007/978-94-007-5449-2_1

Andrew Lloyd. (2023). *Vertical Farming: The Future of the Farming Industry*. https://www.intelligentgrowthsolutions.com

Ania Wieczorek. (2003). Use of Biotechnology in Agriculture—Benefits and Risks. *Biotechnology*.

Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences*, *115*(25), 6506–6511. https://doi.org/10.1073/pnas.1711842115

Behere, P. B., & Bhise, M. C. (2009). Farmers' suicide: Across culture. *Indian Journal of Psychiatry*, *51*(4), 242–243. https://doi.org/10.4103/0019-5545.58286

Ben Lutkevich. (n.d.). *Agri-tech*. https://www.techtarget.com/whatis/definition/agri-tech

Beus, C. E., & Dunlap, R. E. (1990). Conventional versus Alternative Agriculture: The Paradigmatic Roots of the Debate*. *Rural Sociology*, *55*(4), 590–616. https://doi.org/10.1111/j.1549-0831.1990.tb00699.x

Butz, Earl. (1972). *Address before the Virginia Agribusiness Council, Richmond, Virginia, February 26, 1972.*

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

De Ponti, T., Rijk, B., & Van Ittersum, M. K. (2012). The crop yield gap between organic and conventional agriculture. *Agricultural Systems*, *108*, 1–9. https://doi.org/10.1016/j.agsy.2011.12.004

Durham, T. C., & Mizik, T. (2021). Comparative Economics of Conventional, Organic, and Alternative Agricultural Production Systems. *Economies*, *9*(2), Article 2. https://doi.org/10.3390/economies9020064

Gardner, G., & B. Halweil. (2000). Overfed and Underfed: The Global Epidemic of Malnutrition. *Worldwatch Paper*, *150*.

Gebbers, R., & Adamchuk, V. I. (2010). Precision Agriculture and Food Security. *Science*, *327*(5967), 828–831. https://doi.org/10.1126/science.1183899

Hathaway, M. D. (2016). Agroecology and permaculture: Addressing key ecological problems by rethinking and redesigning agricultural systems. *Journal of Environmental Studies and Sciences*, *6*(2), 239–250. https://doi.org/10.1007/s13412-015-0254-8

Heady, Earl O. (1976). *'The agriculture of the U.S.' Scientific American 235:107-27.*

Hellin, J., & Fisher, E. (2019). The Achilles heel of climate-smart agriculture. *Nature Climate Change*, *9*(7), 493–494. https://doi.org/10.1038/s41558-019-0515-8

Intensive Agriculture. (1998). In *Encyclopædia Britannica, revised and updated by Amy Tikkanen*. https://www.britannica.com/topic/intensive-agriculture

Iseman, T, & Miralles-Wilhelm, F. (2021). *Nature-based solutions in agriculture: The case and pathway for adoption*. FAO and TNC. https://doi.org/10.4060/cb3141en

Knorr, Dietrich, and Tom R. Watkins (Eds.). (1984). *Alterations in Food Production. New York: Van Nostrand Reinhold.*

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Kuepper, G. (2010). *A Brief Overview of the History and Philosophy of Organic Agriculture*.

Kumar, S., & Kumar, A. (n.d.). *ROLE OF GENETIC ENGINEERING IN AGRICULTURE*.

Lichtfouse E. (2004). Agronomy for sustainable development. *Agronomie*, *24*, 445.

Lichtfouse, E., Navarrete, M., Debaeke, P., Véronique, S., & Alberola, C. (Eds.). (2009). *Sustainable Agriculture*. Springer Netherlands. https://doi.org/10.1007/978-90-481-2666-8

Lieskovský, J., Bezák, P., Špulerová, J., Lieskovský, T., Koleda, P., Dobrovodská, M., Bürgi, M., & Gimmi, U. (2015). The abandonment of traditional agricultural landscape in Slovakia – Analysis of extent and driving forces. *Journal of Rural Studies*, *37*, 75–84. https://doi.org/10.1016/j.jrurstud.2014.12.007

OECD. (n.d.). *Managing water sustainably is key to the future of food and agriculture*. https://www.oecd.org/agriculture/topics/water-and-agriculture/

Peeters B. (2012). Permaculture as alternative agriculture. *Kasarinlan: Philippine Journal of Third World Studies*, *26*((1–2)), 422–434.

Rhodes, C. J. (2012). Feeding and Healing the World: Through Regenerative Agriculture and Permaculture. *Science Progress*, *95*(4), 345–446. https://doi.org/10.3184/003685012X13504990668392

Sahagian, D. L., F. W. Schwartz, & D. K. Jacobs. (1994). Direct anthropogenic contributions to sea level rise in the twentieth century. *Nature*, *367*, 54–56.

Singh, R., & Singh, G. S. (2017). Traditional agriculture: A climate-smart approach for sustainable food production. *Energy, Ecology and Environment*, *2*(5), 296–316. https://doi.org/10.1007/s40974-017-0074-7

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

Stephen R. Gliessman. (2006). *Agroecology, The Ecology of Sustainable Food Systems, Second Edition*.

Sumberg, J., & Giller, K. E. (2022). What is 'conventional' agriculture? *Global Food Security*, *32*, 100617. https://doi.org/10.1016/j.gfs.2022.100617

Uneven Ground. (2020). ILC. https://www.landcoalition.org/en/uneven-ground/executive-summary/

Veteto JR, & Lockyer J. (2008). Environmental anthropology engaging permaculture: Moving theory and practice toward sustainability. *Culture Agric*, *30*((1–2)), 47–58.

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission.
This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein.

BREATH

O1.3 Study on transfer possibilities of teaching methods

IAMB
Institute for Applied Mycology and Biotechnology

Katarina ČESNIK

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

Introduction

After an in-depth research into agricultural practices required to conduct the Study on Agriculture, we have identified various teaching methods to disseminate and facilitate understanding of these practices and concepts. Below, we will mention a few that we consider most suitable to transfer from one audience to another or from one theme to another.

The main principle was to discover decompartmentalized approaches, to encourage more integrated, interdisciplinary, or collaborative ways of thinking and working. These methods should be adapted to a short-term professional training context and aimed at a professional audience of ecological transition advisors.

Illustration by La Mari Muriel

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

Teaching methods identified in agriculture

In the diverse field of agriculture, practitioners range from those with lower educational degrees to those with advanced qualifications. To effectively transfer knowledge among such a varied group, different teaching methods need to be employed.

1.On site or On-farm demonstrations

These demonstrations are effective for disseminating of practices, knowledge and techniques. The primary goal of these demonstrations is to introduce innovations and foster knowledge sharing among various stakeholders through a multi-actor approach. This method typically involves cooperation and active participation from all participants in the learning process.

Source : The FarmDemo Team

For any demo event it is important to explicitly state clear objective(s) and key messages well in advance. They determine all the other decisions you will make during the preparation and the performance of the demo event: the set-up, which actors to involve, the evaluation of effectiveness. Start by addressing the 'why' (why are we doing this demo) and then the 'what' (what do we want to demonstrate). From this demo objective subsequently follows the 'who' (the targeted audience for the demo) and the'how' (the demo set-up and learning methods)(FarmDemo, 2022)

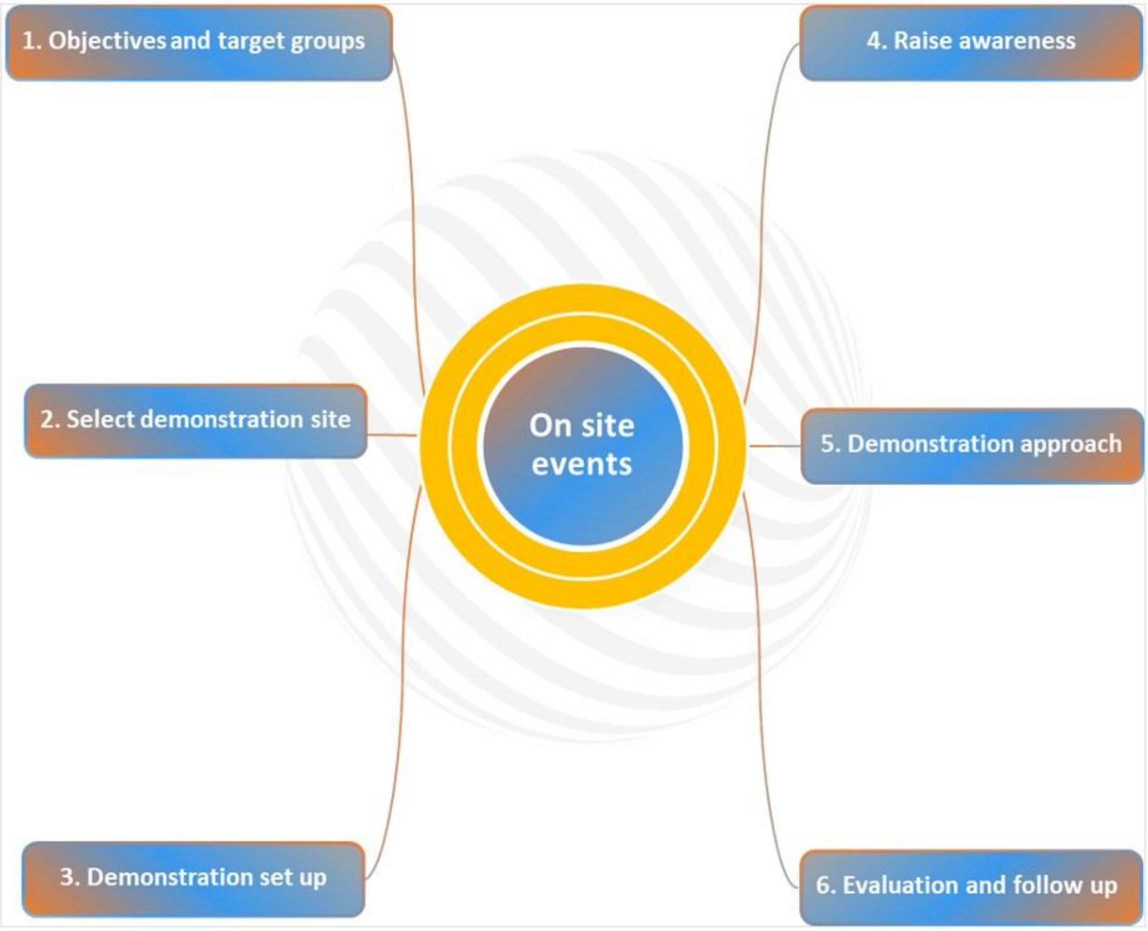
Recommendations for our training cycle

- At the end of the training or as a dissemination event, this method can be used to share the practical application of training methods in real settings. By following the six simple steps from the FarmDemo Design Guide for On-Farm Demonstrations, you can create

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

events for various target groups and objectives. This flexibility allows for the creation of events that engage diverse stakeholders and cover a range of fields, not just farming.



Source: Design and plan a field demonstration in six steps: H2020 FarmDemo guide

2. Learning through apprenticeships and mentoring

Is a common pedagogical method in agriculture. For example, in permaculture design, if a person wants to obtain a Diploma in Applied Permaculture Design, they need to present their portfolio, which they have developed in collaboration with their mentor. Mentoring enables for the specific knowledge and skills to be transferred.

The value of mentoring

Was mentoring beneficial? Of the one hundred and thirty two valid responses to this question in the survey, only two considered that they had not benefited from the process. The majority of interviewees felt that mentoring should start in the early stages of a person's career (Turner & Warren, 2008).

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

Table 1: Mentoring functions (after Kram 1988: 162)

Sponsorship. 'Opening doors'. Having connections that will support the protégés career advancement.	**Rôle modelling**. Demonstrating behaviour, skills, attitudes worthy of emulation that aid the protégé in achieving competence, confidence and a professional identity.
Coaching. Teaching "the ropes". Giving relevant positive and negative feedback to improve the protégé's performance.	**Counselling**[4]. Providing a forum for addressing central development concerns. Tendering advice and guidance, and a "sounding board".
Protection. Providing support in different situations. Taking responsibility for mistakes outside the protégé's control. Acting as a buffer.	**Acceptance and confirmation**. Providing ongoing support, respect and admiration, which strengthen self-confidence and self-image.
Exposure. Creating opportunities for the protégé to demonstrate competence. Enhancing visibility through attendance at meetings/ events.	**Friendship**. Mutual caring and intimacy that involves reflection of experiences outside the work setting.
Challenging. Delegating assignments, creating opportunities that will stretch the protégé's knowledge and skills in order to enhance development in preparation for anticipated career moves.	

Source : (Turner & Warren, 2008)

Benefits, however, will only be manifest if the mentoring experience is successful, which is more likely to be the case if the principles that guide good practice are followed.
The main ones are:

- Mentoring is a voluntary activity;
- Mutual trust is central to success.
- Mentoring is not a rigid activity, and its practice will give rise to variations due to individual needs, attitudes, inter-personal skills, resources and differences in organisations' cultures and practices;
- It is an active two-way process;
- Either participant can opt out without prejudice;
- Although there is a measure of altruism on the part of the mentor, there need to be other rewards (material and/or intangible) if the relationship is to be sustained;
- The relationship is non-judgemental, and non-directive;
- It is essential that both parties in a mentoring relationship act ethically

(Source: (Turner & Warren, 2008))

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

Recommendations for our training cycle

- To support our training cycle, at the end of the session we could incorporate this teaching method by assigning participants a project related to the training objectives. Additionally, providing a few mentorship hours from the training host organization for 2-3 months after the training to help participants with their assignments and to discuss any emerging problems. This type of feedback loop would not only assist participants but also enable the host organization to track participants' progress after the training and gather valuable information for future training sessions.

3. Stories and Storytelling

Is a method that is easily transferable and has a wide range of influence. In storytelling, we use common, easily understandable language, making it accessible to a varied audience. Storytelling has been used since the beginning of human history as a medium to transmit knowledge and lived experiences. With stories, we can make information and facts tangible since they engage our feelings and are relatable.

In early times, storytelling was used to explain significant and often frightening natural events, and special types of stories were written about heroes and gods and were used to bind individuals to common belief systems and to explain natural phenomena (e.g. myths). Moral tales conveyed the first codes or laws that ensured the harmony, co-operation, and ultimate success of early human populations (Tobin & Snyman, 2004).

The benefits of storytelling to the individual can be found both in the giving and the receiving, both as a storyteller and as a story listener. As a storyteller the individual stands to benefit in terms of personal satisfaction (feeling of selfesteem), recognition (the story itself is a valuable contribution), belonging (telling the story helps in relationship-building). Stories can be a very powerful way to represent and convey complex, multi-dimensional ideas. Well designed, well-told stories can convey both information and emotion, both the explicit and the tacit, both the core and the context (Tobin & Snyman, 2004).

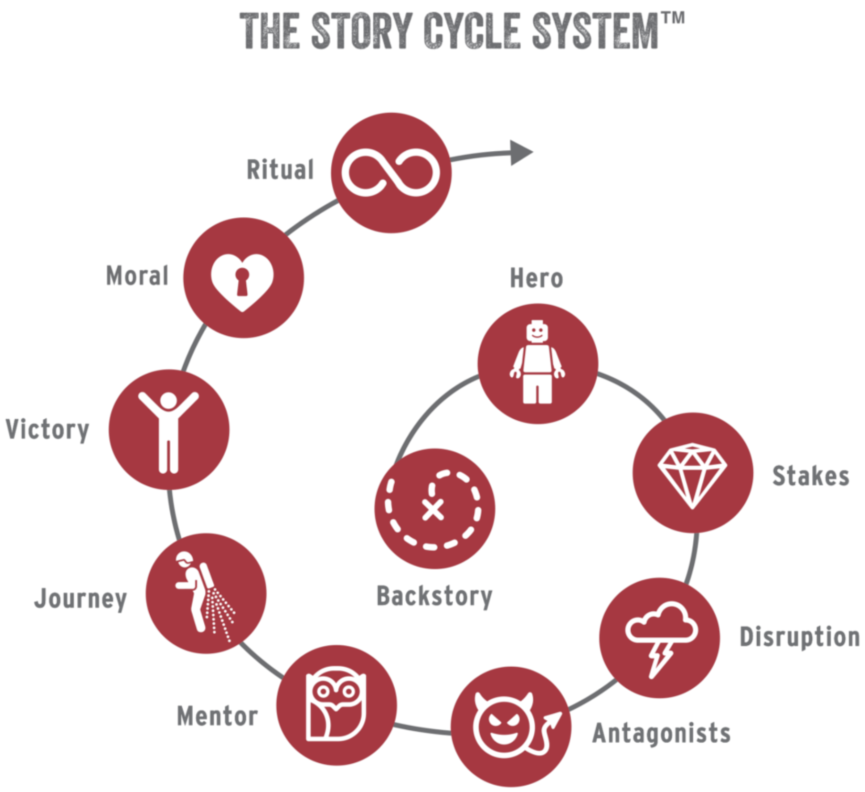
Recommendations for our training cycle

- Since stories have been recognized as a useful tool for presenting and understanding complex ideas, the training cycle should include the time dedicated to the creation and telling of stories. This type of activity can help a diverse group of people become a connected team with shared values and a common goal.
- Through storytelling, we can transmit our experiences and demonstrate what we have learned through trial and error. Stories help us make sense of past mistakes and extract valuable knowledge and wisdom. Therefore, it is crutial, to allocate time and space

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

during training sessions for participants to share stories and lessons, allowing collective insights to emerge.



Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

Appendix : Innovative hubs (ecosystems) to support knowledge transfer

As a transferable method, we would like to present two innovative types of hubs (ecosystems) found in the field of organic farming. These types of hubs support research and innovation in the organic farming sector and provide a platform where new methods and practices can be tested and shared among diverse stakeholders. They focus on accelerating innovation through sharing knowledge.

1. Living labs – In the case of **organic living labs**, the improvement of and experimentation with organic farming practices is in the centre of R&I, with the aim of finding solutions to build better linkages with the food system by looking at social and behavioural aspects. Organic living labs are mainly farmer-led initiatives; therefore, they are developed to address farmers' needs on a very practical level using co-creative methods to plan and conduct real-life experimentations such as on-farm trials, experimental fields set up on working organic farms, or product development. Since these living labs are simultaneously looking for solutions to address problems on the scale of the larger food system, they actively involve and integrate other stakeholders of the organic value chain, from consumers to companies, into their research process as equal partners to propose ideas, test them, and promote them further (Jonasz & Verga, 2022).

2. Lighthouses – These are single sites, like a farm or a park, for demonstration, education and peer-to-peer learning where good practices are tested or are in place and can be shown to inspire other practitioners to move towards sustainable land management. In addition, in lighthouse sites, researchers work together with land managers to ensure that their research responds to concrete needs encountered in the field. In this sense, organic lighthouses are single farm sites or network of farms where organic practices are demonstrated for educational purposes or to showcase site-specific inspiring examples and to increase the adoption of innovative solutions among farmers. These lighthouses often work together with research institutions or companies to conduct experiments and tests to improve organic practices (Jonasz & Verga, 2022).

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '

References

FarmDemo. (2022). *Design guide for on-farm demonstrations*. FarmDemo. https://trainingkit.farmdemo.eu/wp-content/uploads/2020/03/818_Design_guide_for_on-farm_demonstrations_EN_LR.pdf

Jonasz, G., & Verga, K. (2022). *Organic living labs and lighthouse farms in Europe*. https://tporganics.eu

Tobin, P. K. J., & Snyman, R. (2004). *Storytelling and knowledge management: What's the story so far?*

Turner, R., & Warren, M. (2008). *Mentoring in Agriculture: An Investigation Into Its Occurrence and Form*. *13*(4).

Co-funded by the Erasmus+ Programme of the European Union

'This project has been funded with the support of the European Commission. This publication (communication) is solely the responsibility of the author and the Commission is not responsible for any use that may be made of the information contained therein. '