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CAP direct payments system's linkage with environmental sustainability indicators

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Abstract. *Environmental issues have been one the most important for sustainable agricultural development in recent years. The EU common agricultural policy (CAP) direct payments (DP) system, which requires the most significant financial resources, should also promote environmental sustainability in agriculture. However, there is a lack of systematic approach and instruments to assess the impact of the DP system to environmental sustainability. This paper examines the linkages between DP system and environmental sustainability indicators. The underlying research question is: how 2004-2013 CAP DP system had impacted environmental sustainability. To answer this, the article uses a comparative analysis, a statistical analysis, theoretical modelling as a basis to determine, prove and evaluate the linkages between DP system and agricultural environment sustainability indicators. The article also provides empirical results of Lithuania and Puglia region (Italy). These regions were selected because of the similarity by area size and population, however with different DP systems.*

Keywords: *CAP, direct payments system, environmental sustainability, impact evaluation*

Reikšminiai žodžiai: *BŽŪP, tiesioginių išmokų sistema, aplinkosauginis tvarumas, poveikio vertinimas*

Introduction

As commercial activities, agriculture and forestry are aimed primarily at production and rely on the availability of natural resources, the development of commercial activities has brought new environmental pressures to bear on the natural capital stock (Thier-Lange (2012), EU Commission (2000)). The intensification of

agriculture led to the degradation of biodiversity, and the depletion of soil, water and air. On the other hand, they are also increasingly threatened by marginalization and abandonment of agricultural land use due to economic forces practically aimed by CAP. These differing challenges posed by intensification and abandonment of farming highlight the complexity of the relationship between agriculture and the environment.

In Mac Sharry reform (2003) as well as in the debate on the 2014–2020 programming period of the EU CAP direct payments and rural development policy, a lot of attention revolves around the policy's contribution to enhancing resource use efficiency, decreasing environmental impact and restoring ecosystems (Pacini *et al*, 2015).

The year 2003 was a breakthrough year for CAP moving towards sustainable agricultural development. 2003 reform introduced a radical rebuilding of the CAP, consolidated the shift to income support by the introduction of a single payment scheme not linked to production of any particular product ('decoupled') and introduced the 'cross compliance' concept, linking payments with respect of food safety, environmental protection and animal health and welfare standards (Commission…, 2003). This transformation was aimed at linking CAP support measures with environmental issues. From then on farmers were to receive direct payments based on the area of agricultural land, decoupled from production. In order to qualify for support, the so-called cross-compliance requirements, including good environmental and agricultural condition (GAEC) of land, had to be fulfilled (Phelps, 2007). It was expected that the decoupling would further reduce the overproduction of agricultural products by exposing farmers to market forces (Britz et al., 2006; Phelps, 2007) and indirectly contribute to the environmental issues. Indeed, in the EU at large, the production surpluses of several important sectors as well as exports decreased significantly compared to the pre-decoupling levels (EU Commission, 2011 (a, b); Trubins, 2013).

Moreover, full decoupling of direct payments led to several risks including environmental problems in areas with few economic alternatives (Renwick et al, 2012). Nevertheless, the reforms included a significant degree of national discretion in implementation that allowed member states to retain some elements of the former coupled direct payments either in part or in their entirety, the full decoupling of payments was aimed to be done till 2013.

The aim of the article is to identify environmental indicators; those impacted by the system of CAP direct payments provided in 2003-2013 and evaluate the impact of the direct payments system in Puglia region (Italy) and Lithuania. These regions were selected because of the similarity by area size and population, however with different DP systems.

The article uses a comparative analysis, a statistical analysis, a regression analysis, theoretical modelling. The 2004-2013 FADN dataset and national statistics data is used in the paper.

DP Impact on environmental issues

Since 2003, the reform of the CAP towards sustainable development prompted scientists to examine the impact of most financed measure (~70 % of total CAP budget) - direct payments - on agricultural sustainability, especially including environmental aspects. Various researchers ambiguously assess the mentioned impact, highlighting both positive and negative impact (Renwick et al., 2012; Helming & Peerlings, 2013; Moro & Sckokai, 2013; Baldock et al, 2007 ir kt.). There are also studies that simultaneously address multiple measures with multiple environmental objectives and targets are underrepresented in the scientific literature.

Some scientists analyse effects on environmental sustainability of total subsidies received by farmers under CAP, without separating individually the impact of the direct payments system.

Renwick et al. (2012) examined the potential impact of agricultural and trade policy reform (from 2003) on land-use across the EU focusing particularly on the issue of land abandonment. Using a novel combined application of the CAPRI and Dyna-CLUE models estimated the extent of change across Europe under removal of Pillar 1 support payments and trade liberalization. The reforms are particularly felt on livestock grazing farms situated in the more marginal areas of Europe, which also coincide with areas of high nature value. Therefore, farmland *biodiversity* is likely to be reduced in these areas. For some countries, a process of specialization in production and simplification of the landscape occurred which is also detrimental from a farmland biodiversity perspective. However, using a range of environmental indicators, related to nutrient surpluses, GHG emissions, soil erosion and species abundance, an overall improvement in the environmental footprint of agriculture is likely (Renwick et al., 2012). Meanwhile, Helming, Peerlings (2013) examined the direct payments' impact on environment per income distribution. Using the Dutch Regionalised Agricultural Model (DRAM) DRAM it was shown that the policy switch from farm payments based on historical entitlements towards a flat rate has a large effect on income in Dutch agriculture. This especially accounts for intensive dairy farms and arable farms with relatively high farm payments per ha in the initial situation. According to Helming, Peerlings (2013) the policy switch towards a flat rate would decrease the total *emissions of nutrients* to the environment from agricultural production. Moreover, the average dairy farm would become more extensive. This gives room for further improvement of the environmental performance at the farm level. These effects were amplified if risk is included in the model. Sensitivity analyses showed that with the higher current agricultural prices the magnitude of the changes is smaller. Despite this, Helming, Peerlings (2013) provided CAPRI model results for the Netherlands which showed similar outcomes for group of activities than DRAM. The size of the effect of the flat rate is however smaller as supply elasticities of agricultural activities in CAPRI are relatively small. Such researchers as Moro & Sckokai (2013) exercised theoretical assumptions that direct payments stimulate possible distortions to key inputs like water or chemicals.

An in-depth analysis related to the DP systems' impact on agricultural environment was provided by Badlock in 2007. Direct payments till 2003 have been environmentally beneficial in terms of supporting extensive cattle grazing across the EU, particularly in LFAs, and helping to limit intensification in more productive regions (Baldock et al, 2007). However, they have also increased overall cattle numbers and sustained the existing intensive systems of production with their adverse environmental consequences. Biodiversity, landscape, water quality and soils have benefited from extensive cattle grazing, both within and outside LFAs. According to Badlock et al. (2007) direct payments have contributed to an increase in the number of beef cattle numbers in the EU and this has had negative impacts in terms of greenhouse gas emissions and air quality.

However, biodiversity and landscapes have benefited from grazed habitats being extensively grazed by cattle or mixed stock. Extensification payments have also contributed to be continuation of traditional farming practices which sustain features such as small fields, boundary walls and hedges. Water quality and soils have also benefited from extensification payments with more land being subject to low intensity management, resulting in less eutrophication and siltation and soil erosion. Fewer farms have intensified, thereby avoiding adverse impacts on water quality.

Table. **1.1. DP Impact on environmental issues**

Direct payment system impact on	Water quality	Water resources	Biodiversity	Landscape	Soils	Air quality/ climate change
Up to 2003: Direct payments Extensification payments						
	+		+	+	+/-	-
	+	+	+/-	+	+	
2004-2013: Coupled/CNDP SPS/SAPS (decoupled)						
	-	+/-	+	+	+/-	-
	+	+	- -		+	+
Post 2013 (flat rate)	+				+	+

Source: Badlock (2007); Renwick et al. (2012); Helming, Peerlings (2013)

Continuous analysis of Badlock et al. (2007) report is provided to find impact on the linkages between separate direct payments' system elements on environmental issues. In new Member States (as of 2004) complementary national direct payments (CNDP), supported beef and dairy production and, in certain cases particular systems of production (for example suckler cow systems), only had a marginal impact on restructuring trends which is resulting in fewer farms and farmers and more production concentrated in medium and larger farms. The environmental impacts of

coupled payments included, firstly, those arising from management choices directly attributable to the payments and secondly those resulting from adherence to cross compliance conditions.

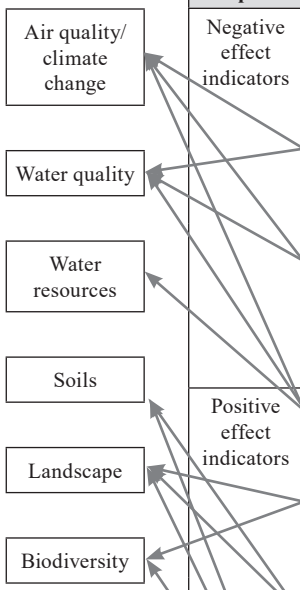
Badlock et al. (2007) analysis of environmental impacts of decoupled payments showed that reductions in environmental pressures are likely following an anticipated fall in cattle numbers. At the same time, the risk of undergrazing and biodiversity losses increases.

The SPS and SAPS in principle avoid the direct production incentives of previous policies and the associated environmental costs. However, given the greater risk of reduced grazing and pasture maintenance in sensitive areas, cross compliance rules, including those on the conversion of permanent pasture, have a clear role in the policy architecture alongside targeted rural development measures.

Materials and methods

In order to evaluate and measure the impact of direct payments on environmental issues in agriculture, environmental aspects influenced by the direct payment system (see table 1) should be linked with statistical indicators.

Ang et al., 2015, Van der Meulen, 2014; Barnes, Thomas, 2014; Longhitano et al., 2012; Gerrard et al., 2012, Westbury et al, 2011; Brady, 2011, etc. examined the environmental indicators in assessing the environmental sustainability of agriculture and linked them with environmental effects (Fig. 1).



Type of impact	Environmental indicator (Yi)	Variable	DATA source	Authors
Negative effect indicators	Cost of plant protection products or relative cost (i.e. pesticides' cost and agricultural production ratio) (Y1)	EUR/ EUR	FADN	Gerrard et al., 2012; Badlock, 2007.
	Costs for chemical fertilizers (Y2)	EUR/ha	FADN	Van der Meulen, 2014; Longhitano et al., 2012; Gerrard et al., 2012; Westbury et al, 2011
Positive effect indicators	Livestock density (Y3)	LU/ha	National statistics	Helming, Peerlings,2014; Gerrard et al. 2012; Longhitano et al., 2012; Lelyon et al., 2011; Brady, 2011;
	Temporary and permanent grassland, pasture and UAA ratio (Y4)	ha/ ha	National statistics	Barnes, Thomas, 2014; Westbury et al, 2011; Brady, 2011; Dorgai, Udovecz, 2009; Baldock et al., 2007
	Agricultural land use diversification (crop diversity index: e.g., Shannon or Simpson diversification index (Y5)	ha/ ha	National statistics FADN	Ang et al., 2015; Vidickienė, Melnikienė, 2014, Gerrard et al., 2012, Brady, 2011; Westburry et al., 2011; Baldock et al., 2007.

Fig. 1. **The linkage between environmental indicators and environmental effects**

The figure provides the indicators, which are impacted by the direct payments system and their links to environmental elements (on the left of the figure). The red line shows the links and negative effect of increased indicators value (forced by direct payments) to environmental elements. The green line shows similarly, however, with a positive effect.

In many cases authors used constructed models, like AGMEMOD or CAPRI, which identify the linkage between direct payments and environmental indicators, however, these models don't detail direct payments by its distribution and its aims. Thus, by using a regression analysis the compatibility and suitability of indicators provided in Fig.1 are checked both on the data of Lithuania and some data of Italy (Puglia region). All provided environmental indicators are used as endogenous ($Y_{1,\dots,5}$) (1.1).

$$Y_i=\beta_0+\beta_1X_{1i}+\dots+\beta_jX_{ji}+U_i \quad (1.1)$$

However, livestock density is also used as exogenous variable. Exogenous variables are also direct payments both decoupled (X_{dec}) and coupled (X_c), agricultural production prices (X_{app}) (crop production – X_{cpp} and livestock production – X_{lpp}), total output crops & crop production (X_{ocp}), area of crops (X_{ac}), fertilizers (X_{fp}) and pesticides prices (X_{pp}), yields in agriculture (X_{yl}). The first two environmental indicators and their linkage with direct payments provided bellow (1.2).

$$Y_1=\beta_0+\beta_1X_{dec}+\beta_2X_c+\beta_3X_{cpp}+\beta_4X_{pp}+\beta_5X_{yl(t-1)}+\beta_6X_{ocp}+\beta_7X_{ac}+U_1$$
$$Y_2=\beta_0+\beta_1X_{dec}+\beta_2X_c+\beta_3X_{fp}+\beta_4X_{cpp}+\beta_5X_{yl(t-1)}+\beta_6X_{ocp}+\beta_7X_{ac}+U_2 \quad (1.2)$$

According to the fact investigated in literature that impact of direct payments on usage of plant protection products and chemical fertilizers is usually similar and recognized through farmers' behaviour seeking profit by intensifying their agricultural activities, both equations Y_1 and Y_2 are summed up ($Y_{cpf}= Y_1+ Y_2$) (1.3)

$$Y_i=\beta_0+\beta_1X_{1i}+\dots+\beta_jX_{ji}+U_i \quad (1.3)$$

The livestock density in EU depends on the structure of separate country's agriculture, which in terms depends on several factors such as a subsector's (crop and livestock) profitability, market stability, CAP and national aid policy' impact. According to (Matthews, 2016) averaged over the period 2004-2013, direct payments have accounted for 47% of farm net income, other public transfers 15%, and market income the remaining 38%. The direct payment system's both including coupled and decoupled payments plays a crucial role on farm profitability and intention to maintain the same agricultural activity. CAP livestock extensification policy (from 2003) had a huge impact on livestock density in EU. In order to evaluate the impact of direct payments on livestock density – endogenous variable (Y_3), such exogenous variables were selected (1.4): direct payments both decoupled (X_{dech}) and coupled with livestock (X_{clh}) per 1 ha of UAA, livestock production prices (X_{lpp}) (index), cereal and other field crops (excl. forage) area[1] in total UAA (X_{cat}) and total livestock output per LU (X_{lolu})

1 The higher it is the less density is.

$$Y_3=\beta_0+\beta_1X_{dech}+\beta_2X_{clh}+\beta_3X_{lpp}+\beta_4X_{cat}+\beta_5X_{lolu}+U_3 \quad (1.4)$$

The bigger share of temporary and permanent grassland in total UAA (on a farm and national level) usually depends on farm's extensification policy, or on livestock density in farm (region or country). However, it is obvious, that profitability usually plays a crucial role in farming practice and behaviour, thus, direct payment system and agricultural production prices impacts the share of temporary and permanent grassland. The regression equation (1.5) provided bellow includes livestock density (Y_3), decoupled (X_{dech}) and coupled with livestock (X_{clh}) direct payments per 1 ha of UAA, crop production price index (X_{cpp}), total livestock output per LU (X_{lolu}).

$$Y_4=\beta_0+Y_3+\beta_2X_{clh}+\beta_3X_{cpp}+\beta_4X_{lolu}+U_4 \quad (1.5)$$

The last observed and the direct payment system's impacted environmental indicator - agricultural land use diversification that is illustrated by Shannon Diversity Index. According to Sipiläinen, Huhtala (2012) this index captures both the richness and evenness of the crops cultivated on the farms. Shannon index is calculated by formula: $H=-\sum_{j=1}^{s}p_i\ln p_i$, here

S - total number of species in the community (richness);
p_i - proportion of S made up of the i-th species

Shannon's equitability (E_H) is calculated by dividing H by H_{max} (here H_{max} = lnS). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

The index is a typical landscape diversity indicator, one that can be seen as reflecting the esthetic value of a diverse agricultural landscape. On the other hand, in the literature on risk management in agriculture, crop diversity has been attributed a private value as an option whereby risk-averse farmers can hedge against uncertainty (Sipiläinen, Huhtala, 2012).

In case of Lithuania, according to FADN data there are observed 6 common species in farms (cereals, other field crops, vegetables and flowers, orchards, other permanent crops, forage crops); for Puglia (Italy) is 8 with additional: vineyards and olive groves.

On these grounds the direct payment system as a risk management instrument is indicated to measure if it impacts farms linkage to monoculture. The more payments are decoupled (X_{dec}) the less linkage should be and the bigger range of coupled crop payments (X_{cc}) also reduces the linkage to monoculture. Another strong factor is the change in market and selling prices on different types[2] of crops (for Lithuania: cereals, other field crops, vegetables and flowers, orchards, other permanent crops, forage crops; for Puglia (Italy) additional: vineyards and olive groves). The bigger market price the higher profitability can provide (1.6).

2 FADN typology

$$E_h=Y_5=\beta_0+\beta_1X_{dec}+\beta_2X_c+\beta_3X_{cpc}+U_5$$

$$X_{cpc}=max_{0\le PI\le 1}PI_{j(t-1)}-min_{0\le PI\le 1}PI_{j(t-1)} \quad (1.6)$$

Where PI is a price index for crop type j at time t-1.

After recognition and evaluation of CAP direct payments system's impact on $Y_1 \ldots Y_5$ variables, the next step is construction of composite index (which a part of the future paper).

Results

According to the 2004-2013 provided FADN and national statistics datasheet, the correlation matrix of exogenous indicators of showed, that there is a strong correlation in both Lithuania (0.977) and Puglia region (0.736) cases between decoupled direct payments and farm's cost on fertilizers combined with costs on crop protection products (. Meanwhile, in Lithuania there is also a strong negative correlation (-0.791) of coupled direct payments on, however, in Puglia there is a weak-moderate negative correlation (-0.370) between coupled payments and.

According to linear regression results for Lithuanian case such exogenous variables as crop production price index (X_{cpp}), lagged yields of cereals ($X_{yl(t-1)}$) and output crop and crop production (X_{ocp}) were eliminated as insignificant (1.7).

$$Y_{cpf}= -2761.48 + 0.873X_{dec} + 78.87X_c + 0.785X_{ac} \quad (1.7)$$

The limitation in data didn't allow evaluating fertilizers and crop protection prices. However, on theoretical review, their change was too small to influence farmers' behaviour.

According to the fact (calculation made on FADN database Lithuania) that share of decoupled payments in farmers net income raised from 14 % in 2004 to 45 % in 2013 (total share of direct payments in farmers income raised from 32 % to 48 %), it was one the main stimulator for farmers to invest in fertilizers and crop protection products both in getting more yield of profitable crops (such as cereals, and other grains) and expand their farm area (the area of cereal and other grains has increased by 81.4 % on average in 2013 compared to 2004) in order to get more decoupled payments as they were linked with UAA ha (payments per ha of UAA).

The results of the impact of the direct payments system to livestock density showed, that there is a strong negative correlation (-0.76) between decoupled direct payments and livestock density in Lithuania (-0.76) and Puglia (-0.81). Coupled payments also has a strong correlation, however, positive. Thus it means that the more payments were decoupled the less livestock density was. The regression analysis for Lithuanian case also provided, that decoupled payments are significant variable in terms of livestock density. Moreover, coupled payments were lagged and were more significant at (t-1) time. The livestock production price index was determined

as not significant at 90 % confident level; however, it had slight impact on farmers' behaviour and involved in equation (1.8).

$$Y_3 = 0.22 - 0.001X_{dech} + 0.004X_{clh} + 0.001X_{lpp} \quad (1.8)$$

Nevertheless in terms of provided Lithuanian regression and correlation analysis results, decoupling of direct payments have had influenced the decrease in livestock density by 10-12 % (in 2013 compared to 2004) in Lithuania, and if the same equation variables were at a confident level of 90-95 % in Puglia, there would be an up to 20-25 % decrease.

According to the fact that in Puglia the livestock density is of one the smallest across EU (0.14 LU/ha UAA in 2013, in Lithuania it is 0.35 and also one of the smallest) and in terms of biodiversity and landscapes, the decreasing of it has a negative impact.

The decrease of livestock density together with increase of decoupled direct payments and increase of crop prices negatively influenced share of temporary and permanent grassland in total UAA in farms in Lithuania (decreased by 38.6 % in 2013 compared to 2005) (1.9) (see also annex 3).

$$Y_4 = 0.22 - 0.0011X_{dech} + 0.485Y_3 - 0.0003X_{cpp} \quad (1.9)$$

However, from this point of view the situation in Puglia differs as livestock density doesn't influence the share of temporary and permanent grassland in total UAA (correlation is -0.21). Only decoupling of direct payments has slightly impact on the share. However, in accordance with data shortage on crop price indices didn't allow making a full view on dependencies among variables.

Examination of agricultural land use diversification by using Shannon index, showed very diverse result in Lithuania and Puglia region (Italy) (Fig. 2).

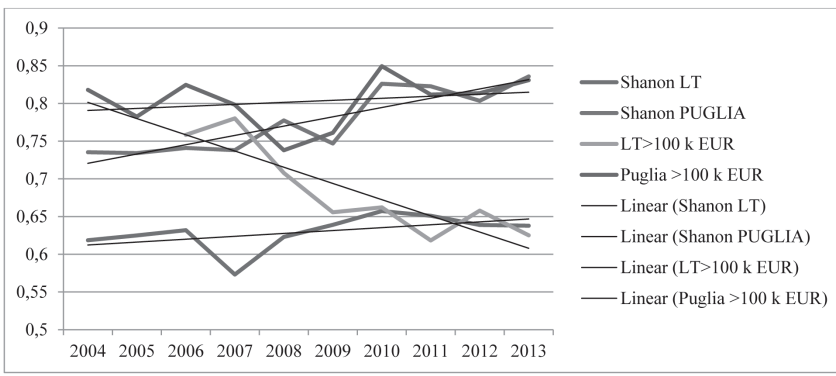


Fig. 2. **Shannon index in Lithuania and Puglia region (Italy) for both all farms and farms accumulating more than 100 k EUR of SO (standard output)**

The comparison of the results of Lithuania and Puglia suggests that the crop diversity level for the whole 2004-2013 period was higher in Puglia. However, Puglia not only had a higher level of crop diversity, but also the diversity level was almost uniform in different farming types (by economic size) with a similar growth tendency. By contraries, it can be said, that in Lithuania the crop diversity level of bigger by economic size farms was as high as in Puglia in 2006-2007; however, from year 2008-2009 it dropped dramatically actually due to 2 reasons – the 2008-2009 crisis and presenting of the full decoupling of direct payments at these years in Lithuania that encouraged farmers to use more area of the most profitable crops in order to get both more payments and profit from selling.

	Shannon LT, >100 k EUR	**Shannon LT**	**Puglia >100 k EUR**	**Shannon Puglia**
Decoupled payments	-0.883	0.512	0.347	0.910
Coupled payments	0.756	-0.664	0.203	-0.270
Price change (max-min) (t-1)	-0.045	-0.215	NA	NA

The regression analysis didn't provide any sufficient and logical results using observed variables, described above. The only variable – decoupled direct payments – could have had a negative influence on Shannon index for farms accumulating more than 100 k EUR of SO in Lithuania or a positive influence on all farms in Puglia (see correlation matrix above).

Conclusions

1. Since CAP was linked with sustainable development, various researchers ambiguously assesses the impact of direct payments on environmental sustainability, highlighting both positive and negative impact.
2. The analysis of scientific literature allowed determining the indicators, which are impacted by the direct payments system and their links to environmental sustainability elements.
3. Tested regression equations led to the assumption that the theoretical connection provided in literature are confirmed empirically by using Lithuania's and Italy's FADN datasets.
4. Empirical research has shown that the DP system provided in the EU from 2004 to 2013 had a larger negative effect on the environmental sustainability in Lithuania than in Puglia. Particularly strong negative influence in Lithuania was due to the decoupling of direct payments and prolonging application of SAPS system.

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BŽŪP tiesioginių išmokų sistemos sąsajos su aplinkosauginio tvarumo rodikliais

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Anotacija

Aplinkosaugos klausimas yra vienas svarbiausių tvaraus žemės ūkio vystymosi kontekste pastaraisiais metais. Daugiausiai finansinių išteklių skiriamai ES bendrosios žemės ūkio politikos (BŽŪP) priemonei – tiesioginių išmokų (TI) sistemai – nuo 2004 metų iškeltas tikslas prisidėti prie aplinkosauginio tvarumo žemės ūkyje. Nagrinėjant mokslinę literatūrą, pasigendama sisteminio požiūrio ir priemonių įvertinti TI sistemos poveikį aplinkosauginiam tvarumui. Straipsnyje nagrinėjamos ir grindžiamos sąsajos tarp TI sistemos ir aplinkosaugos tvarumo rodiklių. Pagrindinis tyrimo klausimas – kokią įtaką 2004–2013 metais BŽŪP TI sistema turėjo aplinkosauginiam tvarumui. Siekiant atsakyti į šį klausimą, straipsnyje remtasi lyginamąja ir statistine-regresine analizėmis, teoriniu modeliavimu – nustatyti, pagrįsti ir įvertinti ryšiai tarp DP sistemos tikslų ir žemės ūkio aplinkosauginio tvarumo rodiklių. Straipsnyje taip pat pateikiami empirinio tyrimo rezultatai Lietuvos ir Apulijos (Italija) regionuose. Jie buvo atrinkti dėl fizinio regionų ploto, gyventojų skaičiaus panašumų ir skirtingų BŽŪP TI sistemų taikymo.

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