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AGRÁRERDÉSZETI RENDSZEREK LEHETŐSÉGEI ÖKOLÓGIAI GAZDÁLKODÁSBAN

[POSSIBILITIES OF AGROFORESTRY SYSTEMS IN ORGANIC FARMING]

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Abstract. Agriculture is the only provider of human food. However, currently demand seems to exceed the limitations of conventional farming practices, as the latter often rely on scarce resources. The focus of agricultural research appears to be shifting towards another approach, namely sustainable farming, which is hoped to pose a solution for the aforementioned issue. Considerable yield and farm resilience are expected from such a practice to withstand and mitigate negative effects of climate change and provide for human well-being. This paper aims to investigate such possibilities focusing on the Carpathian basin's climate. First, current trends are analyzed, then ecological farming and its challenges are explained in further detail. Finally, agroforestry is introduced as an approach and framework to react to these challenges. As a result, connection points are highlighted which indicate that combining ecological farming with agroforestry could indeed be the basis of a safe and sustainable agriculture.

Keywords: agroecology, biodiversity, ecosystem services, intercropping, sustainability

Introduction

With respect to agriculture, Hungary has exceptional resources. Its temperate climate is influenced by continental and oceanic factors. A significant part of the Carpathian Basin is plains that are protected by the surrounding mountain range from outer factors. Consequently, although long hours of sunshine and quality soil support plant growth, droughts damage crops and production more often than in neighbouring regions. Therefore, the limiting factor is most often precipitation, so much so that regular watering might be required. Throughout the history of the region, agriculture has always played an important role in the country's economy: its output allowed the export of goods while satisfying domestic needs as well. As such, its significance exceeds the scope of nutrition inasmuch as it reflects society's structure and trends, while also interacting with the environment. However, studies

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suggest that current technology cannot keep up with the increasing demand, thus a new, restructured approach needs to be taken (Valkó, 2017 p. 17.).

Current trends in agriculture

Compared to other sectors, agriculture has a special connection with the environment because of its unique characteristics, meaning, agriculture is more vulnerable and exposed to changes (and can react to these only with a delay). Furthermore, the significance of agriculture in inducing environmental changes should not be neglected.

Main areas of environmental degradation related to agriculture include, but are not limited to, the following.

Emission (ITM 2018; KSH 2017)

- CO_2: within agriculture, animal husbandry and crop farming are the prime sources of carbon-dioxide emission, but consumers' changing habits are also accountable (e. g. increasing meat and dairy consumption).
- CH_4: airborne methane comes mostly from decomposed organic matter, that is, manure treatment and use, and livestock's digestion. Besides contributing to global warming, methane behaves also as an ozone precursor. Approximately 1/3 of CH_4 emission in Hungary is related to agriculture.
- NH_3: agriculture is the most significant source of ammonia emission and contamination, more specifically manure treatment and fertilizer use. Besides contributing to eutrophication, ammonia also has an acidifying property which threatens water quality and ecosystems.
- N_2O: comes mostly from manure and nitrogen-containing fertilizers, thus indirectly from the emission from fertilized soil. Agriculture is the main emitter of dinitrogen-oxide.

Soil and technology (Frison et al., 2011; Greenpeace, 2014)

- Fertilizer use is also to mention as the most important source of soil and water contamination within agriculture. Besides nitrogen, phosphorus also causes eutrophication (if applied irresponsibly).
- Besides the chemical properties of soil, its physical attributes are also exposed to anthropogenic effects on arable land. Tillage, machines and vehicles can also influence soil properties: water content, mixing of layers – poor quality soil layer

gets to the surface, flat surface – erosion, deflation. Machinery on its own can have negative environmental consequences: noise, air pollution, soil and water contamination through leaking fuel and other substances, etc.

- Agriculture's impact on ecosystems is a manifold problem. On the one hand, habitat loss is a direct consequence of increasing agricultural area. As such, the area of natural ecosystems is reduced but anthropogenic damage is not limited to arable land for the reasons mentioned above. On the other hand, cultivated crops and farm livestock often do not fit into the natural flora and fauna system, which is why pesticides are often applied to prevent economically disadvantageous interactions. Moreover, large, homogenous fields also jeopardize biodiversity. Taking this approach further, many studies are now focusing on bees, arguing that if the tendency continues, natural resources will not be able to adapt to the changes, eventually leading to a dramatically reduced pollination rate, and eventually to environmental and economic loss.

Although common practice does not seem to apply the following technique, several studies support that exploiting biodiversity enhances agricultural performance. That is, biodiversity can contribute to a better resistance to diseases and invasive or harmful species. With respect to animal husbandry, a balanced diet promotes a healthy immune system that, again, prevents the spread of diseases. Diversity is often mentioned related to climate change as well, because "artificial", man-made ecosystems (that consist of significantly fewer components) are more sensitive to sudden changes and extreme conditions. All this could result in yield loss.

Deforestation (Bartha, 2003; Szabó, 2006;, Padányi and Halász, 2012; Somogyi, 2016; Parliament, 2019)

- The major cause of forest loss is related to agriculture, but the issue is not directly related to modern technologies (though modern influences somewhat change the magnitude of environmental pressure). Instead, deforestation has a historical scale and is just as old as agriculture itself. It is estimated that during the occupation of the Carpathian basin, close to 60% of Hungary's current area was covered by forests (in contrast to the 20% today). Written documents prove that in subsequent centuries, the landscape went through drastic changes and large forests scaled down into smaller, isolated patches of woods either to gain more land for agriculture or to get timber. Only in the 19-20th centuries did the issue reach a threshold where some professionals understood the importance of afforestation and sustainability, so a strategic approach and long-time planning is a fairly new

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concept in forestry. However, deforestation remains a serious problem, as no accurate measures have been taken to effectively slow down or stop the process.

- A most profound impact of deforestation, besides the aforementioned factors (habitat, resistance, biodiversity), is on the carbon cycle. Studies suggest that ¾ of terrestrial carbon is bound in forests and it has also been proven that forests behave as slow carbon sinks – the latter cannot compensate for anthropogenic emission, though. The carbon content of forest soil is relatively high and it often exceeds that of trees themselves. However, given a healthy microclimate (anaerobic conditions), carbon remains bound for a significantly longer period until decomposition. In contrary, after clear-cutting or on agricultural areas, where an excess amount of oxygen is present, carbon is released at a much higher rate from the soil. Therefore, the objective should be conserving carbon already bound in forests and increasing forest area while taking measures adequate for the purpose (clear-cut harvest puts excess pressure on the environment and is best avoided for the above reasons). It is also true here that homogenous, low-diversity plantations do not tolerate climatic changes so the method most beneficial both in environmental and economic terms could be the planting of native species in high-diversity forests.

Agriculture is more susceptible to changing weather patterns than other industries – the latter are less exposed to climatic extremes or do not suffer damage to that extent due to adaptation techniques and measures. Climate models suggest that possible outcomes for the following decade, albeit with various rates, point in the same direction, so the tendency expected is fairly clear (dependent, of course, on a number of variables, e. g. policies). However, although estimated averages have an exact pattern, a more intense deviation is likely to occur in terms of environmental factors (temperature, precipitation, etc.). As such, both short and long-term impacts of climate change have to be taken into account. Furthermore, studies suggest that Hungary might be affected more severely by climate change than neighbouring areas – mainly because of geographical aspects (Kemény et al., 2019).
Climate models suggest that the following aspects will undergo drastic changes in the following decade.

Temperature (Kemény et al., 2019; Mezősi et al., 2014)

- The majority of models predict an increase in average temperature by the end of the century, most of them estimate a 1-3 °C.

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- Extreme weather is expected to occur more frequently, most importantly heatwaves, but extreme cold periods might also be seen.

Precipitation (Mezősi et al.,, 2014)

- The overall amount of precipitation is predicted to decrease this century.
- The distribution of precipitation will be most likely closer to random and dominated by extremes. Heatwaves could be accompanied by dry weather ultimately resulting in droughty seasons, by contrast, heavy rainfalls and storms could damage crops and as a secondary effect, could bring floods as well.

These changes will have manifold impacts on agriculture, varying in degree. Due to the number of variables hence to the uncertainty of future events, only general scenarios are discussed here in further detail.

Perhaps the biggest challenge agriculture is facing is the estimated temperature increase and less precipitation since these two factors are central to plant growth and reproduction. Such climatic conditions will be critical for species that do not tolerate heat or do not have the potential to survive drought. Plants' yearly cycle (flowering, ripening, etc.) is often induced by weather changes, and abnormalities also affect produce quality. It has been shown for numerous crops (like wheat and corn, the number one crops in Hungary) that climate change will lead to a changing schedule in the cycle (e. g. harvest). Furthermore, plants that are already under stress (e. g. nutrient depletion, water deficit, excess sunlight or drought) are often less resistant to pests (Sileshi et al., 2008). To respond to these changes, either crop species must be replaced with more resistant ones (which involves both national- and international-level issues) or new, more efficient plant protection forms and technologies must be introduced. Note that new methods and technologies (like high-intensity irrigation, intense fertilizer use, protective equipment, etc) do not vouch for a sustainable yield, though (Kemény et al., 2019).

Climate change does not only affect crops and animals. Drought and heatwaves are also harmful for human health: direct impacts include lower labour efficiency and performance as well as higher mortality rates (due to dehydration, cardiovascular diseases, melanoma) whereas indirect impacts can be allowing vectors to spread faster or further, or contributing to allergic reactions getting more severe by elongating the pollination season, etc. Agricultural workers are especially exposed to these threats due to the nature of their work. Additionally, lower yield could lead to nutrition-related issues: food availability, access and price. Consequently, a demographic shift could be expected, including concern over the availability of

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workers in some areas, migration, etc. (Paldy and Bobvos, 2010; IPCC 2014). Besides the measurable degree and consequences of climate change, there is some evidence suggesting that stakeholders' behaviour also plays an important role in forming its actual impact. Li et al., highlight that adaptation mainly originates from observing extreme events, such as droughts or floods, but in general, stakeholders often delay decision-making and are not willing to implement innovations. Other studies emphasize the role of regional and local institutions by designing a guideline to maintain productivity through regulating and managing the market, offering financial support, etc. (S. Li et al., 2016; IPCC, 2014).

Ecological farming, challenges, benefits, aims, vision

Ecological farming is a type of agricultural concept that, besides its strictly regulated form, incorporates the vision of sustainability. As such, its definition reflects the pillars of sustainability – according to IFOAM (2008), ecological farming is "a production system that fosters the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved". Furthermore, the four principles promoted by IFOAM are those of:

- health: all participants of agriculture are connected, their health and well-being cannot be separated from each other
- ecology: production must harmonise with the natural processes, agriculture must not deplete the environment
- fairness: all participants must be treated equally and respectfully
- care: all actions must be taken with precaution and responsibility.

In practice, ecological farming is highly regulated by international and national policies, from which relevant measures concerning Hungary are listed as follows.
REGULATION (EU) 2018/848 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007
Commission Regulation (EC) No 1235/2008 of 8 December 2008 laying down detailed rules for implementation of Council Regulation (EC) No 834/2007 as regards the arrangements for imports of organic products from third countries + amendments

COMMISSION REGULATION (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control + amendments
Minister of Rural Development Decree No. 34/2013 (X. 14.) on the certification, production, distributions, labelling and inspection of agricultural products and foods consistent with requirements for organic farming
The concept of ecological farming has a history of nearly five decades in Hungary, but only recent years have brought a definitive development in this area. The most significant change was introduced within the framework of the Rural Development Programme starting in 2014. Its aim was to encourage a more environment-friendly approach on the part of farmers and other parties to agriculture, including the protection of wildlife and biodiversity, the improvement of soil conditions and water usage efficiency. Consequently, ecological farming comes with numerous restraints, but the programme operates with a financial supporting system to compensate for the difficulties. Therefore, during the five-year duration of the programme, the number of ecological farmers increased 2.5 times and the land area dedicated to this purpose also increased 2.3 times. However, the total of land used for ecological farming still covers only 300,000 ha (less than 6% of all of the agricultural area), but a definite trend is emerging, which is hoped to continue into the future within the framework provided by current regulations (e. g. Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007).

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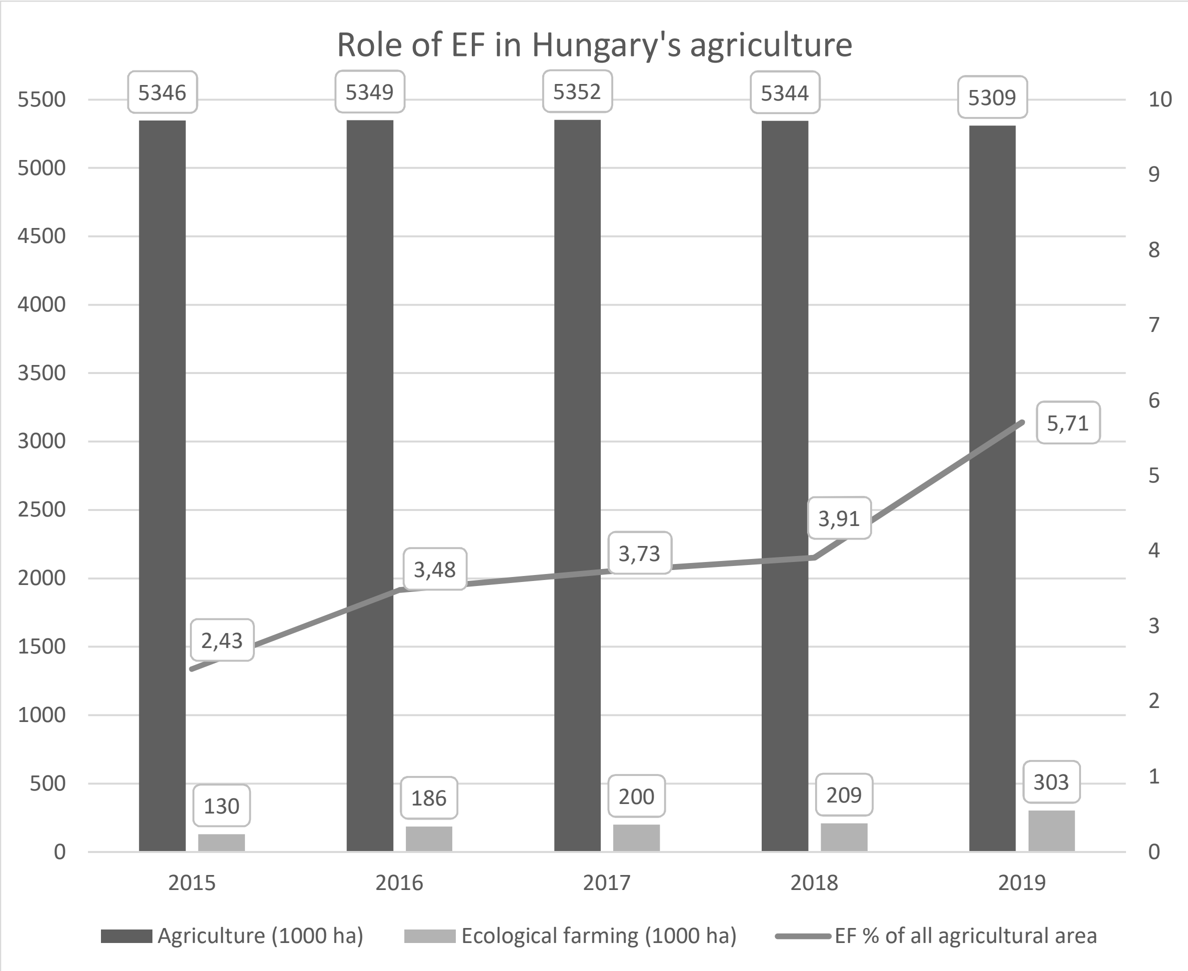
Figure 1. Comparison of area of ecological farming and all agricultural land in Hungary



With respect to current tendencies, a slight growth of area utilized for organic farming is seen in previous years, possibly caused by a revision of support schemes. Ecological farming, in line with the above principles, has the potential to provide high quality products while seeking social equity and taking the biotic and abiotic environment into consideration in such a way that production is expected to be sustainable. Therefore this type of agricultural management is based on a holistic approach, meaning that production is, instead of a strict input-to-output direction, based on systematic processes and cycles. Optimally, local and regional balance serve as a basis for farming, and so do local resources ("closed system" in theory). More specifically, numerous studies confirm that this approach has, without being exhaustive, the following effects (ÖMKI, Parlament 2018):

- enhances biodiversity,
- augments soil quality,
- does significantly lower contamination in groundwater, streams and lakes compared to conventional farming,
- lowers the occurrence of certain diseases among plants and animals,
- its products are rich in nutritional value, micro- and macronutrients, vitamins,
- mitigates climate change.

Studies suggest that organic farming is potentially less exposed to climatic changes than conventional farming (Jouzi et al., 2017).

Notwithstanding that ecological farming can have an overall positive impact on the environment and consequently climate change, such systems can only be manageable in the long term if the method benefits stakeholders, so both social and economic aspects have to be taken into account when analysing the most common challenges stakeholders have to face. These challenges arise mostly from the stringent regulations and requirements, combined with the special role of ecological farming in agriculture and economy. As the use of chemicals and fertilizers in ecological farming is restricted, other methods are to consider in all stages of production.

Although there are huge differences among agricultural areas in terms of different climatic and environmental conditions, ecological farming generally results in lower yields compared to conventional methods. Furthermore, higher costs of production are also present mainly as a result of increased labour intensiveness. Additional machinery requirements and the need to purchase new equipment also contributes to the relatively high cost of organic farming (Moudry et al., 2009). With respect to income, conventional farming is more profitable than organic farming because of lower yield – but moderate material requirements (e. g. limited fertilizer use) somewhat make up for the difference. However, some studies reveals opposite tendencies: as the demand for organic products increases, so does the income of such farmers (Pimentel et al., 2005). Social acceptance and the willingness to buy organic products is often problematic as some factors incorporated into the product's price are not directly beneficial to the consumer nor are quantifiable in this manner as they are more far-reaching than the scale of the producer-consumer cycle (e. g. environmental impact) (Moudry et al., 2009).

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Soil quality is an important factor in nutrient cycling, which is central to ecological farming. This is especially true for N, the absence of which results in a reduced growth and yield. As organic farming relies on natural processes, this could cause problems during transition from conventional to organic farming due to the previous one-way flow of nutrients and the damaged ecosystem of the soil. This period is also crucial for pest management as the restrictions in organic farming do not provide such effective intervention techniques as in conventional farming (Zinati 2002). As such, nutrient supply best relies on nutrient cycling, a closed system that is preferred so as to minimize adverse environmental impacts. This is why, as an example, nitrogen fixing organisms are crucial in organic farming (Goulding et al., 2009). However, nutrient management appears to be one of the major challenges of organic farming (Jouzi et al., 2017).

Fortunately, there are several fertilization solutions, the most efficient is said to be manure. Although manure enhances the physical and chemical properties of the soil, it can be difficult to properly disperse on the field because of its weight, volume, and varying nutrient content. Moreover, if not treated correctly, manure can favour the spread of weed (Barry and Merfield, 2008). Numerous studies list the control of pathogens as well as weed and pest management as the fundamental tasks in organic farming, arguing that the options here are far less effective than conventional methods (NAK, 2015). Even though there are solutions so contain diseases, prevention seems to be the preferred alternative.

Agroforestry

In Hungary, a set of favourable conditions for agriculture has contributed to economic growth for long enough to be fundamental for the country. However, current tendencies suggest that agriculture's role is now unsteady and the sector suffers from human interference while also contributing to climate change. Current practices are not suitable for long-term land management, nor is the approach prevailing in the farmer community. Without diminishing the significance of pioneer technologies such as biotechnology, there is another option for adaptation, which is also promising for economic growth, climate change mitigation and thus sustainability. This is how the modern idea of agroforestry was created, although the method had already been used for millennia.

Agroforestry's basic concept is that introducing forests into agriculture provides many of the benefits mentioned above while not reducing the area available for agriculture. Forests as the most important terrestrial carbon sink could contribute to

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mitigating climate change by modifying the input-output ratio of greenhouse gases, for instance by storing carbon-dioxide below ground. Furthermore, protection from soil erosion and deflation prevents the release of carbon from the soil. Spatial arrangement is an interesting aspect with large potential. Trees could be planted to, inter alia, favour machines managing crops, or to provide shade for crops that do not tolerate direct sunrays, serve as shelter for animals, etc. But besides this, in areas exposed to erosion, tree rows planted perpendicularly to the slope mitigate this effect. As such, a special arrangement can be chosen suiting every purpose. (Nair 2012). In forests, most of the carbon is bound in the soil. As such, minimizing soil disturbance prevents its recirculation into the atmosphere – contrary to current forestry practices, such as clear-cut and forced/induced regeneration. Trees introduced into agroforestry, although not to the extent of close-to-nature forests, follow similar pathways to bind carbon, admitting that the rate and effectiveness of the process is a function of species, system composition, and other variables (Lorenz and Lal, 2014).

Agroforestry practices have a long-standing history. Through ancient times and the middle ages, several examples are seen for this mode of farming: the symbiosis of fruit trees and undergrowth, or animals grazing in forests feeding on nuts, safe from heat and sunrays. However, in past centuries, as agricultural practices shifted, machinery appeared, simplicity and crop yield became priority, trees were disappearing from agricultural land, since they were seen as hindering, if not limiting factors of profit. Recent decades have not brought about a change of attitude either, although deforestation, climate change and social responsibility and awareness are often mentioned as some of the biggest concerns of humanity. The question remains to be answered in the upcoming decades: do conventional technologies remain dominant, or will profit lose its role as the number one priority in favour of environment protection and sustainability?

Three main branches of agroforestry, based on the components, are as follows:

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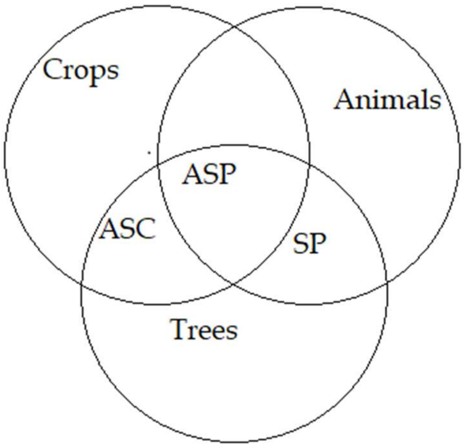
Figure 2.: Agroforestry systems classified based on their components (based on FAO 2015)



Agroforestry systems can be further grouped based on the ratio of trees and other components, or the spatial structure of the system. As such, some common arrangements are:

- shelterbelts: providing protection from wind and airborne contaminants, thus creating a liveable microclimate,
- alley cropping: trees in rows with crop in between: trees provide shading and fertilize the soil with fallen leaves,
- grassland with trees: trees' shadow protects animals from the sun, animals can eat leaves or use the trunk to scratch themselves.

According to the report of AGFORWARD, the total territory of agroforestry systems in 2016 was 38.100 ha, which equals 0.41 % of the country and 0.81% of agricultural area. Nearly 95% of agroforestry systems is livestock agroforestry, the rest being utilised for agrisilviculture (Herder et al., 2016).

Agroforestry is often criticized for being economically less beneficial than growing crops alone, but there is evidence that the goods derived from trees compensate for the slightly decreased yield to area ratio, while also providing other options for income: e. g. harvesting herbs, timber, etc. Land equivalent ratio describes this relationship by providing a comparison of sole cropping and intercropping – according to FAO (1985): "ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level. It is the sum of the fractions of the intercropped yields divided by the sole-crop yields". If the result exceeds 1, agroforestry produces higher yield than monocultures under similar conditions. Average land equivalent ratio for agroforestry estimates at

1,2-1,4, however, significantly higher values were also observed in some cases (Zamozny, 2018, Rahaman et al., 2018). Agroforestry systems have the potential to increase yield under some circumstances: for instance, a study found that agroforestry resulted in higher cocoa yield than conventional agriculture in tropical climate (Jacobi et al., 2014).
Trees affect the environment both locally and globally. With climate change mitigation and adaptation being the most important global impacts of this aspect, local impacts are discussed from the point of view of farm resilience, potential in organic farming and social/economic factors.

Nutrient cycling

Plant welfare and consequently yield is proportional to soil quality and climate. That is, nutrient availability, humus content, physical and chemical structure, water content, exposure to weed and pests as well as weather, including extremes all influence the amount and quality of yield. Agroforestry systems appear to tolerate extreme weather better than conventional fields, mainly because of a more balanced water cycle relying on supplementary water through deep roots. Farm-scale nutrient cycling is often difficult to analyse as material appears to flow in one direction, with input from outside in the form of fertilizers and seeds/seedlings, and output as harvested goods that are, again, removed from the site. In an agroforestry system, however, trees enter the cycle so the interaction between system elements and system parameters are altered.
With a reasonable vertical structure and careful species selection, trees are able to reach deeper with their roots, taking up substances from lower soil layers and bringing these into the nutrient cycle without interfering with crops' needs. Furthermore, increased biodiversity and thus a range of different needs prevents soil depletion so crops can share resources without exploiting the land, causing nutrient deprivation and lowering yield. The same holds for water. Trees can suck water from the depth and carry it up to the surface through evapotranspiration, so that the microclimate in their vicinity gets enriched with water vapour. Observations showed surface and groundwater contamination to have been reduced in agroforestry systems. Promising results include, for instance, a reduction in nitrate concentration. Besides water and nutrient uptake, tree litter, such as leaves and small branches, also contributes to a more stable nutrient cycle by raising organic carbon content and the availability of nutrients (e. g. N, K, P). There is evidence that this phenomenon was more expressed around the trees and less marked with further away from them. This

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could help solve nutrition- and fertilizer-related problems, as a deeper understanding of ecological interactions could encourage a more considerate and moderate fertilizer usage (Pardon et al., 2017). Organic farming can benefit from agroforestry as such a system can promote nutrient cycling if the right species are selected, which could be critically important in mitigating one of the major problems of organic farming, namely, the loss of nutrients. Parts of trees (e. g. fallen leaves) and the trees' microclimate help enrich soil, foster soil health and nourish soil organisms so that the below-ground segment of nutrient cycling is improved by providing a more efficient uptake of nutrients (Udawatta et al., 2019). Besides, trees have other, larger-scale benefits that reach beyond the area of agricultural land, for instance by contributing to purifying air and water (Shibu, 2009).

Competition

Managing competition is essential for successful agroforestry practices as trees and crops may require similar resources, such as water, light and nutrients. Competition may be minimized by setting up a reasonable spatial and temporal structure that is also in line with the aims of the farmer. Shading has to be taken into account as a limiting factor for plant growth but can be controlled by pruning or with fewer trees, should a higher crop yield be the objective (Nicodemo et al., 2016). Interestingly, trees in agroforestry systems tend to adapt to the surrounding crops by growing their roots even deeper, reducing competition and introducing new nutrient reservoirs into the nutrient cycle (Cardinael et al., 2015).

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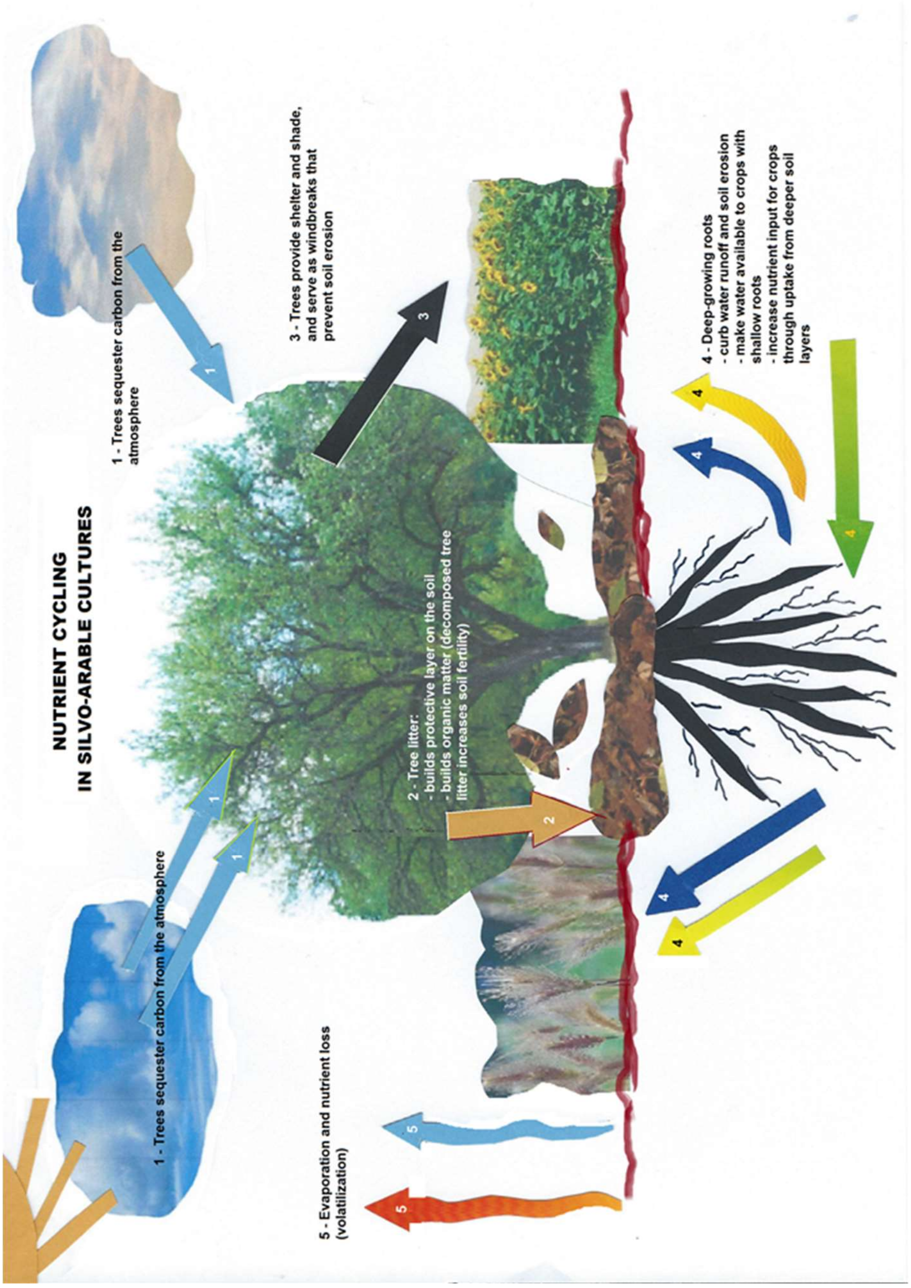
Figure 3. : Schematic cycle of nutrient transport



Diversity, pest management

Trees, in various compositions, can serve as passages for species by connecting smaller, fragmented habitats and can serve as habitats on their own as well, thereby promoting biodiversity. Shading also influences microclimate considerably as it prevents evaporation from the soil, serves as a windbreak and provides a more tolerable environment for many species. Trees can function as fences as well by preventing or slowing down the spread of airborne pathogens (Shibu, 2009). If trees are planted as living fences surrounding an agricultural area, they can protect the land from outer factors, even from contamination from non-organic farming (Altieri and Nicholls. 2008).

Agroforestry provides an opportunity for integrating ecosystems, and healthy ecosystems consist of a wide range of species. Healthy ecosystems provide a scale of ecosystem services, most of which can be important financially as well (Udawatta et al., 2019). Consequently, preventing environmental degradation is a result of such farming – from an economic aspect, biodiversity can offer several options for generating income, suggesting that this approach might be able to connect environmental and economic issues and provide a joint solution (Leakey, 1998).

Protection from pathogens and harmful species is nonetheless a question of knowledge and understanding. Studies underline the importance of choosing the ideal tree species that fit in the farm's structure, which are highly tolerant and resistant against diseases. These species can serve as habitat for natural enemies of pests while not falling prey to pests immediately, eventually decreasing the speed of their spread. (Dix et al., 1995)

Agroforestry practices have promising results in weed management by shrinking their habitat and through allelopathy (Kohli et al., 2008). Furthermore, they are beneficial for biological pest management by providing habitat for a diverse range of species, including pests' natural predators as well. Therefore, agroforestry seems to be a promising area to support farm resilience, especially in organic farming, where pest control is a crucial concern (Boinot et al., 2019).

Socioeconomic factors

Agroforestry practices benefit local communities by providing a range of ecosystem services, thereby promoting social activities and creating jobs, the latter also the result of the nature of agroforestry as forest management practices are scheduled for periods when there is less work with the crops themselves. Wood cutting and pruning are typical for winter, both for economic and environmental reasons. On the

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one hand, most of agricultural work culminates in the other seasons so to avoid manpower shortage, a proper timing of tasks with distributing work more evenly over the year is paramount. On the other hand, certain types of work on trees are better done in winter since tree metabolism is slower at this colder time of the year, also, in case of deciduous species, leaves do not complicate the work. Further benefits are that crops are not damaged and the frozen soil is also less vulnerable. Hamidian et al. (2011) found that agroforestry systems could have a positive effect on numerous aspects of society, such as: income, migration, tourism, education employment all year round, festivals due to increased income. All in all, forestry and agriculture offer job opportunities throughout the year, preventing locals from having to migrate in the hope of making a better living, instead, creating jobs in providing goods, like timber, with a supplementary income (Umrani and Jain, 2010 p. 38.).

Summary

Agroforestry systems appear to be beneficial in both economic and ecological terms, furthermore, there is evidence from various parts of the world including Europe that its social aspects could also raise awareness and contribute to a wider recognition of nature protection, while providing opportunities for tourism and education. As such, promoting an approach that emphasises the benefits of agriculture-forest interaction may serve as a basis for social movements to shape attitude (Krummenacher et al., 2008).

Table 1. illustrates a systematic summary of aforementioned topics, different colours aim to represent connection points. These connection points underline how agroforestry systems could contribute to sustainability through supporting EF practices, meaning that in these cases, introducing AF to EF is beneficial in coping with related issues and ensuring farm resilience, thus economic growth as well.

Table 1. *: Social, economic and environmental aspects of EF, AF and climate change*

	AGROFORESTRY SYSTEMS	ECOLOGICAL FARMING	CLIMATE CHANGE
ENVIRONMENTAL	- extreme weather mitigation (local) - effective pest management - additional yield from trees - erosion - biodiversity - reduced fertilizer need - shelter, habitat	- limited availability of tolerant species - pest management - yield - contamination from conventional farming - fertilization - adaptation to climate change	- extreme weather - invasive species - low yield - ecosystem damage - loss of species - schedule change - burn, frostbite - poor quality products
ECONOMIC	- local market - additional income - multipurpose farming - labour all year round - food security - ecosystem services	- based on import - income - machinery requirements - limited availability of fertilizers, high cost - high cost of product - poor availability for customers	- market - low yield – low income - poor quality – low price - increased cost of plant protection, watering - prices
SOCIAL	- reduced migration - social recognition of nature protection - tourism - education - job opportunities - social movements	- manpower demand - knowledge, education - social acceptance - willingness to buy organic	- migration - education, knowledge, willingness to act - diseases - higher death rate - reduced work productivity - job loss

REFERENCES

[1.] Altieri M.A., Nicholls C.I. (2008): Ecologically Based Pest Management in Agroforestry Systems. – In: D. R. Batish eds. et al. Ecological basis of agroforestry, CRC Press, Boca Raton.

[2.] Barry P. and Menfield M. (2008): Nutrient management on organic farms. – Teagasc Environmental Research Centre, Johnstown Castle, Co. Wexford.

[3.] Bartha D. (2003): Történeti erdőhasználatok Magyarországon. – Magyar Tudomány 48(12): 1566-1577.

[4.] Boinot S., Poulmarc'h J., Mézière D., Lauri P., Sarthou J. (2019): Distribution of overwintering invertebrates in temperate agroforestry systems: Implications for biodiversity conservation and biological control of crop pests. – Agriculture, Ecosystems and Environment. 285: 106630. https://doi.org/10.1016/j.agee.2019.106630

[5.] Cardinael R. [et al.] (2015): Competition with winter crops induces deeper rooting of walnut trees in a Mediterranean alley cropping agroforestry system. – Plant and Soil. 391:219-235 https://doi.org/10.1007/s11104-015-2422-8

[6.] den Herder M, [et al.] (2016): Current extent and trends of agroforestry in the EU27. Deliverable Report 1.2 for EU FP7. Research Project AGFORWARD 613520, August 2016, 2nd Edition. https://livingagrolab.eu/wp-content/uploads/2023/02/D1_2_Extent_of_Agroforestry.pdf

[7.] Dix M, [et al.] (1995): Sustainable pest management in agroforestry ecosystems. – In: Society of American Foresters. Convention (USA).

[8.] FAO (1985): Guidelines: Land Evaluation for Irrigated Agriculture. FAO Soils Bulletin 55;

[9.] FAO (2015): Agroforestry systems. http://www.fao.org/forestry/agroforestry/89998/en/

[10.] Frison E. A, Cherfas J, Hodgkin T. (2011): Agricultural Biodiversity Is Essential for a Sustainable Improvement in Food and Nutrition Security. – Sustainability 3(1): 238-253. https://doi.org/10.3390/su3010238

[11.] Goulding K, Stockdale E, Watson C. (2009): Plant Nutrients in Organic Farming. – In: Kirchmann H, Bergström L. (eds.) Organic Crop Production - Ambitions and Limitations. Springer, Dordrecht, https://doi.org/10.1007/978-1-4020-9316-6_4

[12.] Allsopp, M. [et al.] (2014): Mérgek vagy méhek? Úton a fenntartható mezőgazdaság felé. – Greenpeace Magyarország Egyesület, Budapest. Mergek_vagy_mehek.pdf (archive-it.org)

[13.] Hamidian A., Zehtabyan G., Khosravi H. (2011): Socio-Economic Benefits of Agroforestry for 1st National Conference of New Approaches in Natural Resources Sustainable Management.
[14.] IFOAM (2008): Definition of organic agriculture. https://www.ifoam.bio/why-organic/organic-landmarks/definition-organic
[15.] Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.) (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 151 p.
[16.] ITM (2018): NÉS (Melléklet a 23/2018. (X. 31.) OGY határozathoz),
[17.] Jacobi J, Schneider M, Rist S. (2014): Agroforstwirtschaft als ökologisch, ökonomisch und sozial nachhaltige Landnutzungsform: Fallbeispiel Kakaoanbau in Bolivien. – Elemente Der Naturwissenschaft (100):4-25. 10.18756/edn.100.4
[18.] Jouzi Z, [et al.]: Organic Farming and Small-Scale Farmers: Main Opportunities and Challenges. – In: Ecological Economics 132, 144-154. https://doi.org/10.1016/j.ecolecon.2016.10.016
[19.] Kemény G., Molnár A., Fogarasi J. (szerk.). (2019): A klímaváltozás hatásának modellezése a főbb hazai gabonafélék esetében [Modelling the impact of climate change for the key cereal crops in Hungary]. – NAIK Agrárgazdasági Kutatóintézet, Budapest.
[20.] Kohli R. K, Singh H P, Batish D. R, Jose S. (2008): Ecological Interactions in Agroforestry: An Overview. – In: Batish, D. [et al.], (eds): Ecological basis of agroforestry. CRC Press, Boka Raton. https://doi.org/10.1201/9781420043365.pt1
[21.] Krummenacher. J. [et al.] (2008): Ökonomisches und ökologisches Potenzial der Agroforstwirtschaft. – Agraforschung 15(3):132-137.
[22.] KSH (2017): A nemzetgazdasági ágak üvegházhatású gáz- és légszennyezőanyag-kibocsátása. http://www.ksh.hu/docs/hun/xftp/idoszaki/pdf/uveghazhatas15.pdf
[23.] KSH (n.d.): Az ökológiai gazdálkodás szerepe egyre nagyobb az agráriumban. http://www.ksh.hu/docs/hun/xftp/stattukor/okogazd/index.html#abiogazdlkodshelyzetemagyarorszgon
[24.] Leakey Roger R. B.(1998): Agroforestry for Biodiversity in Farming Systems. – In: Collins, W.W. and Qualset, C.O. (Eds.). Biodiversity in Agroecosystems. CRC Press, Boca Raton, USA.

[25.] Li S., [et al.] (2017): Relating farmer's perceptions of climate change risk to adaptation behaviour in Hungary. – Journal of Environmental Management 185, 21-30. https://doi.org/10.1016/j.jenvman.2016.10.051

[26.] Lorenz K., Lal R. (2014): Soil organic carbon sequestration in agroforestry systems. A review. – Agronomy for Sustainable Development 34, 443-454. https://doi.org/10.1007/s13593-014-0212-y

[27.] Mezősi G, Bata T, Meyer B. C, Blanka V, Ladányi Zs. (2014): Climate Change Impacts on Environmental Hazards on the Great Hungarian Plain, Carpathian Basin. – Int. J. Disaster Risk Sci. 5, 136-146. https://doi.org/10.1007/s13753-014-0016-3

[28.] Moudry J, Hartl W, Cudlínová E, Moudry J, Konvalina P, Smárek J. (2009): Major problems of organic farming - experience transmission. – Lucrări Ştiinţifice, Seria Agronomie 52(1):327-333.

[29.] Nair, P.K.R. (2012): Climate Change Mitigation: A Low-Hanging Fruit of Agroforestry. – In. Nair, P.K., Garrity, D. (eds.): Agroforestry The Future of Global Land Use. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4676-3_7

[30.] NAK (2021): Ökológiai gazdálkodás. Kézikönyv a támogatási kérelem benyújtásához. – Nemzeti Agrárgazdasági Kamara, Budapest.

[31.] Nicodemo M. L. F. [et al.] (2016): Reducing competition in agroforestry by pruning native trees. – Revista Árvore 40(3): 509-518. https://doi.org/10.1590/0100-67622016000300014

[32.] ÖMKI (2012?): 50 érv a biogazdálkodás mellett. – Ökológiai Kutatóintézet Nonprofit Kft., Gödöllő. 50 érv a biogazdálkodás mellett (oszk.hu)

[33.] Padányi J., Halász L.: A klímaváltozás hatásai. – Nemzeti Közszolgálati Egyetem, 2012.

[34.] Paldy A, Bobvos J. (2010): Climate change and health-challenges for Hungary. – Med Srod. 13(1):19-29.

[35.] Pardon, P.: Trees increase soil organic carbon and nutrient availability in temperate agroforestry systems; in Agriculture, Ecosystems & Environment, Volume 247, 1 September 2017, 98-111. https://doi.org/10.1016/j.agee.2017.06.018

[36.] Parlament (2018): A biogazdálkodás története és tendenciái: elemzés az országgyűlési képviselők részére. – Országgyűlés Hivatala, Budapest. https://www.parlament.hu/documents/10181/1763272/Elemz%C3%A9s_2018_Biogazdalkod%C3%A1s.pdf/efbe988d-5f9f-af3b-1654-ec4e1f90531d

[37.] Parlament (2019): Klímaváltozás és mezőgazdaság. – Infojegyzet 53: december 9. https://www.parlament.hu/documents/10181/1789217/Infojegyzet_2019_53_klimavaltozas_es_mezogazdasag.pdf/266bafc1-246b-b450-e4dc-db850c894170?t=1575887136013

[38.] Pimentel, D. [et al.] (2005): Environmental, energetic, and economic comparisons of organic and conventional farming systems. – Bioscience 55(7): 573-582. https://doi.org/10.1641/0006-3568(2005)055[0573:EEAECO] 2.0.CO;2

[39.] Rahaman A. [et al.] (2018): Productivity and Profitability of Jackfruit-Eggplant Agroforestry System in the Terrace Ecosystem of Bangladesh. – Turkish Journal of Agriculture-Food Science and Technology 6(2): 124. https://doi.org/10.24925/turjaf.v6i2.124-129.1330

[40.] Shibu J. (2009): Agroforestry for ecosystem services and environmental benefits: An overview. – Agroforestry Systems 76: 1-10. https://doi.org/10.1007/s10457-009-9229-7

[41.] Sileshi G., [et al.] (2008): Diseases, Insect Pests, and Tri-Trophic Interactions in Tropical Agroforestry. – In: Batish, D. R. et al. (eds.) Ecological basis of agroforestry. CRC Press, Boca Raton.

[42.] Somogyi Z. (2016): Fűben-fában karbon. http://www.scientia.hu/fubenfabankarbon/Fuben-faban_karbon.pdf

[43.] Szabó P. (2006): Erdőgazdálkodás a középkorban. – In: Laszlovszky J, Ferenczi L and Szabó P (ed.). Magyar középkori gazdaság- és pénztörténet. 81-103. Bölcsész Konzorcium, Budapest.

[44.] Udawatta P. R, Rankoth L, Jose S. (2019): Agroforestry and Biodiversity. – Sustainability 11(10): 2879. https://doi.org/10.3390/su11102879

[45.] Umrani R. and Jain C. K. (2010): Agroforestry systems and practices. – Oxford Book Company, Delhi.

[46.] Valkó G. (2017): A fenntartható mezőgazdaság indikátorrendszerének kialakítása az Európai Unió tagországaira vonatkozóan; Központi Statisztikai Hivatal, Budapest.

[47.] Zamozny G. (2018): Agrárerdészeti ismeretek. Útmutató Környezetbarát és Jövedelmező Gazdálkodási Módszerekhez. – Német Szövetségi Környezetvédelmi Alapítvány (DBU); BTU, Cottbus. https://mek.oszk.hu/18900/18937/18937.pdf

[48.] Zinati G. M. (2002): Transition from conventional to organic farming systems: I. challenges, recommendations and guidelines for pest management. – Hort. Technology 12(4): 606-610. https://doi.org/10.21273/HORTTECH.12.4.606

Összefoglaló. A mezőgazdaság az emberi táplálék egyetlen forrása. Jelenleg azonban úgy tűnik, hogy a kereslet meghaladja a hagyományos gazdálkodási gyakorlat korlátait, mivel ez utóbbiak gyakran véges erőforrásokra támaszkodnak. Emiatt a mezőgazdasági kutatás fókusza egy másik megközelítés, nevezetesen a fenntartható gazdálkodás felé tolódik el, amely a remények szerint megoldást kínál a fent említett kérdésre. Egy ilyen rendszertől jelentős hozam és kiemelkedő ellenálló képesség várható el, hogy elviselje és enyhítse az éghajlatváltozás negatív hatásait, és biztosítsa az emberi jólétet. E tanulmány célja, hogy megvizsgálja ezeket a lehetőségeket, a Kárpát-medence éghajlatára összpontosítva. A jelenlegi trendek elemzése után részletesebb tárgyalásra kerül az ökológiai gazdálkodás és annak kihívásai. Az agrárerdészet az e kihívásokra való válasz keretrendszereként kerül ismertetésre. Ennek eredményeként olyan kapcsolódási pontok körvonalazódnak, amelyek azt jelzik, hogy az ökológiai gazdálkodás és az agrárerdészet ötvözése valóban a biztonságos és fenntartható mezőgazdaság alapja lehet.