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Exploring the Farm Level Opportunity Cost for Protecting Environment: Evidence from Turkey

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ABSTRACT

The study spatially explored the farm-level opportunity cost of protecting environment and examined the sufficiency level of government support for covering farm level of opportunity cost in TR83 region of Turkey. By using questionnaires, research data were collected from randomly selected 334 farms that participated in Environmentally Friendly Agricultural Land Protection Program (EFALP) and purposively selected 27 conventional farms. Farm-level opportunity cost of protecting environment was calculated via subtracting gross revenue calculated under condition of protecting environment from the gross revenue calculated under conventional ones. Gross revenue under conventional condition and under condition of protecting environment was elicited by using the MOTAD linear approximation of the quadratic programming. Sufficiency of government support for protecting environment was revealed through taking the difference between farm-level opportunity cost for protecting environment and total government support payment for environmental consideration to farm included in EFALP. Research results showed that government support paid to sample farms did not cover opportunity cost of farm for protecting environment in TR83 region. Considering spatially differentiation of farm-level opportunity cost for protecting environment when policy makers determine the quantity of government support may positively enhance the dissemination of EFALP programs and reduce the adverse effects of agricultural practices.

Keywords: Agricultural Land Protection, Environmental protection, Government support, MOTAD model, TR83 region.

INTRODUCTION

The agricultural sector has undergone a structural change due to technological advancements, the policies adopted, and the funds transferred. Current farms tend to continue their activities using production systems that highly benefit from modern inputs and technologies. The environment and proper use of natural resources have been neglected while experiencing this change, and this has led to environmental problems. Therefore, sustainable use of natural resources and utilization of environmentally-friendly production systems have become important today. This issue has become one of the agenda issues for the policy makers of the majority of the developed countries and a many of the developing countries. As in all other countries, utilization of environmentally-friendly production systems in Turkish agricultural sector have been encouraged and financial supports have been given for environmentally-friendly production systems to protect the environment. But despite all these efforts, issues of environmental protection and proper use of natural resources have not yet reached the desired level due to the fact that initiatives and supports intended for environmental protection are designed and determined without considering and calculating the farmers' opportunity cost regarding the

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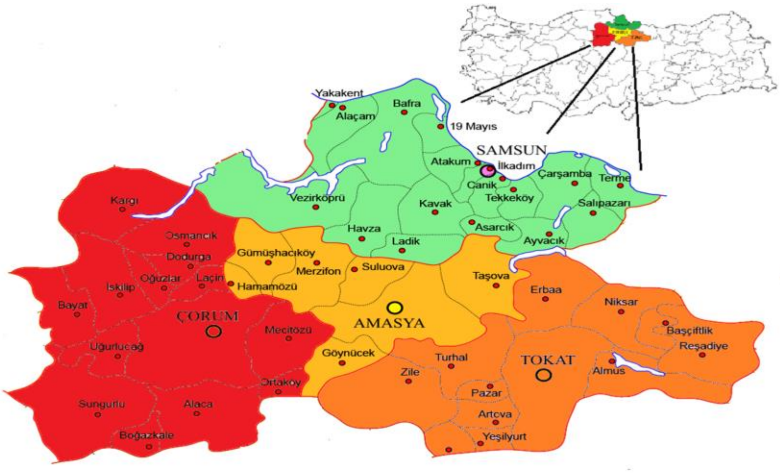
protection of the environment and natural resources. That is why this study intended to test the hypothesis of whether government payment for protecting environment compensate the farm level opportunity cost of environmental protection, or not.

Intensification of the use of technology and chemical inputs in agriculture has required consideration of environmental factors; the concepts of agriculture and environment have become issue to be addressed together in scientific studies (Hediger and Lehmann, 2003; Karaer and Gürlük, 2003; Akça *et al*., 2005; Türkmen, 2007; Günden and Miran, 2008; Şahin *et al*., 2008; De Serres *et al*., 2010; Stevens 2011; McCarthy 2014; Sun *et al*., 2019). The opportunity cost between certain global environmental factors and farm income have been revealed through different methods in many previous studies (Kasal, 1976; Mimouni *et al*., 2000; Falconer and Hodge, 2001; Jehangir *et al*., 2002; Stoorvogel *et al*., 2004; Groot *et al*., 2007; Igari *et al*., 2009; Wang and Shen 2016; Kanter *et al*., 2016; Machado *et al*., 2016; Rendon *et al*., 2016; Meyfroidt, 2017; Hutton *et al*., 2018). However, the opportunity cost of protecting environment and natural resources in Turkey has not been sufficiently addressed yet. Despite its significance, opportunity cost of protecting environment for farms in Turkey is still unknown. There is very limited study based on original farm level data related to the opportunity cost of protecting environment in Turkey. To reduce the lack of knowledge on the opportunity cost of protecting environment, the purpose of this research was to spatially explore the farm-level opportunity cost for protecting environment and examine the sufficiency level of government support for covering farm level opportunity cost in TR83 region of Turkey. While previous research studies conducted in Turkey neglected the risks when producing optimum farm plans and assumed the existence of certain information, this study aimed to incorporate the risk factors when exploring opportunity cost of protecting environment and examined the sufficiency of government supports.

MATERIALS AND METHODS

Environmentally Friendly Agricultural Land Protection (EFALP) Program

All nations have implemented the environmental protection programs to cope with environmental challenges such as greenhouses emission, soil erosion, etc. Turkish government, therefore, have put EFALP program into practice in order to protect the quality of soil and water, to conserve natural resources, to prevent soil erosion and to minimize the adverse effects of agricultural practices. Common Agricultural Policy (CAP) of EU also targeted to provide sustainable management of natural resources in order to cope with environmental challenge (Haniotis, 2011). EFALP program is consistent with the targets of 2020 CAP reform. Environmentally good practices of Turkish farms, including EFALP program, were minimum tillage, crop rotation, soil analysis, terrace, embankment, screening, stone collection, drainage, gypsum application, sulfur and lime application, mulching, green fertilization, grazing management, switching to pressurized irrigation system, integrated plant protection, and increasing population of beneficial microorganism. Government has paid the environmental support annually under three different categories in 58 different provinces for three years. In the first category, government has disseminated the minimum tillage based agricultural practices among the farmers and paid 350 TRY [Dollar equals to 3.52 Turkish Liras in 2020 (CBRT, 2017)] per hectare to each farmer participating in the EFALP. Second category included conserving the natural resources and preventing erosion. Government has paid 600 TRY to EFALP farmers under this category. Third category includes the following: integrated product management procedure when using



Figurer 1. Map of the research area.

fertilizers and plant protection products, switching to pressurized irrigation systems in order to minimize water consumption, adoption of environmentally friendly production system such as organic agriculture, good agricultural practices, etc. Farmers who participated in the EFALP program under third category received 1,350 TRY per hectare, on average. In addition to the third category support, the government also provides environmental support for organic agriculture and good agricultural practices. Amount of the environmental support given under third category depends on the crops. Currently, for good agricultural practices, government has paid 500 TRY per hectare for fruits or vegetables, 1,000 TRY for ornamental plants or medicinal and aromatic plants, 1,500 TRY for greenhouse cultivation, and 100 TRY for paddy. When the farmers switch to organic culture, farmers get 1,000 TRY per hectare for growing fruits and vegetables, 700 TRY for medicinal and aromatic plants and cash field crops. Finally, 100 TRY support is paid per hectare for field and forest products (Anonymous, 2018).

The Research Region

TR83 Region consists of Amasya, Çorum, Tokat, and Samsun provinces (Figure 1). The yellow area is Amasya, the red area is Çorum, the green area is Samsun, and the brown area is Çorum on the map. The region constitutes 5.4% of EFALP land and 19.1% of EFALP farms in Turkey (Table 1).

Research area includes Amasya, Çorum, Tokat, and Samsun provinces of Turkey. The research area constitutes 5.4% of EFALP land and 19.1% of EFALP farms in Turkey. Samsun has the biggest land of EFALP in TR83 Region. Most of the farms are in Samsun, while Çorum is the smallest province in terms of land and number of

Table 1. Some characteristics of EFALP in research area.

Provinces	Land		Number of farms	
	ha	%	Number	%
Amasya	24,820.0	0.96	2,580.0	5.50
Çorum	6,395.0	0.25	463.0	0.99
Samsun	90,346.0	3.51	3,623.0	7.72
Tokat	16,499.0	0.64	2,275.0	4.85
TR83	138,133.0	5.36	8,941.0	19.06
Turkey	2,577,115.0	100.00	46,921.0	100.00

farms. Since these four provinces have different geographical and climatic conditions, each district has different farming system and cropping patterns. Onion, sugarcane, cherry, peach and apple are common in Amasya, while maize, wheat, potato, bean, and strawberry are the cash crop in Çorum. In Tokat, grapes, maize, wheat, bean and chickpea dominates the cropping pattern. Paddy, hazelnut, pepper, cabbage and tomato are the main cash crop in Samsun. The research area generally produces fruits, vegetables, field crops, greenhouse plants, and live animals.

Research Data

Research data were collected from two different types of farms. First type of farms was EFALP farms under third category in TR83 Region of Turkey. Second type of farms was named as conventional replica of EFALP farms. When determining the optimum sample size for EFALP farms, stratified random sampling method was used for each district. To set ceteris paribus condition between EFALP and conventional farms, 3 conventional farms resembling EFALP farms were purposively selected as a control group for each district in terms of farmland, soil characteristics, socio-economic characteristics, operator profile, production pattern, capital structure and climatic conditions. Ultimately, farm level research data were collected from totally 361 farms (334 from EFALP farms and 27 from conventional farms) by using structured questionnaire. Questionnaires were administered to the sample farmers during the production year of 2016-2017 (Table 2).

Calculation of the Opportunity Cost of Protecting Environment

Optimum farm plans were elicited for both EFALP farms and conventional farms. Opportunity cost of protecting environment was calculated by subtracting the estimated farm incomes for conventional farms from that of EFALP farms. Minimization of Total of Absolute Deviation (MOTAD) model as a linearized version of Quadratic Programming (QP) is better adapted for the post optimality analysis and MOTAD may lead to much smaller problems for complex farm organization (Hazell, 1971). The MOTAD linear approximation of the QP and combinations obtained with MOTAD are an acceptable proxy for the E-V combinations obtained from quadratic function (Mc Carl and Önal 1989; Lambert and Mc Carl 1985; Hardaker and Troncoso 1979). Therefore, MOTAD programming model as a linearized version of QP suggested by Hazell (1971) was used to elicit the optimum farm plans under two different scenarios.

The Expected Variance (E-V) criterion was preferred, because it was consistent with not only the separation theorem, but also elicited probability that reflects the likelihood occurrence of different gross revenue levels for a given farm plan. Therefore, Expected mean Absolute gross revenue deviation (E-A) plans were transformed to the efficient E-V farm plans. When deriving efficient E-V farm plans, the sampling distribution of estimated variance and mean absolute gross revenue deviation were used. The variance of farm plans was calculated by using Equation (1) suggested

Table 2. Optimum sample size of farms in the research area

Provices/Districts	EFALP farms	Conventional farms
Amasya (Merkez)	57	3
Amasya (Suluova)	29	3
Amasya (Taşova)	16	3
Çorum (İskilip)	5	3
Çorum (Bayat)	10	3
Tokat (Erbaa)	45	3
Tokat (Niksar)	44	3
Samsun (Bafra)	79	3
Samsun (Çarşamba)	49	3
TR83	334	27

by Hazell (1971) to generate E-V efficient farm plan.

$$\frac{1}{s-1}\sum_{h=1}^{s}\left[\sum_{j=1}^{n} c_{hj}x_j - \sum_{j=1}^{n} g_j x_j\right]^2 \quad (1)$$

Where, h=1, s denote the s observations in a random sample of gross revenue, g_j is the average value of sample, $\sum_{j=1}^{n} c_{hj}x_j$ is the total gross revenue of a particular farm plan generated with observed gross revenue for the h*th* farm, and $\sum_{j=1}^{n} g_j x_j$ is the total gross revenue for the same farm plan generated with sample mean gross revenue.

The MOTAD utilizes the linear programming to simulate the farmers' planning decisions under risky conditions (Brink and Mc Carl, 1978). MOTAD programming is based on the minimization of absolute deviation in total farm gross revenue. MOTAD model differs from classical linear programming model due to inclusion of matrix D and vector of probability of gross margin of production activity in the programming model. Matrix D reflects the deviations of gross margin of production activities from expected gross margin. When constructing the matrix D, 10 years historical data covering yields and prices of production activities, input quantities, and input prices from 2007 to 2016 was used.

The formulation of the MOTAD programming model used in the study is as follows:

$$Minimize\ Ld^{-}$$

Subject to

$AX \leq B$

$DX + Zd^{-} \geq 0$

$C'X = \lambda$

$X, d^{-}, \lambda \geq 0$

In MOTAD model, X is the activity level, Z is the descriptor vector in the model, A is the matrix of input-output coefficients, B is the vector of resource constraints, C is gross revenue of activities and D is the deviations of gross margin of activities from expected gross margin in a given year. The vector of d^{-} denotes yearly total negative deviations summed over all risky activities. Ld^{-} represents the summed total negative deviations overall years. λ is a scalar parametrized from zero arbitrarily to a large number based on sensitivity analysis.

Land, rotation requirements, labour, working capital, barn size, and feed requirements for animals were constraints of the MOTAD model developed for the representative farms of each districts. Production activities in the MOTAD programming model were cereals, horticultural crops, fattening and dairy cattle. Additional activities included in the model were labour and land hiring, borrowing working capital, feed production and purchasing.

The opportunity cost of protecting environment was spatially calculated at farm level. Then, provincial and regional level opportunity cost values were elicited using the mean values of farm level opportunity cost. The difference between the sacrificed revenue for farms participating in EFALP and government payment provided by EFALP was attributed to the sufficiency level of government payment for protecting environment. When calculating the total opportunity cost of protecting environment in TR83 region, the share of EFALP farms in total farms, their activities in TR83 region, mean value of farm land for EFALP farms at district and provincial level, and total land in TR83 region were used. The values of the farm level opportunity cost of protecting environment per hectare were multiplied by the total land covered by EFALP in order to find out the total opportunity cost of protecting environment for TR83 region. To explore the sacrificed revenue for protecting environment, the total amount of support given by the government was subtracted from the total opportunity cost calculated for the study area. The sacrificed revenue was then divided by the total number of farms including EFALP program to calculate the amount at farm level.The ratio of the farm level sacrificed revenue for protecting environment to the farm revenue is the indicator used to give a measure of the share

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of the opportunity cost of protecting environment.

RESULTS AND DISCUSSION

Research results showed that the farm level opportunity cost of protecting environment in TR83 region was 3060 TRY per hectare. The amount of government support given to the good agricultural practices for environmental protection in the research area was 1,790 TRY per hectare. According to this research finding, the government payment to EFALP farms for protecting environment in TR83 region did not compensate the farm level sacrifice for protecting environment, estimated as 1270 TRY per hectare. This result is aligned with previous studies reporting that payments of programs designed and applied for environmental protection around the world failed to meet the opportunity cost of protecting environment (Mimouni *et al*., 2000; Stoorvogel *et al*., 2004; Wang and Shen, 2016; Meyfroidt, 2017). Similarly, Igari *et al*. (2009) explored the link between opportunity cost for the protection of the natural areas and farm income sacrificed by the farms in Brazil. They suggested that the economic benefit gained from programs intended to protect natural areas was lower than the opportunity cost of protecting environment. Research results also showed that the opportunity cost of protecting environment and the adequacy of supports has changed geographically in TR83 region. While the amount of farm level sacrifice for protecting environment was the lowest in Niksar, it was the highest in Taşova (Table 3). With the exception of Çarşamba, supports given to the farms included in EFALP program did not completely cover the opportunity cost of protecting environment. The research finding that the adequacy of supports has changed geographically confirmed the results of the study conducted by Falconer and Hodge (2001) in UK. They recommended implementation of taxation policies that changed depending on the geographical conditions to minimize the use of agricultural pesticides causing environmental problems due to the fact that opportunity cost of protecting environment varies depending on ecological conditions in UK.

Regarding Samsun, the opportunity cost of protecting environment varied from 2,195 to 3,491 TRY. The sacrificed revenue of EFALP farms for protecting environment in Çarşamba and Bafra were 95 and 1,941 TRY, respectively (Table 3). Results reported for Bafra confirmed the results of research conducted by Eryılmaz (2017), who stated that the opportunity cost of farms for protecting environment was 92.56 TRY in Bafra. Çarşamba had the smallest sacrifice in TR83 region for protecting environment. This finding was corroborated with the results of the Yıldırım *et al*. (2018), who suggested that government payment compensated the EFALP farms' sacrifice for protecting environment in Çarşamba, resulting in high level farmers' satisfaction in Çarşamba.

In TR83 region, it is clear from the above evidence that the sufficiency level of government payment for protecting environment varied spatially in the research area. In TR83 region, EFALP farms faced with sacrifice by a total of 115 million TRY in order to protect the environment. Considering all 8,941 farms involved in EFALP, it could be stated that average EFALP farm sacrificed approximately 12,865 TRY every year to protect the environment, which was 10.6% of the annual farm revenue of 121 thousand TRY. Tokat District had the smallest sacrifice for protecting environment, while that of Çorum was the highest. EFALP farms in Tokat sacrificed approximately 9.3% of their farm revenue for protecting environment due to the fact that switching to organic agriculture did not cause significant changes in yield. In Çorum, EFALP farms sacrificed 19.7% of their farm revenue (Table 4).

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Table 3. The opportunity cost of protecting environment by districts.

Provinces	Districts	Gross income in optimal plan (TRY ha^{-1}) Farms protecting environment (A)	Farms not protecting environment (B)	The opportunity cost of protecting environment (TRY ha^{-1}) (C= B-A)	Mean amount of support (TRY ha^{-1}) (D)	Difference (TRY ha^{-1}) (E=D-C)	Max amount of support (TRY ha^{-1}) (F)	Difference (TRY ha^{-1}) (G=F-C)
Amasya	Center	38851	41656	2805	1350	-1455	1350	-1455
	Taşova	22016	25838	3822	1350	-2472	1350	-2472
	Suluova	21821	23713	1892	1350	-542	1350	-542
Çorum	İskilip	12097	16145	4048	2350	-1698	2350 [a]	-1698
	Bayat	13069	16653	3584	1350	-2234	1350	-2234
Tokat	Erbaa	16774	19833	3059	1650	-1409	2350 [a]	-709
	Niksar	32422	35086	2664	2000	-664	2350 [a]	-314
Samsun	Bafra	14255	17746	3491	1550	-1941	1850 [b]	-1641
	Çarşamba	28887	31082	2195	2100	-95	2350 [a]	+345
TR83	Total	22244	25306	3062	1648	-1256	1794	-1268

[a] Max amount of support were taken account for organic agriculture. [b] Max amount of support were taken account for good agricultural practices by vegetables/fruits.

Table 4. The sacrifice of farms for protecting environment.

Provices	Land allocated to ÇATAK (ha)	Opportunity cost of protecting environment (TRY ha^{-1})	Total opportunity cost of protecting environment (Million TRY) (A)	Total amount of Support within ÇATAK (Million TRY) (B)	Difference (B-A) (Million TRY)	Sacrifice of farms for environmental protection (Thousand TRY/Farm)	The share of sacrifice in farm income (%)
Amasya	24,819.7	2944	73.1	33.5	-39.6	15.3	12.1
Çorum	6,394.8	3742	23.9	10.8	-13.1	28.3	19.7
Tokat	16,499.1	2865	47.3	38.8	-8.5	3.7	9.3
Samsun	90,345.8	2999	270.9	184.3	-86.6	23.9	16.5
TR83	138,133.3	3062	405.3	290.3	-115.0	12.9	10.6

CONCLUSIONS

The study results rejecyed the hypothesis that government payment for protecting environment compensated the farm level opportunity cost of environmental protection. In the light of the research findings, the average opportunity cost of protecting environment was 3,060 TRY per hectare in TR83 region, spatially variable according the local conditions.Among the provinces involved in this research, the highest sacrifice for protecting environment was recorded in Çorum and Samsun. The sacrificed revenue of EFALP farms to protect the environment was on average 160 TRY, corresponding to 11% of their farm revenue. They had to sacrifice 11% of their farm revenue for protecting environment.

The estimation of the amount of payments for specific intervention in agriculture is done normally considering the increase in costs or decrease in revenues resulting from the application of the measure. According to the results of this analysis, The sacrificed revenue of EFALP farms to protect the environment was on average 1,260 TRY, corresponding to 11% of their farm revenue. In the assessment of the amount of environmental supports such as EFALP, organic agriculture, or good agricultural practices, decision makers should take into account the opportunity cost of protecting environment and its variability. Because of different local conditions and different kind of agriculture, the opportunity cost should be calculated spatially in order to avoid over- or under-compensations. Since the estimation of the opportunity cost of protecting environment involves many aspects of the agricultural farm management and requires specific competencies in modelling, a collaboration among Universities, Ministry of Agriculture and Forestry, agricultural organizations and farmers could increase the efficacity of the environment targeted policies. Farmers' associations could play an important role in making the farmers aware about the environmental practises and the benefits generated in the medium and long term for the future generations.

Future research should focus on comparing the effects of different types of government compensation policies for adopting specific environmental practices at farm level worldwide.

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بررسی هزینه فرصت در سطح مزرعه برای حفاظت محیط: شاهدی از ترکیه

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چکیده

این پژوهش، هزینه فرصت در سطح مزرعه را برای حفاظت محیط در نقاط مختلف منطقه TR83 در ترکیه بررسی کرد و کفایت سطح برنامه های حمایتی دولت را برای پوشش دادن این هزینه ها سنجید. با استفاده از یک پرسشنامه، داده های پژوهشی از ۳۳۴ مزرعه جمع آوری شد که به طور تصادفی انتخاب شده و در "برنامه دوستدار محیط و حفاظت اراضی کشاورزی" (EFALP) مشارکت داشتند.علاوه بر آنها، به طورهدفمند ۲۷ مزرعه معمولی نیز برای این پژوهش انتخاب شد. سپس، با تفریق درآمد ناخالص محاسبه شده در شرایط حفاظت از محیط از در آمد ناخالص در مزارع معمولی، هزینه فرصت در سطح مزرعه برای حفاظت محیط محاسبه شد. در آمد ناخالص در شرایط معمولی و در شرایط حفاظت از محیط با استفاده از مدل تقریب خطی برنامه ریزی درجه دو MOTAD به دست آمد. نیز، از طریق تعیین تفاوت بین هزینه فرصت در سطح مزرعه برای حفاظت محیط با کل پرداخت حمایتی دولت برای ملاحظات محیط زیستی به مزارع مشمول در برنامه EFALP، درجه کفایت برنامه حمایتی دولت برای

حفاظت محیط به دست آمد. نتایج تحقیق نشان داد که پرداخت حمایتی دولت به مزارع نمونه ای، هزینه فرصت مزارع را برای حفظ محیط در منطقه TR83 پوشش نمی دهد. به این قرار، در زمانی که سیاست سازان مقدار حمایت دولت را تعیین می کنند، در نظر گرفتن تفاوت های مکانی هزینه فرصت برای حفاظت محیط می تواند به طور مثبتی ترویج برنامه EFALP را ارتقا داده و اثرات نامناسب فعالیت های کشاورزی را کاهش دهد.

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