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ANALYSIS OF FARMING SYSTEM OUTPUTS AND METHODS OF THEIR EVALUATION

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Abstract
Farming outputs in agriculture depend on the nature of production, i.e. different farming systems generate different outputs. All these outputs are important for the society, and, therefore, require an integrated approach in view of the specific farming characteristics, where market and non-market outputs are taken into account. Therefore, the paper focuses on analysis of farming system outputs and methods of their evaluation. The objectives of this paper are to define the features of different farming systems and their outputs, then, to analyse the methods of evaluation of farming system outputs used in the studies. In order to achieve the research aim, analysis of economic scientific literature has been conducted; characteristics of farming systems and their outputs have been analysed; evaluation methods of the market and non-market farming system outputs, revealing their advantages and disadvantages, have been examined. Methods of systemic and logic analysis have been applied to analysis of the farming system outputs and their evaluation. The analysis has shown that intensive farming systems generate more market goods, while extensive farming systems – more public goods. Price-based methods are mostly used for the evaluation of market outputs of farming systems. Stated preferences methods are the most universal techniques used for the determination of the values from non-market farming system outputs. Hedonic pricing approaches are used for evaluation of specific agricultural public goods related to recreation or leisure and related to the particular groups of users.
Key words: agriculture, farming systems, market, non-market outputs, externalities, public goods.

Introduction

Agriculture is a specific activity, which, beyond the supply of food and fibre, shapes the landscape, provides natural resources, and preserves biodiversity. It also contributes to the viability of rural areas and their development, food security, and preserves the cultural heritage. Positive externalities of agriculture manifest themselves in the form of public goods, while intensive and environmentally unbalanced agricultural activity causes damage to the environment. These farming outputs depend on different technologies of production, i.e. different farming systems generate different outputs. However, all these non-market outputs from agriculture are not taken into account when assessing the value of farming system output. Usually, only farming outputs provided through market by separate farming systems are subject to evaluation on the basis of statistical data on micro or macro level, or certain non-market goods provided by the farming systems. There is lack of an integrated evaluation of farming system outputs in view of the specifics and intensity of farming.

Works by foreign researchers provide comprehensive analysis of the issues of non-market agricultural aspects, usually focusing on evaluation of the benefit or damage to society from agricultural activity. Some of them have been dedicated to identification of the benefit provided by certain farming systems (Arriaza *et al*., 2008; Szabo, 2010; Jianjun *et al*., 2013; Albert *et al*., 2017), others – the value of damage (Pretty *et al*., 2000; Kubíčková, 2004; Tegtmeier & Duffy, 2004; Wagner *et al*., 2017). Market agricultural outputs are analysed on micro level on the basis of the Farm Accountancy Data Network data, and on macro level on the basis of data of the National Accounts. Although there is great interest among scientists in separate estimation of market and non-market outputs of farming system, external cost and benefit, and their integration into the assessment of efficiency of farming systems during the last decade, little effort has been made to evaluate the impact of farming systems on agricultural outputs comprehensively.

The objectives of this paper are to analyse the features of different farming systems and their outputs, then, to analyse the methods of farming system output evaluation used in recent studies. The paper is structured as follows: the first section of the results and discussion analyses the characteristics of farming systems and their outputs with the focus on intensive and extensive farming systems. The following section outlines the main valuation approaches appropriate for valuation of farming system outputs. Attention is paid to the analysis of the differences between valuation methods and specifics of their application. Conclusions are drawn in the last section of the paper.

Materials and Methods

In order to achieve the research aim, analysis of economic scientific literature has been conducted; characteristics of farming systems and their outputs have been examined; evaluation methods of the market and non-market farming system outputs have been analysed; the relevance of comprehensive analysis of different farming system outputs has been substantiated. The main focus has been put on the analysis of non-market outputs of the farming systems and methods of their evaluation. Methods of systemic and logic analysis have been applied to analysis of farming system outputs and methods of their evaluation.

Results and Discussion

Characteristics of farming systems and their outputs

Farming systems are classified into intensive versus extensive farming systems according to the agro-technological approach. The intensive farming systems also are known as *high-input farming system* (Poux, 2008; Nemecek *et al*., 2008; Zhukova *et al*., 2017) or *conventional farming system* (Pacini *et al*., 2003; Crittenden *et al*., 2015). *Extensive farming systems* are designated as *low-input farming systems* (Poux, 2008; Nemecek *et al*., 2008, *et al*.), or *low intensity farming systems* (Beaufoy *et al*., 1994; Gómez Sal & González García, 2007). The intensive farming systems are mostly focused on achievement of the highest productivity, while the focus of extensive farming system is eco-friendly farming. Archambeaud (2008) defines intensive farming systems as systems where agricultural equipment plays a very important role in securing the productivity, there is high usage of fertilizers, pesticides or other protectors against weeds, diseases and pests. They are high productivity farming systems with negative impact on the environment and biodiversity. Traditionally, extensive farming systems are defined as systems where the amount of fertilizers, pesticides or other protectors is reduced. Therefore, such farming systems depend on the use of internal resources and are more sustainable than the intensive farming systems (Fess *et al*., 2011; Poux, 2008). Pointereau, Bochu, Doublet (2008) emphasize that these systems could cover different types of production as organic, integrated, high nature value, etc., where the main focus is on optimizing the internal farm resources and reducing the use of external resources. According to the definitions of intensive and extensive systems and following the review of studies, the advantages and disadvantages of these alternative farming systems have been identified and shown in Table 1.

In comparison to intensive farming systems, where non-farming input is mostly used, extensive farming systems mostly use the farm input, and, therefore, have low production outputs. However, from the environmental point of view, extensive farming systems create positive externalities, have the potential to reduce the pollution risk, improve the landscape or improve biodiversity. Extensive farming does not cause such environmental problems as soil or water pollution, and it does not require many inputs. However, the outputs are not very high in comparison to the intensive farming. There are also difficulties with extensive farming: first, there is a need for huge agricultural land areas that do not generate high outputs; second, there is a need for more manual work and taking care of crops and animals; and third, the agricultural products are more expensive. Therefore, it could be noted that intensive farming systems secure the society with private/marketable goods and are usually related to economic efficiency of production,

Table 1

The advantages and disadvantages of intensive and extensive farming activities

Intensive	Extensive
Advantages	
Rational land use	Preservation of natural landscape
Global food security	Preservation of wildlife habitats
Cheaper food products	Better quality and safer food products
Growing revenues for food export	More people involved in agricultural activities
Faster work using the modern equipment	Government supported activity
Doesn’t need a lot of manual work	Lower additional cost (no need to buy mineral and other chemical fertilisers)
Disadvantages	
Technical equipment operation cost	More expensive food products
Additional cost of fertilisers, chemicals	More care for crops and animals grown
Capital replaces the labour, less people are involved in agricultural activities	More hand work needed
Need for specialists with higher qualification	Large agricultural land areas needed
Damage to environment, landscape, soil, water	Lower productivity

Source: created by authors according to Pacini *et al*. (2003); Scmid, Niggli, & Pfiffner, (2008); Poux, (2008); Nemecek *et al*. (2008), *et al*.

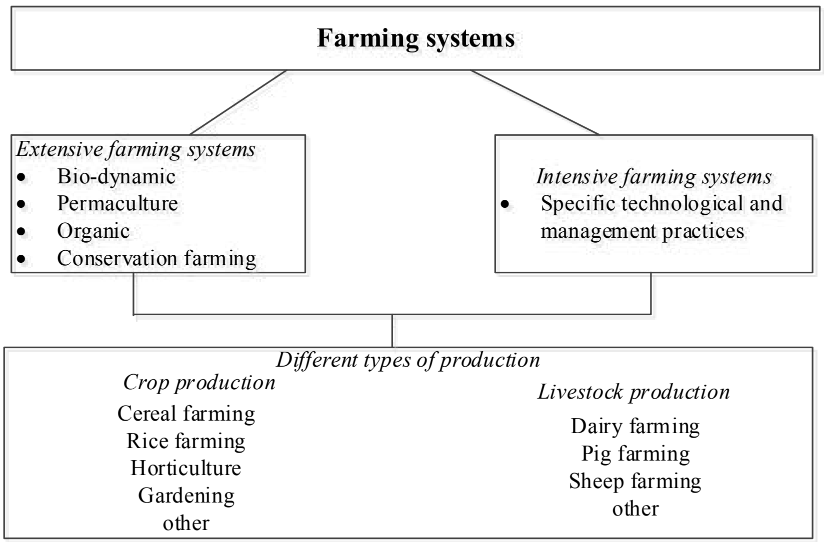

Figure 1. The typology of farming systems.

while extensive farming systems provide the society with more environmental and social public goods. The intensive and extensive farming systems may involve specific agricultural production activities such as dairy, cereal, sheep or other. All of these farming systems rely on plants which, in turn, depend on the soil (Podolinsky, 1985). Therefore, the outputs of the farming system are influenced by the type (intensive or extensive) of the farming system and the agricultural production activity chosen. Figure 1 illustrates the typology of farming systems.

There are four main types falling under the category of extensive farming systems: organic, bio-dynamic, conservation farming, and permaculture. Conventional farming is interpreted as intensive farming system, which has specific technological and management practices.

Therond *et al*. (2017) states that the biodynamics is an approach to farming, where farmers are seeking to create a diversified and balanced farm ecosystem. The main features of this ecosystem are the generation of health and fertility from within the farm itself as much as possible. Therefore, the fertilizers are prepared from manure and herbs, which help farmers to enhance the nutrition, quality, and flavour of the food being raised.

Permaculture is a system of cultivation intended to maintain permanent agriculture. It relies on renewable resources and a self-sustaining ecosystem. The focus of permaculture is placed on mindful and purposeful system design; its central premise is that when human beings can design systems that capitalize on the inherent abilities of the system components and the natural interactions between these subcomponents, the system will be more resilient, enduring and sustainable. In this sense, the philosophy behind permaculture is that by adhering to a set of design principles, man-created eco-systems or cultures will enjoy greater permanence (Jelinek, 2017).

As highlighted by (Rigby, Cáceres, 2001), the main goal of organic farming is the creation of sustainable production system, maximally using on-farm renewable resources, and invoking the management ecological and biological processes. This good farming practice provides appropriate levels of crop, livestock and human nutrition, protects from pests and diseases, and secures the appropriate return to the human and other resources. The last type of extensive farming systems is conservation farming. Rockstrom *et al*. (2009) defines it as a management system based on three principles that should be applied in unison in a mutually reinforcing manner: minimum physical soil disturbance, permanent soil covers with live or dead plant material (e.g., crop residues), and crop diversification, (e.g., crop rotations, cover crops or intercrops with legumes). Therefore, all types of extensive farming systems are fully focused on environmentally-friendly management practices, seeking to preserve the nature and improve the better provision of ecosystem services.

Farming systems could differ not only from the point of view of intensity, but also from the production specifics or type of production, as crop production (which could be cereals, rape, or other) or livestock production (such as sheep, pig or other). The outputs of these specific farming systems give different positive economic outputs as food products and different external outputs or externalities. For better understanding, they have been analysed and presented in Table 2.

The analysis of different agricultural production specifics has shown that intensive farming systems make negative impact on environment. It could damage different ecosystem services, such as water

Table 2

The outputs of different farming systems

Agricultural production	Market outputs (products)	Non-market outputs (externalities)
Crops	Wheat, rape, barley, rye, cotton	- An aesthetic values of the landscape (a beautiful monotonic landscape, mosaic landscape with some variety, with a lot of variety) - Nitrogen run off damages - Phosphorus run off damages - Pesticide run off to the underground water
Rice	Paddy rice	- Emissions of CH_4, N_2O, NH_3 to the air - Nitrate and phosphorus run off to the water - Eutrophication due to the N and P fertilizer use
Dairy farming	Milk	- Ammonia emissions to the air - Contamination with nitrates - Greenhouse emissions - Nitrogen run off
Pig farming	Pigs	- Nitrate run off - Nitrogen emissions to the air - Phosphorus surplus
Extensive livestock breeding	Meat	Beautiful views due to the beautiful breeding animals
Orchards Gardens	Fruits	Beautiful agricultural landscape

Source: created by authors according to Reinhard *et al.* (2000), Kiatpathomchai, (2008); Asmild, Hougaard (2006); Arriaza *et al.* (2008); Battini *et al.* (2016), Lungarska & Jayet (2018) *et al*.

quality, soil quality, air quality, biodiversity, etc. It depends on the agricultural production activities, for example, crop production mostly damages soil, surface and underground water, while pig production affects the quality of soils and water. As stated by Wagner *et al*. (2017), all these farming systems have adverse impact on the human health, and environment; and the biggest part of it usually originates mainly from livestock husbandry. The extensive farming systems make positive impact on ecosystem services, including cultural services, such as aesthetic, spiritual, educational and recreational ones. Therefore, it should be noted that when calculating the value of farming system outputs, not only market output, but also positive and negative externalities should be taken into account.

Valuation of farming system outputs

The concept of Total Economic Value (TEV) defines the broadest scope of different market and non-market farming system output valuation exercises and is widely used in scientific research studies. According

Table 3

The concept of the total economic value of farming system (adapted from Pearce & Moran, 1994)

Total economic value =				
Use value (1,2,3)		+	Non-use value (4,5)	
1	2	3	4	5
direct use value	*indirect use value*	*option use value*	*bequest value*	*existence value*
<u>Consumable:</u> agricultural products, fodder, fuels <u>Non-consumable:</u> recreation, agricultural landscape	Benefits of ecosystem functions: the protection of rivers, basins, soil, flood protection, landscape quality, water quality and cleaning, protection of local systems	The future benefits of current generation	Future generation benefit	Knowledge of the existence of disappearing species, conservation of biodiversity

Table 4

Relationship between valuation methods and value types of farming system outputs

Approach		Method	Value/farming system output
Direct market valuation approaches	Price based	Market prices,	Direct and indirect use (food, fuel, tourism, private landscapes)
	Cost-based	Avoided cost, Replacement cost, Restoration cost,	Direct and indirect use (flood control, groundwater recharge,)
	Production-based	Production function approach	Indirect use (How soil fertility improves crop yield)
Stated preference		Contingent Valuation, Choice experiments, Contingent ranking, Deliberative group valuation	Use and non-use (all non-market outputs provided by farming systems)
Revealed preference		Travel cost, Hedonic pricing	Direct and indirect use (agricultural landscape, water availability, flood protection)

to the TEV concept, the farming system outputs fall into two main categories of welfare gains or losses: use value and non-use value. The use value consists of direct use value, indirect use value, and option use value; the non-use value encompasses two categories - bequest value and existence value (Table 3).

The direct use value of farming system outputs consists of welfare gains or losses that could be received from direct consumption of a good (bad) or service (disservice), for example, from eating a fruit, enjoying the beautiful agricultural landscape or walking on green beautiful meadows. All outputs from agricultural production, as well as recreation services fall under the direct use value category. The indirect use value is received from the indirect use of ecosystem services, such as the use of air quality, flood protection, water quality and other benefits, which come from the ecosystem regulating services (Madureira *et al*., 2013). The option value consists of the personal welfare gain or losses, which are associated with securing the option of possible uses of the goods or services in the future. Pearce & Moran (1994) emphasize that this type of value appears due to the doubts about unsecure use of goods in their future; so they are willing to pay for the opportunity to use these services (1 and 2 category) in the future. The non-use value category of TEV consists of all the welfare gains (or losses) that are not related either with the direct use (in the present or in the future) or the indirect use of goods or services. This value includes a set of non-use people's welfare gains (or losses) supposed by altruistic behaviour towards other people in the future (bequest value) or present (vicarious value), and sensible attitudes towards environment, or other species of flora and fauna (existence value) (Madureira *et al*., 2013).

Within the TEV framework, if available, values are derived from information on individual behaviour provided by market prices relating directly to the farming system output. In the absence of such information, price information must be obtained from parallel market transactions. They could be related to the goods to be valued. If both direct and indirect price information on farming non-market output are absent, hypothetical markets may be created in order to derive these values. These situations within the TEV framework fall into the three groups of the available techniques used to value farming outputs: (a) direct market valuation approaches, (b) revealed preference approaches and (c) stated preference approaches (Chee, 2004). Valuation methods and value types of farming system outputs are shown in Table 3.

Farming market outputs could be easily evaluated under the direct market valuation approaches as (a) market price-based approaches, (b) cost-based approaches, and (c) approaches based on production functions. The main advantage of using these approaches is that the data from existing markets is used, thereby reflecting actual preferences or costs to people. Moreover, such data – i.e. prices, quantities and costs are actual and are relatively easy to obtain (de Groot *et al*., 2010). Vaznonis (2009) stresses that cost-based approaches usually are employed when analysing the quality of natural environment, by calculating the farmers' income loss or additional costs appeared, which are connected to environmentally-friendly farming.

In the absence of the markets, researchers are employing different non-market valuation approaches to analyse the outputs of the farming systems. Stated preference approaches are the adequate solution to collect the data on individual economic values on non-market goods or services from the farming systems. This approach implies application of survey-based methods, where the hypothetical market for goods and services is created (Bienabe & Hearne, 2006). Thereby, their implementation consists of the construction of a contingent market questionnaire, which is given to the potential beneficiaries or losers of the changes in the provision level of the non-market - good (bad) or service (disservice). As revealed by the studies (for example, Madureira *et al*., 2013), the Contingent Valuation method and the Choice Experiments approach are the main techniques for the design and implementation of such contingent markets and the assessment of economic values. The revealed preference approaches include only the use values of the farming system, and can be applied only to the users of these goods' populations. Therefore, these aspects could have an additional limitation in application of this approach. For example, there are different groups of users for agricultural landscape and water availability, and quality. The first product could be important for incoming residents for recreation, while the second will be vitally important for local residents (the users of the watershed). In these cases, as stated by Madureira *et al*. (2013), the travel cost method could be used for measuring the value of agricultural landscape at different sites and Willingness to pay or Willingness to accept approach to measure the compensation for drinking water quality and availability at different watersheds.

In addition, farming outputs provided through market by separate farming systems could be easily evaluated on the basis of statistical data at micro or macro level by invoking direct market valuation approaches as price based approaches. For evaluation of non-market outputs, different non-market evaluation approaches could be used. The selection of appropriate method is substantiated by evaluation goals.

Conclusions

Agricultural production activities have positive or negative impact on the environment such as soil, quality of air and water, landscape and biodiversity. It depends on the intensity of agricultural activities and the agricultural production specialisation. Intensive farming systems secure the society with private/ marketable goods and are usually related to negative externalities, while extensive farming systems offer the society more environmental and social public goods. The measurement of farming system outputs uses market prices and is limited, because positive and negative externalities are created along with the commodity goods and services in the agricultural activities. Therefore, the integrated/comprehensive approach, covering market and non-market outputs of farming system is needed.

The concept of the total economic value could be applied for the analysis of farming system outputs, where all of them fall under two main categories, such as use and non-use values, and manifest themselves as gain or losses for individuals. Within the TEV framework, if available, values are derived, from information on individual behaviour provided by market prices relating directly to the farming system output. In the absence of market prices, Cost-based, Production-based, stated preference and revealed preference approaches are used. Stated preference approaches are the most versatile methods, as they cover valuation of all non-market outputs from the farming system. The revealed preference approaches are quite limited methods, as they are suitable only for evaluation of agricultural public goods related to recreation, or leisure, and are associated with the users related to the product under evaluation process.

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