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IMPACT OF AGRI-ENVIRONMENTAL ECOSYSTEM SERVICES ON FARM LANDSCAPES

ABSTRACT

More than a third of the Earth's total land area is used for agriculture and grazing, leading to alarming rates of land conversion and habitat loss for a variety of plant and animal species. Conventional agricultural production, in both methods and practice, is responsible for high rates of biodiversity degradation, soil erosion, reduced water potential, and impacts on a range of ecosystem services. In Bulgaria, research on economic and other issues related to agroecosystem services is at an early stage. With few exceptions, there is a virtual lack of research on the dominant forms of agroecosystem services management in the country. This paper aims to investigate the impact of implementing ecosystem services on the shaping of the landscape on farms. As well as to further the understanding of the impact of multiple agroecological ecosystem services in farm landscapes.

KEYWORDS: agro-ecological services, landscape, impact, implementation

JEL: J43, Q57, Q58

INTRODUCTION

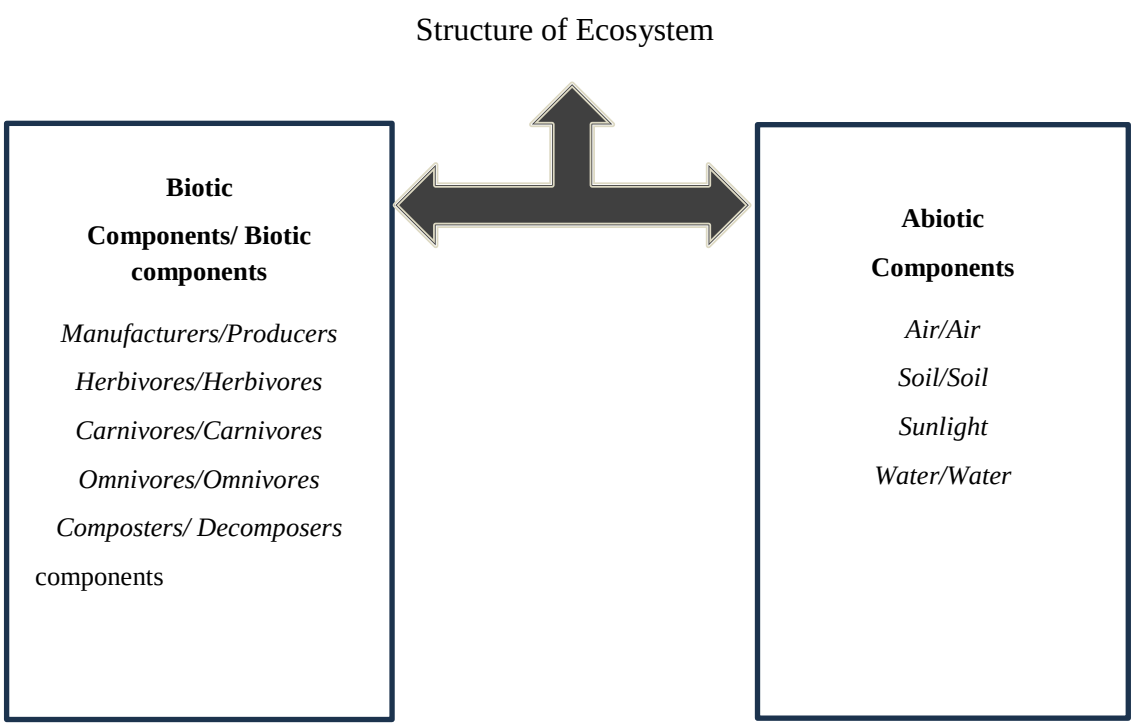
An ecosystem is a system consisting of biotic and abiotic components that function together as a unit. Biotic components include all living things, while abiotic components are non-living things. Thus, the definition of ecosystem science includes an ecological community consisting of diverse populations of organisms living together in a particular habitat. Any sustainable development of ecosystems must overlap the ecological, economic and social elements equally. Our development should not disturb the development of future generations and they should have access to the same natural resources as us. In general, the state of ecosystems in Bulgaria is good, but in some places there are serious processes of degradation and efforts must be made to restore them and identify the causes of negative impacts. When the concept of ecosystem was defined and the idea that nature functions as a single whole was introduced, the theory of systems had not yet been developed. After the justification of the systems approach, the possibility of studying the structural-functional organization of ecosystems was realized. The founders of the systems approach came to the conclusion that each system is a collection of components with given properties, functioning interdependently, united into a whole to achieve certain actions and goals. Ecosystem services are the conditions and processes by which natural ecosystems and the organisms that make them up maintain and replenish their life. These services maintain biodiversity and the production of ecosystem goods. Ecosystem goods and services are the benefits that humans derive directly or indirectly from ecosystem functions.

The most important thermodynamic characteristic of ecosystems is their ability to create and maintain a high degree of internal order, with each system in equilibrium not only with its external environment but also in the relationship of its individual parts. The ecological equilibrium of an ecosystem is understood as a state of balance between its constituent elements and the processes occurring within it. As between the ecosystem and its environment, this equilibrium is maintained by the ecosystem's own mechanisms of self-regulation.

Essentially, the definition of an ecosystem in biology is that it acts as the basic unit of nature. Just as a living organism consists of cells that act as the structural and functional units of life, nature also consists of basic units called ***ecosystems*.**

Figure 1 shows the structure of the ecosystem, which shows the interrelationship between its different components.

Figure 1. Ecosystem structure



Source: author's work

Ecosystem services are products and other benefits that people receive from natural ecosystems (MEA, 2005). Or it can be summarized that ecosystem services are the benefits that people receive through their interactions with nature. These benefits are associated with several dimensions such as people's quality of life, need for food, water, health, security and livelihood, to cultural and spiritual meaning including identity that people gain through their relationship with ecosystems. A large part of agro-ecological ecosystem services is applied in agriculture. Although the main purpose of agriculture as a sector of the economy is food production, farmers have recently been encouraged to provide a wide range of ecosystem services to meet the needs of the population (Kazakova; Nedkov; Nikolov; Todorova; Bachev; Grigorova and Kazakova; EEA; Yordanov et al.; Chipev et al.).

Farm landscapes are viewed as coupled social-ecological systems and are the result of interactions between biophysical and social environments. Consequently, the combination of factors such as climate, geology and ecology, as well as management practices, technologies,

skills, institutions and societal demand, leads to the provision of ecosystem service impacts on top of farm landscapes.

According to authors Zhang W, Ricketts T. H, Kremen C., Carney K.& Swinton S. M. (2007), depending on how farms are managed, agriculture can be the source of many harmful methods and practices that will result in wildlife habitat loss, harmful substances in the soil and air, sedimentation, greenhouse gas emissions, pesticide poisoning, and other Any trade-offs associated with using appropriate agricultural management methods and practices are critical to realizing the benefits of ecosystem services and reducing environmental damage

Agroecosystem services can provide farmers and communities with a set of different rules, divided into two groups:

▪ **Regulatory rules**. These include flood control, water quality control, soil carbon storage, climate change mitigation, pesticide use reduction and appropriate crop treatment.

▪ **Cultural rules**, could include education, recreation, tourism, area vitality, and others. Biodiversity conservation can also be considered a cultural ecosystem service influenced by agriculture Daily G. C. (ed.) (1997).

Swinton S. M., Lupi F., Robertson G. P. & Hamilton S. K. (2007) conclude that conversion of natural habitats to cropland can on the one hand have a strong impact on the ability to produce important ecosystem services, but on the other many agricultural systems can also be important sources of certain services. Agricultural land use can be considered as a certain intermediate stage in human development between natural and agricultural ecosystems.

2. RESEARCH METHODOLOGY

According to Bashev (2020) "Agrarian" ecosystems and "agrarian" ecosystem services are those associated with agricultural "production". The hierarchical system of agroecosystems includes multiple levels (from individual agricultural plot/plot, area, micro-region, macro-region, etc.), while their (ecosystem) services are classified into different categories (supporting, economic, recreational, aesthetic, cultural, educational, biodiversity conservation, water purification and retention, flood and fire protection, climate regulation, etc.) (MEA). The term 'management of (agro)ecosystem services' refers to the management of human actions and behaviours related to the conservation, enhancement and restoration of ecosystems and ecosystem services (Bachev 2021)**.**

The present study aims to deepen understanding of the application of multiple agroecological ecosystem services on farm landscapes. Measuring the value of ecosystem services and ensuring an effective level of provision requires three main approaches to the implementation of agroecological ecosystem services (Polasky S. 2008).

1. Provision of agro-ecological ecosystem services ('ecological production function');
2. Valuation of agro-ecological ecosystem services ('valuation');
3. Develop policies, tools for effective delivery of agro-ecological ecosystem services ("incentives, management").

With respect to the first approach, a number of scientists and ecologists have engaged in decades of research to improve understanding of how ecosystem services are produced (Costanza et al. 1997; Daily 1997; MEA 2005). Basic knowledge of ecosystem structure and function is continually increasing, yet we know considerably less about how these factors determine the provision of the full suite of agroecological ecosystem services to an individual ecosystem (NRC. 2005). A better understanding of the processes that influence agroecological ecosystem

services will allow prediction of the outcomes of their implementation, given their specific characteristics and the corresponding negative impacts on them. This means that an **"ecological production function**" can be generated. In practice, most 'ecological production function' studies focus on the provision of one or two well understood and researched ecosystem services. Thus, as a result of analysing the different processes, the predictability of the application of ecosystem services on the farm landscape will increase. Despite the wealth of research, this is one area that needs considerable attention (Kazakova; Nedkov; Nikolov; Todorova; Bachev; Grigorova and Kazakova; IAOS; Yordanov et al.; Chipev et al.).

Under the second approach, **determining the value of agro-ecological ecosystem services** usually uses a market valuation, but can also use a non-market valuation. Valuing services arising from agricultural activities is a relatively straightforward task because agricultural commodities are traded in different markets. Separately, some ecosystem services provide a high contribution to agricultural production, and their value can be measured by estimating the change in the quantity or quality of agricultural output resulting from an increase, decrease or removal of some services. This approach has been used to estimate the value of pollination services and biological control services (Gallai N., Salles J. M., Settele J. & Vaissiere B. E. 2009). Additionally, the values of such services can be easily determined by comparing opportunity costs: different substances, pesticides that will substitute natural pest control. The other main method is the use of non-market valuation. It can be based on a particular consumer choice - behaviour or a particular attitude as a result of a market survey. Thus, these surveys for a particular 'conditional' valuation or attitude result in consumers being asked what they are willing to pay for the implementation of the agri-environmental ecosystem service they have chosen accordingly. What is important here is to understand the views of farmers as farmers: what they would be willing to accept in return for the provision of a particular ecosystem service (Swinton S. M., Lupi F., Robertson G. P. & Hamilton S. K. 2007).

One of the main difficulties in managing agri-environmental ecosystem services is that those providing such services do not always benefit from them. Many ecosystem services are synonymous with public goods. Although farmers benefit from various ecosystem services, their activities can strongly influence the provision of services to third parties who do not control their production. Examples include: the impact of different farming practices on the conservation of water resources, pest populations and many others. Therefore, the main purpose of measuring and valuing ecosystem services is to use this information to design and implement certain policies and specific incentives for farmers to better and efficiently manage both farms and limited natural resources (Bashev; Bashev et al.; Bachev, 2021; Todorova).

In implementing the third approach, namely **developing policies, instruments for effective delivery of agroecological ecosystem services ("incentives, management")**, incentives to farmers can be in the form of government payments for agroecological service delivery or initiatives of various private organizations by implementing environmental programs (Swinton S. M. 2008). Agri-environment schemes aim to mitigate the negative environmental effects of intensive agriculture by providing financial incentives to farmers to adopt environmentally friendly farming practices. In the US, they provide support for investments in soil conservation and other readily observable practices to maintain or improve certain ecosystem services, as exemplified by the 2002 Farm Bill Conservation Security Program. Many European countries also provide government support for environmentally sound agricultural practices that maintain ecosystem services. A recent evaluation of over 200 pairs of fields in five European countries showed that agri-environmental programmes have minor to moderate positive impacts on biodiversity, but largely fail to protect rare or threatened species (Kleijn D., et al.2006).

Agri-environmental services have been identified as a practice that can be supported through the eco-schemes under the first pillar of the Common Agricultural Policy (CAP). They are also

highlighted as one of the sustainable farming practices that can help achieve the objectives of the European Green Pact and its related Farm to Table and Biodiversity strategies. Under Horizon 2020, the EU is funding several research projects dedicated to the development of agri-environmental research. These projects contribute to a better understanding of the practical application of ecological and low-intensity agricultural practices and their benefits for the environment, climate and society.

3. TYPES OF AGRO-ECOLOGICAL ECOSYSTEM SERVICES AND THE IMPACT ON FARM LANDSCAPE DESIGN

Nearly 40% of the earth's surface is associated with rural economic production: crop cultivation, manufacturing, and livestock grazing, allowing tremendous opportunities for humanity and increased economic development (Ramankutty, N., Evan, A.T., Monfreda, C., and Foley, J.A. 2008). Different types of agroecological ecosystem service types generate different impacts on farm landscapes. There have been a number of studies in this regard that compare different types of agroecological systems and the services they provide. An example can be given with conventional monoculture production and organic farming, in particular the effects that agricultural intensity has on biodiversity and ecosystem services (Björklund, J., Limburg, K.E., Rydberg, T. 1999). Other studies present comparative analyses between small and large farms and focus on factors such as: productivity (Lele, M., and Agarwal, U. 1990), soil erosion and loss (Essiet, E.U. 1990), diversity of different bird and plant species (Andersson, E., and Lindborg, R. 2014), and last but not least adaptation to climate change. However, none of these examples provide what the impact of implementing ecosystem services would be on farm landscapes and the environment. Simultaneous valuation of multiple agroecological ecosystem services is necessary to understand the interrelationships between individual services, how they respond to change, such as innovations in management, but also how modification of one service affects all others (Bennett, E.M., Peterson, G.D, and Gordon, L.G. 2009). The types of agroecological ecosystem services are:

▪ **Pest control** - biological pest control in agroecosystems is an important ecosystem service that is often maintained by natural ecosystems. The landscape outside of cultivated crops provides the habitat and diverse food resources needed by arthropod predators, insectivorous birds, and microbial pathogens that act as natural enemies of agricultural pests and provide biological control services in agroecosystems (Tscharntke T., Klein A. M., Kruess A., Steffan-Dewenter I. & Thies C. 2005) These biological control services can significantly reduce pest and weed populations in agriculture, thereby reducing the need for pesticides. It has been estimated that natural pest control services save about $13.6 billion annually on U.S. farms (Losey J. E. & Vaughan M. 2006) This estimate is based on the estimated value of crop losses from insect damage as well as the value of insecticide costs. Studies have shown that insects account for approximately 33% of natural pest control (Hawkins B. A., Mills N. J., Jervis M. A.& Price P. W. 1999).

▪ **Pollination** - Pollination is another important agro-ecological ecosystem service for agriculture that is provided by natural habitats in the farm landscape. About 65% of plant species require pollination. An analysis of data from 200 countries shows that for 75% of crops of global importance for food production, farmers rely on pollination primarily from insects (Klein A. M., Vaissiere B. E., Cane J. H., Steffan-Dewenter I., Cunningham S. A., Kremen C. & Tscharntke T. 2007). Wild insect pollinators are often present in crops of economic importance in addition to honey bees. Of the most important crops pollinated by insects and animals, over 40% depend on wild pollinators. The economic impact of insect pollination on global food production in 2005 in the 162 FAO member countries was estimated at 153 billion

euros, but the vulnerability to loss varies by geographical region (Gallai N., Salles J. M., Settele J. & Vaissiere B. E. 2009).

▪ **Conservation of water resources** - ensuring sufficient quantities of clean water and the level of quality is an essential agri-environmental service. According to various data, agriculture accounts for about 70% of global water consumption. Perennial vegetation in natural ecosystems such as forests can regulate water retention, infiltration and flow across the landscape. Vegetation cover plays a central role in regulating water flow by retaining soil and modifying its structure. Forest soils tend to have a higher infiltration rate than other soils and forests reduce flooding while maintaining constant inflow levels (Maes W. H., Heuvelmans G. & Muys B. 2009).

Another type of agroecological ecosystem service is water availability in agroecosystems, which depends not only on infiltration and inflow but also on soil moisture retention. With climate change, increased rainfall variability is predicted to lead to a greater risk of drought and flooding, in addition higher temperatures will increase the demand for water. Farm management practices can significantly alter this water scarcity. Changing the way soils are tilled or introducing mulching can reduce water evaporation by 35-50%. (Stefanie Rost) and others predict that global crop production could increase by nearly 20% as a result of introducing on-farm water management practices.

▪ **Soil condition** - soil with its structure and fertility provides essential ecosystem services to agroecosystems. Well aerated soils abundant in organic matter are the basis for nutrient uptake by crops as well as water retention (Zhang W., Ricketts T. H., Kremen C., Carney K. & Swinton S. M. 2007). The structure, soil aggregation and decomposition of organic matter are influenced by the activities of bacteria, fungi and macrofauna (earthworms, invertebrates, etc.). Agricultural management practices that degrade soil structure and soil microbial communities include mechanical tillage, disking, cultivation, and harvesting, but management practices can also protect soil and reduce erosion. Conservation tillage and other conservation measures can maintain soil fertility by minimizing nutrient loss. Incorporation of crop residues can maintain soil organic matter, which aids water retention.

CONCLUSION

Agriculture as a whole system provides a variety of agro-ecological ecosystem services that are essential for human well-being. They also provide and use a range of other ecosystem services, including regulating services. Maximizing agroecosystem service provision can lead to improvements in other ecosystem services, but careful management can significantly reduce or even eliminate harmful effects. Agricultural management practices are key to realising the benefits of ecosystem services and reducing the harms of agricultural activities. These challenges will be magnified as a result of climate change. Our ability to assess the value of different agro-ecological ecosystem services will increase the potential in analysing future agricultural management. The application of agroecological system services is a holistic approach that supports sustainable agricultural production while caring for the environment - it works with nature and ecosystem services, enhances farm resilience and diversity, and has the potential to lead to a complete transformation of agricultural activity and food systems. Agri-environmental system services influence a range of agricultural practices, from the breeds and varieties used to soil management practices and crop diversification strategies, to integration into value chains and business models that can support locally adapted practices and provide greater market opportunities for farmers and consumers. Examples of agricultural practices applying agri-environmental principles are organic farming, agroforestry and mixed farming.

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