Managing sustainable development of agriculture – case of Poland

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Abstract
Integration of activities serving for environmental protection and achievement of economic and social objectives is among the most important measures in agricultural policy. This paper presents an example of implementation of the concept of sustainable development of agriculture in Poland. A review of measures related to management of agricultural development at the national level was conducted, and sustainability of farms depending on specialization was assessed. Analyses pertain to 2013. Conducted analysis indicates that the factor with the greatest impact on the sustainability of farms is the production profile. In specialized farms, the economic objective is prioritized, often at the expense of the environment. Animal production poses a particular threat to the environment, which is the result of the concentration and large scale of production. Simplification of plant production occurred in farms specializing in field crops and swine. This is also an unfavorable practice, because it leads to disruption of the ecological equilibrium of agrocenoses. Economic sustainability was achieved by farms conducting intensive production, and this occurred thanks to the large contribution of funds from the EU budget.

Keywords: agriculture, farm, management, sustainable development

JEL Classification: Q18

1. Introduction

In the concept of sustainable development, a need to integrate measures oriented towards searching for solutions intended to conserve the features of the natural environment while allowing for the achievement of economic objectives is emphasized. The need to implement such a model of development is a response to problems arising from industrial development related to loss of the natural character of agriculture. Changing consumer requirements and growing technological capabilities have led to industrialization of agricultural production methods. This is not neutral to the natural environment, which is burdened with all the consequences of this path of development. In effect, the technical and economic efficiency of production is increased, but this also leads to a series of unfavorable phenomena, such as deterioration of the well-being of animals or threats to the natural environment. Management of agricultural development should therefore account for measures integrating preservation of the natural environment while simultaneously allowing for achievement of economic objectives. Lichtfouse et al. (2009) postulate cooperation between scientists in different disciplines in order to develop new, environment-friendly agricultural practices.

Sustainable development of rural areas has become one of the important tasks of the EU's Common Agricultural Policy, which is reflected in the financial policy for the years 2014-2020. Public funds allocated for supporting sustainable development are an expression of this. These matters are regulated by Regulation (EC) No. 1698/2005. According to this regulation, rural development policy should be accompanied by a policy of supporting income, improvement of the condition of the natural environment and improvement of quality of life in rural areas.
Realization of sustainable development is the subject of research on a global scale (Borys, 2005) and on the level of an individual farm (Harasim, 2013; Koloszko-Chomentowska, Wiater and Zukovskis 2015; Mańko, Sas and Sobczyński 2006; Wrzaszcz, 2012).

Ecological aspects are emphasized, above all, in research concerning the global level. However, experience in research indicates that agro-ecological assessment indicators at the national level cannot always be transposed to the regional level (Desjeux et al. 2015), which is why there is a need to adjust indicator to the specific scale and subject of assessment. Ecological, economic and social aspects are all important in sustainability assessment, and they are more frequently applied at the level of an individual farm.

The specialization of farms is an important matter in sustainability assessment. The selected production profile and applied technologies have varying impact on the environment. These interactions have been confirmed by studies (Castoldi and Bechini, 2010; Kuś and Jończyk, 2010; Escribano et al., 2014; Koloszko-Chomentowska, Zukovskis and Gargasas 2015). The technological, biological, and organizational progress that is now taking place provides access to increasingly modern and effective technologies. However, this causes interference in the natural environment, and the manifestations of this interference include the disappearance of many plant and animal species and even deformation or loss of the natural rural landscape.

Achievement of sustainable development of agriculture and rural areas is an integral part of the general concept of sustainable development of a country, knowledge-based development. Such a system of management requires knowledge on the subject of the codependencies between human economic activity and the environment. Those working with the environment are deadline with living nature, which has a significant impact on other means of production. This is also significant from the perspective of development of the entire economy, since care for sustainable development of agricultural contributes to socioeconomic changes in rural areas and full realization of the economic potential of such areas.

Management of agricultural development takes place on two, strictly linked levels. The first is agricultural policy, mainly including implementation of agricultural support programmes financed by public funds (from the EU budget and partially from the national budget). Reception of public subsidies is dependent on a farmer's adherence to the principles of environmental protection. An agricultural, environmental and climate measure is implemented in RDP (Rural Development Programme) 2014-2020. The essence of this measure is to promote practices serving for protection of all elements of nature. It is a continuation of measures taken within the framework of the Agri-environment programme of RDP 2007-2013. Funds received within the framework of the RDP increase income and stimulate demand for investment and consumption.

The second level is implementation of measures at the level of an individual farm, and these measures arise from the development policy accepted at the national level. Farm owners are responsible for implementing these measures. It is they who bear full responsibility for manufacturing high-quality goods and applying technologies in adherence to the principles of protection of natural resources.

The need to conduct studies at different levels results from varying conditions, conditions vary between individual farms and the entire agricultural sector. The specific habitat, economic and organizational conditions of agriculture also have an impact on sustainability assessment, and equilibrium states change under the influence of many factors. This variability of conditions justifies the need for systematic research in this scope.
The objective of this paper was to review measures related to management of agricultural development at the national level as well as to assess sustainable development at the level of an individual farm depending on its specialization, using Polish agriculture as an example.

2. Data and Methods

The review of measures related to support for sustainable development of agriculture was conducted on the basis of studies by other authors and ARMA (Agency for Restructuring and Modernisation of Agriculture) data on payments made within the framework of support for practices protecting the environment. This mainly pertains to funds from RDP 2007-2013 but also to other payments, the reception of which is conditioned by adherence to environmental protection principles. Some economic instruments do not stimulate growth of agricultural production by assumption, but since they have the form of transfers to agricultural holdings, they have an impact on agricultural income as a result. This is inscribed into the concept of sustainable development, because aims pertaining to economic areas of sustainability include achievement of an income which provides farmers with a fair life standard (Lawn, 2003; Liu, 2010).

The second part of research was based on assessment of the level of sustainable development of farms with different production profiles on the basis of FADN data. The assortment of indicators for assessment of environmental sustainability is rather diverse (Belanger et al. 2012, Harasim 2013, Lebaco, Barent and Stihmant 2013). In the case of generally available FADN data, it is only possible to calculate some of them, namely: share of cereals in agricultural land (%) and stocking density (LU · ha\(^{-1}\)). Agricological assessment was supplemented by material pressure indices characterizing the burden on the environment caused by production resources (Piekut and Machnacki, 2011). These are: indirect consumption, value of mineral fertilizers and plant protection products, value of purchased feed, and energy consumption. These indices indicate the intensity of agricultural management. The total net added value per fully employed person (SE415/SE010) and the value of family farm income per fully employed family member (SE430=SE420/SE015), were accounted for in economic sustainability assessment. Profitability of labor was corrected by the balance of subsidies and taxes (SE600) to provide a complete picture of the economic situation of agricultural holdings. All values are given in PLN and EUR. Conversion to EUR was carried out according to the exchange rate used during charging of subsidies by the Agency for Restructuring and Modernization of Agriculture.

According to the accepted objective of research, the following farm types taken into consideration: field crops, dairy cattle, grazing livestock and pigs. These are the most common profiles of agricultural production in Poland. The analysis pertains to 2013.

3. Results and Discussion

RDP 2007-2013 was the largest programme of subsidies for the agricultural and food sector in Poland. PLN 71.4 billion were paid out within the framework of this programme in the years 2007-2013. The majority of funds were allocated to economic initiatives (51%), but nearly 18% of this amount was allocated to so-called restorative economic initiatives, which included measures intended to restore or preserve the condition of the natural environment and of resources indispensable for farming. RDP 2007-2013 was implemented on 4 axes, of which one (axis 2) entirely covered measures related to improvement of the natural environment and rural areas. Within the framework of measures financed on axis 2, the most funds were transferred to farms for conduct of agricultural activity in areas with unfavorable conditions, amounting to
The Agri-environment programme, for which 36.6% of funds were expended, also enjoyed much interest from farmers. Other programmes had a lesser share in funds, but from the perspective of protection of natural resources, these were measures of great significance to their protection. Moreover, subsidies are paid directly to approx. 1.4 million farmers every year, and receipt of these subsidies is dependent on maintenance of land according to good agricultural practice and fulfillment of conditions in the scope of environmental protection. PLN 122 billion in such subsidies were paid out in the years 2004-2014. All of these measures are oriented towards sustainable development of agriculture and rural areas.

Such initiatives are very important not just for the rural population but for society as a whole. According to studies, funds from RDP directed to rural areas in the years 2007-2013 contributed to growth of GDP by 0.61% on average in current prices and 0.32% in fixed prices (Zaleski, 2015).

Table 1: Allocation of funds within the framework of RDP 2007-2013 (axis 2)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Number of contracts</th>
<th>Payments 2007-2013 (thousand PLN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting agricultural activity in areas less favored areas (LFA)</td>
<td>5 857 216</td>
<td>10 891 211.4</td>
</tr>
<tr>
<td>Afforestation of agricultural and non-agricultural land</td>
<td>2 111</td>
<td>566 985.0</td>
</tr>
<tr>
<td>Agri-environmental program</td>
<td>566 626</td>
<td>6936 899.8</td>
</tr>
<tr>
<td>Restoring forestry potential</td>
<td>434</td>
<td>547 042.5</td>
</tr>
<tr>
<td>Together</td>
<td>6 426 387</td>
<td>18 942 138.7</td>
</tr>
</tbody>
</table>

Source: own calculation based on Agency for Restructuring and Modernization of Agriculture data

Management of sustainable development at the level of an individual farm is based on assessment of organization of production according to the principles of good agricultural practice. The basic determinant of organization of plant production is the crop structure, which, besides the level of fertilization, is decisive to the effects of farming. In general, the crop structure is adapted to the production profile. The data presented in Table 2 confirm this. In field crop farms, the share of cereals in the crop structure amounted to over 92%. The name of the production profile, by itself, indicates that cereals are dominant here. This indicator was similarly high in farms specializing in pigs (84.56%). This crop structure is characteristic of farms of this type. Production of pigs for slaughter is primarily based on purchased nutritive fodder. This is confirmed by fodder purchasing data. In such a case, the organization of a farm is based on simplification of plant production, which is unfavorable from the perspective of environmental impact, because it disrupts the ecological equilibrium of agrocenoses.

In dairy cattle farms, the share of cereals in the crop structure amounted to slightly over 35% and did not exceed 30% in grazing livestock farms. In this case, we are dealing with production in which green fodder is the basis of feeding animals. There is a large area of permanent grasslands, which are the natural feed base for ruminants, in farms with such production profiles. Furthermore, these farms cultivate large quantities of corn for green fodder, which is used to feed animals. This results in lesser demand for cereals.

According to the principles of good agricultural practice, the share of cereals in the crop structure should not exceed 66% (Duer, Fotyma and Madej 2002). From this perspective, only dairy cattle and grazing livestock farms met these requirements.
Table 2: Agro-ecological assessment indicators (2013)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Field crop</th>
<th>Dairy cattle</th>
<th>Grazing livestock</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of cereals in crops (%)</td>
<td>92.61</td>
<td>35.14</td>
<td>29.89</td>
<td>84.56</td>
</tr>
<tr>
<td>Stocking density (LU·ha⁻¹)</td>
<td>0.26</td>
<td>1.76</td>
<td>1.02</td>
<td>0.59</td>
</tr>
<tr>
<td>Total intermediate consumption (PLN·ha⁻¹)</td>
<td>3996.25</td>
<td>3949.52</td>
<td>2256.72</td>
<td>9922.21</td>
</tr>
<tr>
<td>Mineral fertilizers (PLN·ha⁻¹)</td>
<td>1200.44</td>
<td>475.71</td>
<td>244.35</td>
<td>664.17</td>
</tr>
<tr>
<td>Plant protection products (PLN·ha⁻¹)</td>
<td>526.40</td>
<td>90.19</td>
<td>52.82</td>
<td>241.62</td>
</tr>
<tr>
<td>Value of purchased feed (PLN·ha⁻¹)</td>
<td>201.57</td>
<td>1645.00</td>
<td>799.15</td>
<td>6781.03</td>
</tr>
<tr>
<td>Energy consumption (PLN·ha⁻¹)</td>
<td>727.68</td>
<td>589.76</td>
<td>399.26</td>
<td>724.71</td>
</tr>
</tbody>
</table>

Source: own calculation

Organization of livestock production is assessed from the perspective of use of produced manure. The number of animals on a holding and their stocking density are both important. Average stocking density in the studied farms did not pose a threat to the environment, since the maximum limit of 1.5 LU·ha⁻¹ (Duer, Fotyma and Madej 2002) was not exceeded. Dairy cattle farms were the exception, in which average stocking density amounted to 1.76 LU·ha⁻¹, and there are threats to the environment in relation to this. These threats result from high livestock concentration in the herd.

Total intermediate consumption per 1 ha of farmland is a general indicator of material pressure on the environment. It encompasses direct costs and general holding costs related to the operations of the agricultural holding. Pigs farms were characterized by the greatest intensity of production. The costs of purchasing fodder were the primary reason for this. The average value of the total intermediate consumption in this group amounted to PLN 9922.21 (EUR 2346.34) per 1 ha of farmland, and this was 2.5 times more than in field crop and dairy cattle farms and over four times more than in grazing livestock farms. Field crop farms used more mineral fertilizers and plant protection products, while dairy cattle farms used a relatively large amount of purchased fodders. The index of costs sustained for purchasing mineral fertilizers and plant protection products is of limited value in the assessment of farm sustainability, however it can serve as a criterion in assessment of trends occurring under given conditions (Sobczyński 2008). It is accepted that the greater the value of total intermediate consumption, the greater the pressure exerted by farms on the environment. Considering the extent to which technology provides means of production, pigs farms should be considered as having the strongest impact on the natural environment.

Farms with high production intensity achieve the most favorable results in economic sustainability assessment. The level of income depends on the value of production and costs incurred. Pigs farms sustained the highest costs, achieved production of the greatest value, and generated the highest income (Tab. 3). This is also confirmed by statistical analysis (Fig.1). The dependence between work productivity (net added value per fully employed person) and the value of income from family farm per fully employed family member was high and amounted to $R^2 = 0.959$. However, this dependence is not always obvious due to the convolution of various economic factors, and it may happen, that high profitability does not always accompany high productivity.

It should be noted that achievement of this level of income was possible thanks to subsidies. The share of subsidies in the income of a family-owned farm amounted to 35.9% in pigs farms.
and to 73.6% in farms specializing in field crops. Grazing livestock farms had the least favorable results. Despite subsidies, the income of a farm per family member working full time was negative and amounted to PLN -1028 (EUR -243).

Table 3: Financial results – economic assessment indicators (2013)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Field crop</th>
<th>Dairy cattle</th>
<th>Grazing livestock</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net value added (PLN·AWU⁻¹)</td>
<td>39 111</td>
<td>36 088</td>
<td>16 433</td>
<td>45 806</td>
</tr>
<tr>
<td>Net value added (EUR·AWU⁻¹)</td>
<td>9 249</td>
<td>8 534</td>
<td>3 886</td>
<td>10 832</td>
</tr>
<tr>
<td>Family farm income (PLN·ha⁻¹)</td>
<td>2 365</td>
<td>2 950</td>
<td>1 282</td>
<td>3 416</td>
</tr>
<tr>
<td>Family farm income (EUR·ha⁻¹)</td>
<td>559</td>
<td>698</td>
<td>303</td>
<td>808</td>
</tr>
<tr>
<td>Family farm income (PLN·FWU⁻¹)</td>
<td>33 083</td>
<td>35 225</td>
<td>15 529</td>
<td>43 387</td>
</tr>
<tr>
<td>Family farm income (EUR·FWU⁻¹)</td>
<td>7 823</td>
<td>8 330</td>
<td>3 672</td>
<td>10 260</td>
</tr>
<tr>
<td>Family farm income corrected (PLN·FWU⁻¹)</td>
<td>9 585</td>
<td>20 374</td>
<td>-1 028</td>
<td>28 794</td>
</tr>
<tr>
<td>Family farm income corrected (EUR·FWU⁻¹)</td>
<td>2 266</td>
<td>4 818</td>
<td>-243</td>
<td>6 809</td>
</tr>
</tbody>
</table>

Source: own calculation

Figure 1: Dependence between work productivity and family farm income
Source: own calculation

\[ y = -4E-06x^2 + 1,1554x - 2106,6 \]
\[ R^2 = 0,9595 \]

4. Conclusion
Sustainable development is a concept that is currently being promoted around the world. Only this model of development provides a chance to conserve the natural environment for future generations. Agriculture is considered to be of special importance in the concept of such development. Integration of activities oriented towards searching for solutions serving for environmental protection and achievement of economic and social objectives is among the most important measures in agricultural policy. This is also reflected in measures taken by the EU in the context of agriculture and rural areas. Management at the national level is based on creating a legal framework to provide a basis for supporting and executing measures protecting the natural environment. Experience gained until now shows that public funds directed to the
agricultural sector within the framework of RDP 2007-2013 not only improved the status of the natural environment but also contributed to growth of the GDP.

The owner of a farm is responsible for managing its sustainable development. When organizing the production process, a farmer should account for the consequences of implementing technology. A farmer is currently subsidized not only based on how much he or she produces but also based on the methods the farmer employs and on whether the farmer takes care of the natural environment, particularly since reception of subsidies is dependent on adherence to the principles of good agricultural practice.

Conducted analysis of sustainable development at the level of an individual farm indicates that the factor with the greatest impact on the sustainability of farms is the production profile. In specialized farms, the economic objective is prioritized, often at the expense of the environment. Animal production poses a particular threat to the environment, which is the result of the concentration and large scale of production. Simplification of plant production occurs in farms specializing in field crops and pigs. This is an unfavorable practice from the perspective of environmental protection, because in such situations, we are generally dealing with disruption of the ecological equilibrium of agrocenoses.

Financial support of farms with public funds has contributed to improving their economic situation. The share of subsidies in the income of a family-owned farm is particularly distinct. In many farms, income consisted solely of subsidies, and without them, the financial result would have been negative. Therefore, there is a low dependence between the income of a farm and labor efficiency.

To sum up, it should be noted that integration of economic and ecological objectives is rather difficult. Measures undertaken both at the national level and at the level of an individual farm provide great opportunities for making the concept of sustainable development of agriculture a reality. This will still require some time.

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