

## ENVIRONMENTAL EXTERNALITIES AND FOOD SECURITY

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**Abstract.** The aim of this study is to evaluate the significance of externalities in order to ensure food security. Particular attention has been paid to environmental services, which are often unnoticed in agricultural production processes. The study is theoretical in nature. The analysis was based on the available literature on food security, environmental services, and the theory of externalities. The results indicate that externalities affect food security. This concerns all four pillars of food security: food availability, food access, food utilization, and stability of supply and access over time. Furthermore, the relationship includes both, the positive externalities provided by the environment and used by agriculture and households, as well as the negative externalities resulting from agricultural production, which adversely affect the environment.

**Key words:** externalities, agriculture, household, food security

## INTRODUCTION

The natural environment is considered as a common good, and it is the only source of resources, including natural resources such as water or land, which are necessary for human existence and economic development (Costanza et al., 1997). The access to and the utilization of those resources affects the quality of life (welfare) e.g. by ensuring food security at the individual, national and global level. Provision of food security to individuals or societies remains one of the most important challenges that the modern world faces (Godfray et al., 2010). The development of industrial agriculture, which results from the availability of machines

and fertilizers, led to a significant increase in the productivity of agriculture and relatively high food availability, particularly in the highly developed countries (Fuglie et al., 2012). However, there are still about 805 million people in the world who suffer from chronic undernutrition. Most of them, 791 million, live in developing countries (FAO et al., 2014). The situation is believed to be a result of political tensions, income inequality, as well as local and regional difficulties in ensuring adequate food supply. The literature (cf. e.g. Brown, 2012; Rapidel et al., 2011) increasingly often points to the fact that the problems with ensuring food security might result from excessive exploitation of the environment that results from the industrialisation of agriculture, which has been mentioned above. The commercialisation of the sector has led to the situation where income is the basic aim of agricultural activity (instead of food production) and to mass substitution of renewable production factors with non-renewable ones (Woś and Zegar, 2002). Lack of appropriate agricultural techniques and improper resource management (including soil and water management) lead to deterioration of production conditions in the future. That is why it is necessary to use natural resources sustainably to ensure food security and simultaneously minimise the impact on the ecosystem (Godfray and Garnett, 2014; Sadowski, 2015).

The aim of this study is to evaluate the significance of environmental externalities for ensuring food security. Particular attention has been paid to reflection on environmental services and relations between agriculture and the environment.

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## RESEARCH METHOD

The work involves an analysis of the available academic literature on food security and the theory of externalities. The conclusions have been drawn using the inductive method.

In this work, the authors use the definition of food security presented by the FAO (Food and Agriculture Organization of the United Nations), which states that the term refers to “situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO et al., 2014). Based on this definition, four mutually related pillars of security are identified:

- food availability, which is affected by such factors as agricultural production, national production, or the country’s import or exchange capability;
- access to food, which depends on the physical and economic access to food and depends on such factors as people’s income or purchasing power;
- food utilisation, which depends e.g. on ensuring food safety and diversity of diet characterised by high quality and variety of products;
- stability over time, which is affected e.g. by the seasonality of products, climate-related factors (flood, drought), or price fluctuation.

Stability has to be ensured for the three previous pillars to function properly (FAO et al., 2014).

The authors understand externalities as unintended side effects of activity. They result from a situation where the production or consumption of a commodity or a service by a single entity directly affect production or consumption decisions taken by other entities (cf. Prandecki et al., 2014).

The concept of externalities is derived from the neo-classical economics<sup>1</sup> and refers to any phenomena that are not reflected in the market price of a commodity or a service (Samuelson and Nordhaus, 2012). This means that they are an example of market failure, and thus, they are not taken into account in the basic reflection

<sup>1</sup> The concept of externalities appeared as early as in A. Marshall’s “Principles of Economics” in the late 19th and early 20th century, but it was defined precisely when the natural environment was in a disastrous condition in the 1920s. by Arthur Cecil Pigou, in his work entitled “Economics of Welfare” (Fiedor, 2002).

of theoretical economics. There are some attempts to internalise the externalities<sup>2</sup>, but their practical application seems equally ineffective. Nowadays, the way to include externalities in the economic accounts is seen primarily in the use of instruments of institutional economics (Famielec, 2010).

Externalities might be positive (benefits) or negative (cost). In both cases it is difficult to define the parties to the procedure and calculate payments that should be made. Theoretically, in the case of positive externalities, the consumer should pay the producer for the fact that they have arisen, and in the case of negative externalities, the consumer should be compensated for lost opportunities (e.g. the necessity to stop one’s activity due to pollution emitted by the producer). An important characteristic is the lack of the possibility to exclude stakeholders from the consumption of a specific externality.

This reflection focuses primarily on externalities related to the functioning of the natural ecosystem and externalities that result from the influence of agriculture on the natural environment. Both positive and negative externalities have been the subject of the reflection. The externalities have been selected on the basis of their potential influence on food security.

## ENVIRONMENTAL EXTERNALITIES IN AGRICULTURE

The work focuses only on the reflection of environmental externalities and omits the phenomena resulting from other factors, e.g. social ones. What should be understood by environmental externalities are changes to environmental agricultural conditions due to economic decisions that may positively or negatively affect the

<sup>2</sup> The best known methods of internalizing externalities are the Coase theorem and the Pigouvian tax. Internalisation mean not only reduction of negative effects and creation of positive one, but also the compensation for its existence (production and consumption). The two mentioned solutions, however, are not commonly applied. In the case of the former, it is due to the complexity of negotiation and omission of transaction cost of the entire process, and in the latter, due to the difficulties in the estimation of costs (Becla et al., 2012). The other methods of internalization of external effects are state intervention and integration – a merger of stakeholders (Prandecki et al., 2015). There are many possible instruments of indirect valuation of external effects used by state authorities, but their application is not widely acceptable.

production or consumption capability of other entities (Fiedor, 2002). As a result, a certain kind of feedback arises. The agricultural production level depends on ecosystem quality, which depends on such factors as the presence of nutrients in the soil, availability of water and sunlight, plant pollination opportunities, suitable climate conditions, as well as soil erosion and contamination level. Simultaneously, agricultural production influences environment and ecosystem quality. A possible consequence is their impoverishment, which in the long run will result in reduced soil productivity, which might affect food security (Zhang et al., 2007).

Agriculture is permanently bound with the ecosystem, and they form a kind of agri-ecosystem whose basis is full of mutual dependence, exchange, and reinforcement of services (Altieri, 1999; Swinton et al., 2007; Zhang et al., 2007; Power, 2010). These services, which are referred to as ecosystem or environmental services, are also included in externalities because they are not taken into account by the market. They are usually defined as benefits for the man that are obtained directly or indirectly from ecosystems (MEA, 2005). As a consequence, environmental services are categorised as positive externalities. Environmental services are classified in many ways. The most frequently used classification of these services was presented in Millennium Ecosystem Assessment (MEA, 2005), which lists the following groups:

- supporting services, which are necessary for nature to provide other service categories, and which are prerequisites for life on Earth, e.g. the capability of photosynthesis, primary production, soil creation, circulation of elements and substances required for the existence of life (carbon, oxygen, water);
- production services (provisioning services), e.g. food, water, wood, fibre, biofuel;
- regulating services, e.g. absorption of pollutants, climate regulation, mitigation of flood waves, water purification, waste disposal, etc.;
- cultural services, i.e. immaterial benefits for the man, e.g. recreational or religious benefits, cultural diversity, sense of territorial affiliation, perception of the natural and cultural heritage, impact on education, creative inspiration, artistic sense, recreation, and nature tourism.

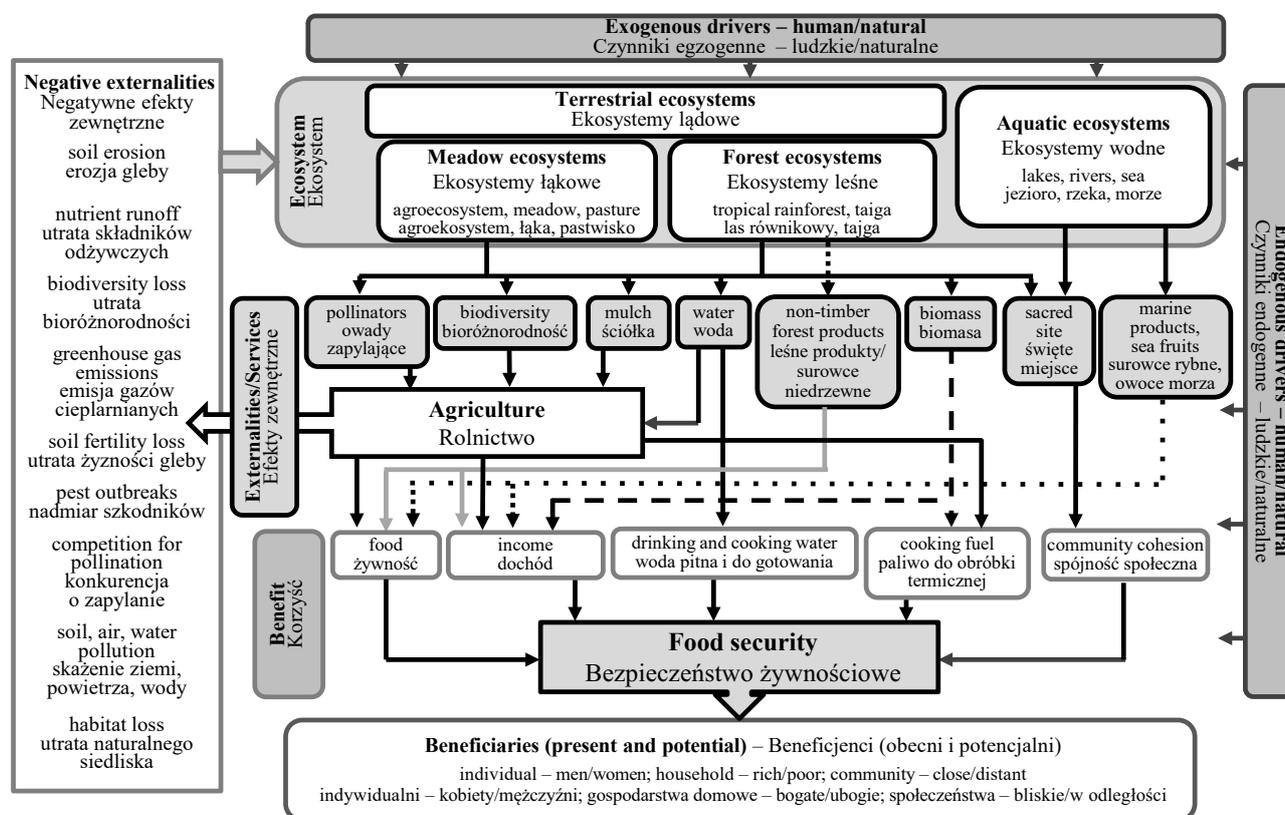
Agriculture takes advantage of the environmental services for production purposes, thus it primarily uses the provisioning services. This is the only type of

services subject to operationalisation. What is more, agricultural production has impact on the remaining groups, i.e. supporting, regulating and cultural services (Costanza et al., 1997; Zhang et al., 2007; Power, 2010; Stallman, 2011). Above all, supporting services include regulation of soil fertility and structure, preservation of biodiversity, regulation of the water and the nutritional cycle. Regulating services provided by agriculture include: pollination, soil retention, flood control, carbon dioxide deposition, mitigation of climate change, weed and disease control. And the cultural services include the beauty of the landscape, the recreational quality, the value for reflection and cognition.

While using natural resources, agriculture generates not only positive, but also negative externalities that result from the application of improper agricultural practices (Zhang et al., 2007; Power, 2010). This group includes loss of biodiversity, reduced soil fertility, pesticide contamination, or influence on climate conditions (e.g. by excessive greenhouse gas emissions). In the long run, this externalities will lead to a drop in the agricultural production potential – both in terms of productivity and reduced quality of agricultural products. As a consequence, it might negatively affect the society's security, including food security (Godfray and Garnett, 2014).

## FOOD SECURITY

Provision of food security requires taking into account a number of factors that are independent of agriculture, but may significantly affect the level of food consumption. In this context population growth and the economic development should be considered as a major factors (Godfray et al., 2010). Urbanisation and increasing income are correlated with changes to consumption patterns, becoming more and more homogeneous, which results in the growing demand for meat, fish, and other products. Production thereof requires increased input of natural resources and causes unfavourable environmental externalities (Kwasek and Obiedzińska, 2013). The above factors lead to increasing demand for limited natural resources. At the moment, humanity uses 50% more natural resources than the Earth is capable to provide, which results in the pressure on more efficient use of natural resources and reduction in negative externalities generated e.g. due to food production (WWF, 2014). Both positive and negative environmental externalities



**Fig. 1.** Influence of environmental externalities on food security

Source: based on Zhang et al., 2007; Poppyl et al., 2014.

**Rys. 1.** Wpływ środowiskowych efektów zewnętrznych na bezpieczeństwo żywnościowe

Źródło: opracowanie własne na podstawie Zhang et al., 2007, Poppyl et al., 2014.

directly or indirectly affect each of the food security pillars. Their influence might be multidirectional, and their scope depends on the level of the country's economic development, e.g. by affecting agricultural production, creating opportunities to gain income, or providing energy that is necessary for processing, distribution or preparation of food in a household (Richardson, 2010; Poppyl et al., 2014). A simplified diagram of existing links between the environmental externalities and food security has been shown in Figure 1.

## FOOD AVAILABILITY

Environmental externalities, such as provision of fresh water, clean air, solar energy, provision of fodder for animals or activity of pollinating insects, are a significant support for production of renewable resources, which

affects food availability (Fig. 1). The basis is the provision of food of plant or animal origin, whose primary source is agriculture. It is an example of an area where humanity uses ecosystems and their resources to produce materials and food products to feed the human population. What is more, forest ecosystems are a rich source of products/materials of plant origin other than wood and of animal origin, so the called – non-timber forest products (seeds, fruit, herbs, seasoning, berries, venison, honey, edible insects, mushrooms), which may significantly contribute to food security (Staniszewski and Nowacka, 2014). It should be remembered, however, that unwary and unsustainable use of non-timber forest products, particularly for commercial purposes, might result in depletion of the resources (Kusters et al., 2006).

In addition, human agricultural activity, which is the basis for provision of food, causes negative environmental

externalities e.g. by quick expansion of cultivated land and soil degradation (erosion and loss of fertility); surface and ground water pollution; use of artificial fertilizers and pesticides; monocultures that result in the loss of biodiversity both with regard to plants and animals; greenhouse gas emissions. All these factors result in changes in ecosystems and the externalities that arise from them, which may affect food security.

## ACCESS TO FOOD

Ensuring access to food requires sufficient quantity of food of proper quality (physical access) and proper means to gain the access (economic access) to ensure properly balanced diet. Agriculture, which depends on the condition of ecosystems to a large extent, plays a significant role here, as it is the basic source of livelihood for 2.5 billion people (Chambon, 2013). Some aspects of the environmental externalities facilitate access to food. The above mentioned non-timber forest products constitute a source of potential income for people, particularly those who live in rural areas. The increase in household purchasing power is one of the factors that facilitates access to food, and the benefits from ecosystem resources provide numerous opportunities to improve living conditions and increase household income to support food purchase (Richardson, 2010). One in six people directly depends on the forest in terms of food and income opportunities. In developing countries, the profit from non-timber forest products may constitute from 20% to 80% of household income (Vira et al., 2015). According to data from the Central Statistical Office of Poland (GUS), in Poland, in 2013, the value of bought forest fruit, berries and forest mushrooms exceeded PLN 106 million, and the value of game (including deer, roe deer, and wild boar) – PLN 65 million (GUS, 2014). However, the statistics does not include the value of raw materials obtained to satisfy the needs of people who collected them (Staniszewski and Nowacka, 2014). For residents of small towns and villages in Poland, sale of non-timber forest products is an important source of income (Barszcz and Suder, 2009).

## FOOD UTILIZATION

Proper management of food in terms of food security refers to the way households use food they have access to. An important factor is ensuring high quality of the

food, i.e. ensuring its safety, so the food does not pose a risk to human life and health. Food safety is an important prerequisite of food security (Obiedzińska et al., 2015). An important issue is to provide clear drinkable water for safe preparation of meals. One of the methods of ensuring safety is heat treatment during meal preparation, which results in destruction of microorganisms and degradation of harmful ingredients. In developing countries, people who live in the forest or nearby use wood and charcoal as a fuel for heat treatment (Richardson, 2010). Over 2.4 billion households use these renewable fuel sources (firewood, crop residue, cattle excrement) for cooking and heating (Vira et al., 2015). The possibility to apply heat treatment makes it possible to vary meals that are prepared, which ensures diverse diet, and increases food digestibility, which facilitates the absorption of nutrients. Moreover, each of the various ecosystem types offers various food that is a rich source of macro- (carbohydrates, protein, fat) and microelements (vitamins, minerals) that makes it possible to balance the diet.

## FOOD STABILITY

To ensure food security, a household or individual must have access to adequate food at all times, despite the emerging crises, whether economic (rising food prices), political (war) and climate (occurring droughts or floods). The concept of stability can therefore refer to both the availability and access dimensions of food security. Agriculture affects the emerging climate change, inter alia, by greenhouse gas emissions (GHG, mainly methane and nitrous oxide), which are classified as negative externalities. According to the estimates provided by FAO in 2011 (2014), greenhouse gas emissions from agriculture amounted to more than 5.3 billion tonnes of CO<sub>2</sub> eq<sup>3</sup>. Agriculture is responsible for 24% of global greenhouse gas emissions (IPCC 2014), in that livestock production generates more than two-thirds of these gases (FAO 2014). Environmental and climate changes are already affecting global and local agriculture. Climate change affects food production, both by causing gradual changes in temperature, increasing or decreasing in rainfall, as well as causing extreme weather events

<sup>3</sup> CO<sub>2</sub> equivalent (CO<sub>2</sub> eq) is a universal unit of measurement for emissions of greenhouse gases, reflecting their differing global warming potential.

like drought or flood (Godfray, Garnett 2012). All these factors affect agricultural activities causing threat to the stability of food availability and access to food at all times, thus ensuring food security.

## CONCLUSION

One of the factors that ensure food security is adequate food supply. In spite of increasing industrialisation, agriculture is and will be dependent on the natural environment. Most of the services provided by the ecosystems have an influence on the level of agricultural production. In this regard, we can list the access to solar energy, water, and mineral components. Other factors, seemingly unrelated to agriculture, e.g. biodiversity level, climate conditions, are also important. Consequently, it should be stated that all four pillars of food security, i.e. food availability, access to food, food utilisation, and stability of food availability and access to food, may vary in time due to environmental externalities.

The relation between the environment and agriculture is bidirectional, i.e. ecosystems are an important factor for agricultural production, but at the same time agriculture affects ecosystems. Sometimes, a minor intervention might lead to changes that will affect agricultural production. The example that is mentioned most frequently is the drop in biological diversity resulting from monoculture, which may lead to decline in the population of various species, including bees and bumblebees. These insects are responsible for pollinating plants, so reduction in their numbers might negatively affect agricultural production. As a consequence, the measures aimed at increasing productivity can result in its decrease.

It should be stressed that the environmental externalities assessment can only be conducted in long term because such changes take place slowly, often unnoticeably, which results in delay. This means that the results are noticeable long after the unfavourable factor have appeared.

The consequences of unsustainable use of the environmental externalities violate the harmony of ecosystems and weaken their capability to produce food in the future, which poses the risk of food insecurity. In the face of numerous externalities, market disturbances, and delays, it cannot be believed that the market itself will provide solutions that will make internalisation of those effects possible. Thus, the state intervention aimed

at ensuring proper level of environmental services that will enable to ensure food security is necessary.

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## ŚRODOWISKOWE EFEKTY ZEWNĘTRZNE A BEZPIECZEŃSTWO ŻYWNOŚCIOWE

**Streszczenie.** Celem niniejszego opracowania jest ocena znaczenia efektów zewnętrznych dla zapewnienia bezpieczeństwa żywnościowego. W szczególności podjęto rozważania dotyczące usług środowiska, czyli procesów zazwyczaj niezauważanych w procesach produkcji rolnej. Opracowanie ma charakter teoretyczny. Analizę przeprowadzono na podstawie dostępnej literatury z zakresu bezpieczeństwa żywnościowego, usług środowiska i teorii efektów zewnętrznych. Uzyskane wyniki wskazują na istnienie wpływu efektów zewnętrznych na bezpieczeństwo żywnościowe. Dotyczy to wszystkich czterech aspektów bezpieczeństwa żywnościowego, tj. dostępności żywności, dostępu do żywności, wykorzystania żywności oraz stabilności dostępności żywności i dostępu do żywności w czasie. Ponadto relacja ta obejmuje zarówno dodatnie efekty zewnętrzne dostarczane przez środowisko oraz konsumowane przez rolnictwo i gospodarstwo domowe, jak i ujemne efekty będące skutkiem produkcji rolnej, które niekorzystnie wpływają na środowisko.

**Słowa kluczowe:** efekty zewnętrzne, rolnictwo, gospodarstwo domowe, bezpieczeństwo żywnościowe

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