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An Analysis of Relationship Between Nitrogen Surplus for Agriculture and Socio-Economic Properties: A Case Study for Turkey

Research Article

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Abstract

This paper presents the analysis of relationship between nitrogen surplus for agriculture (NS) and some socio-economic properties among the regions of Turkey for the period of 2007-2011. The correlations of NS with gross domestic product (GDP) per capita (0.66), permanent meadows and grassland share in utilized agricultural area (UAA) (-0.55), population density (0.49), out-migration rate (-0.42), the export value of agriculture and forestry (0.35), illiterate share (-0.31), number of villages (-0.31), arable land share in UAA (0.29), the value of livestock per capita (-0.26) and permanent area share in UAA (0.23) were observed as statistically significant. A model was established by using C5.0 algorithm to define NS levels of the regions according to socio-economic properties of the regions. According to the model results; permanent meadows and grassland in UAA, GDP per capita, population density, and illiterate share were determined as the important variables to define NS levels of the regions. It can therefore be concluded that the permanent meadows and grassland share in UAA and GDP per capita are the main socio-economic properties having noticeable effect on the environmental quality and human welfare related to NS.

Keywords: Agriculture; Gross Domestic Product; Nitrogen Budget; Permanent Grassland; Turkey

Introduction

Ozbek and Leip [1] summarized the importance of nitrogen (N) to living things as follows; nitrogen (N) is an important source of nutrition for plants; while nitrogen deficiency negatively affects plant growth, nitrogen surplus for agriculture (NS) can cause important problems that affect environmental quality and human welfare [2-4]. These problems can be listed as negative effects on biodiversity, eutrophication and nitrates accumulation in waters, acidification, nitrous oxide emission, corrosion of ozone layer and risks to human health due to exposure to nitrous oxide, ozone and particles [5,3]. The agricultural sector is defined as the main source of nitrogen contamination in underground, surface and air levels [6-10].

There are many studies focused on the relationship between environmental degradation and socio-economic properties, especially the relationship between environmental degradation and income level [11-14]. An important number of these studies on this relationship were about the environmental Kuznets curve (EKC). In literature, there are limited number of studies on the relationship between NS and socio-economic properties [15,16]. In these studies, only income level was analyzed as socio-economic indicator. This paper will ensure a great contribution to the literature in terms of examining the relationship between NS and socio-economic properties among the regions with different climates and socio-economic properties.

The NS values range vastly among the regions in Turkey [1]. The socio-economic differences among the regions in Turkey, which is a geographically big country, are also high. The purpose of this study is to analyze the relationship between NS values and some socio-economic properties (the number of villages, population density, crop patterns (the shares of arable land, permanent area, permanent meadows and grassland in utilized agricultural area (UAA)), organic area share in

UAA, value of livestock per capita, value of crop products per capita, the export value of agriculture and forestry, gross domestic product (GDP) per capita, out-migration rate, illiterate share)among Turkey Nomenclature of Territorial Units for Statistics (NUTS2) regions. The correlation analysis between NS and socio-economic properties of NUTS2 regions was carried out, and a model was established by using C5.0 algorithm to define NS levels of the regions according to their regional socio-economic properties.

Materials and Methods

The nitrogen budget methodology used in this study is based on the methodology recommended in Eurostat/OECD common guideline [17]. In this methodology, NS was estimated by using equation 1.

$$NS = \left(N_{input} - N_{output}\right) / A_{ref} \qquad (1)$$

The reference area (A_{ref}) is UAA (arable land, permanent crop land, and permanent grassland). The inputs (N_{input}) and the outputs (N_{output}) used in NS estimation, and the methodology and the data sources used in the estimations of these inputs and outputs are presented in Table 1. In order to minimize the impact of regional differences in Turkey, where different climates are observed, NUTS2 division was used in the estimations [18,1].

A Pearson correlation analysis between NS and socio-economic properties of NUTS2 regions was carried out by using SAS package software. Turkey's NUTS2 NS data from 2007-2011 was used in the analysis. Socio-economic properties used in the analysis are presented in Table 2.

A model was established by using C5.0 algorithm to define NS levels of the regions according to their regional socio-economic properties. The analysis was carried out using SPSS Clementine 12.0 package software. The C5.0 algorithm is a new generation of Machine Learning Algorithms based on decision trees, which is an important model to realize the classification [19]. C5.0 model works by splitting the sample based on the field that provides the maximum information gain [20]. Information gain (*IG(Y|X)*) was calculated by using entropy (*H(Y)*) (Equations 2 and 3) [21].

$$H(Y) = -\sum_{j=1}^{m} p_j \log_2 \log_2 p_j \qquad (2)$$

$$IG(Y \mid X) = H(Y) - H(Y|X) \qquad (3)$$

In these equations, p_m is equal to $P(Y=V_m)$, and it is supposed that Y can have one of m values (V_1, V_2… V_m). *H(Y|X)* is the average of *H(Y|X=v)*the entropies of Y among only those records in which X has value v.

In C5.0 algorithm, the dependent variable is the target variable that we are trying to understand and/or classify, and the input variables are used for this aim. The input variables were determined as socio-economic properties of the regions at NUTS2 level, and NS was determined as target variable in this study. Target variable used in C5.0 algorithm should be categorical. So that, the target variable NS in numeric type was transformed to the symbolic type by grouping the regions according to NS values. The regions were classified according

Table 1: Inputs and outputs used in NS estimations, and the methodology and the data sources used in the estimations.

Inputs and Outputs in N Balance		Calculation Method	Data Sources
Inputs	1) Mineral fertilizer	Mineral fertilizer * N content	MFAL (Yearly sales data)
	2) Manure production	Number of animals * N excretion ratio	Number of animals: TurkStat (Yearly administrative data) Excretion ratio: IPCC 1996
	3) Seed and planting materials	Cultivated area * Nutrient seed input rate	Cultivated area: TurkStat (Yearly administrative data) Nutrient seed input rate: Eurostat
	4) Biological N fixation	Harvested area of leguminous crop * Biological N fixation ratio	Area: TurkStat (Yearly administrative data) Biological N fixation ratio: Eurostat
	5) Atmospheric N deposition	(Turkey atmospheric N deposition / total area) * A_{ref}	Turkey atmospheric N deposition: EMEP A_{ref}: TurkStat Total area: Eurostat
	6) Total inputs = sum (1,2,3,4,5,6)		
Outputs	7) Crop production	Crop production * N content	Crop production: TurkStat (Yearly administrative data) N content ratio: Eurostat, OECD
	8) Fodder production	(Fodder production * N content) + (Pasture and meadows area * Yield * Consumption ratio * N content)	Fodder production: TurkStat (Yearly administrative data) Pasture and meadows area: TurkStat (2001 General Agricultural Census) Yield, consumption ratio: OECD N content ratio: Eurostat, OECD
	9) Crop residues removed	The amount of crop residues removed not used for feed, bedding and construction * N content of above-ground residues	Cropproductionarea: TurkStat (Yearly administrative data) N content of above-ground residues: IPCC 1996
	10) Total outputs = sum(7,8,9)		
N Surplus	**= 7-10**		

Source : Eurostat, 2012
TurkStat : Turkish Statistical Institute
MFAL : Ministry of Food, Agriculture and Livestock
IPCC : Intergovernmental Panel on Climate Change
EMEP : The European Monitoring and Evaluation Programme

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Table 2: Definitions of socio-economic properties.

Socio-economic properties	Definition	Unit	Socio-economic properties	Definition	Unit
Arable land share in UAA	The share of arable land area in utilized agricultural area (UAA)	%	Value of livestock per capita	Value of livestock is calculated by multiplying production amount with unit price for each livestock.	TL per capita
Permanent area share in UAA	The share of permanent area in UAA	%	Population density	Population density is a measurement of population per unit area.	Population per km^2
Permanent meadows and grassland share in UAA	The share of permanent meadows and grassland area in UAA	%	Number of villages	The number of villages in the region	Unit
Organic area share in UAA	The share of organic area in UAA	%	Out-migration rate	The ratio of all migrants who moved out of the region during a given year relative to the total population in the region.	%
Export value of agriculture and forestry sector	The value of goods of agriculture and forestry sector exported from the region	$	Gross domestic product (GDP) per capita	GDP is a value which is equal to the sum of the values of all goods and services produced by residential institutional units engaged in domestic production activities in an economy in a given period of time, minus the total inputs which are used in the production of these goods and services.	$ per capita
Value of crops per capita	Value of crops is calculated by multiplying production amount with unit price for each crop.	TL per capita	Illiterate share	The share of illiterate population in total population (for 15 years and older)	%

Note: All data were obtained from Turkish Statistical Institute

to their NS values in four groups in a way that the interval of each group was equal. These groups were denominated as low NS (L: NS< 21 kg N ha^{-1} yr^{-1}), lower medium NS (LM: 21 kg N ha^{-1} yr^{-1}< NS < 56 kg N ha^{-1} yr^{-1}), upper medium NS (HM: 56 kg N ha^{-1} yr^{-1}< NS < 91 kg N ha^{-1} yr^{-1}), and high NS (H: NS > 91 kg N ha^{-1} yr^{-1}).

Regional GDP per capita and permanent meadows and grassland data set of 2007-2011 period are absent for Turkey. So that, the regional GDP shares for the year of 2000 were used in the analysis for estimating regional GDP per capita values of 2007-2011 period. The regional shares of permanent meadows and grassland in 2001 General Agricultural Census were used for estimating regional permanent meadows and grassland data set of 2007-2011 period. 2008-2011 data set was used for out-migration rate and illiterate share in the analysis as the data of the year 2007 for these properties are absent.

Results

The correlations of NS with GDP per capita (0.66), permanent meadows and grassland share in UAA (-0.55), population density (0.49), out-migration rate (-0.42), the export value of agriculture and forestry (0.35), illiterate share (-0.31), number of villages (-0.31), arable land share in UAA (0.29), the value of livestock per capita (-0.26) and permanent area share in UAA (0.23) were observed as statistically significant (Table 3). The correlation coefficients of other socio-economic properties were relatively low, and their relationships with NS were not statistically significant.

It is shown from the evaluation graph (Figure 1) indicating the accuracy of the model formed by using C5.0 algorithm that the best line and the model line are very close to each other. This shows that the model has high accuracy. The analyse accuracy ratio of the model is so high as 97.28%. According to the model results,permanent meadows and grassland share in UAA, GDP per capita, population density, and illiterate sharewere found as important variables (Figure 2). The scatter pilot diagrams of the important variables and NS are presented in Figure 3.

The first split of the decision tree was based on permanent meadows and grassland share in UAA. The following split was based on GDP per capita. In case permanent meadows and grassland share in UAA was lower than 27%, the following split was based on GDP per capita. In this case, if GDP per capita was higher than a definite value (13724$) NS was observed high, otherwise it was relatively low. It was also observed that the regions with low permanent meadows and grassland share in UAA, low GDP per capita, and lowpopulation density had relatively low NS (Figure 4).

All of the regions with permanent meadows and grassland share in UAA were higher than 59% presented in low NS group. The regions with permanent meadows and grassland share in UAA was between 27% and 59% were divided in the following split according to the illletrate share. It was observed that the regions with lower illterate share had relatively lower NS (Figure 4).

Discussions

In the regions with high GDP per capita, population density and arable land share of Turkey, where intensification level in agriculture was also high, hence mineral fertilizer usage was high; it was observed that the NS values were also high. The reverse relationship of NS with permanent meadows and grassland can be explained as follows; in the regions of Turkey, where permanent meadows and grassland were high, the extensification level in agriculture in these regions was also

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Table 3: Correlation coefficients between nitrogen surplus for agriculture (NS) and socio-economic properties.

Socio-economic properties	r p-value	Socio-economic properties	r p-value	Socio-economic properties	r p-value
Arable land share in utilized agricultural area(UAA)*	0.29 0.0009	Number of villages*	-0.31 0.0003	Permanent meadows and grassland share in UAA*	-0.55 <.0001
Export value of agriculture and forestry sector*	0.35 <.0001	Organic area share in UAA	-0.15 0.0883	Population density*	0.49 <0.0001
Gross domestic product (GDP) per capita*	0.66 <.0001	Out-migration rate*	-0.42 <.0001	Value of crop products per capita	-0.05 0.5839
Illiterate share*	-0.31 0.0011	Permanent area share in UAA*	0.23 0.0079	Value of livestock per capita*	-0.26 0.0032

*The properties whose relationship with NS is *statistically* significant (p-value<0.05)

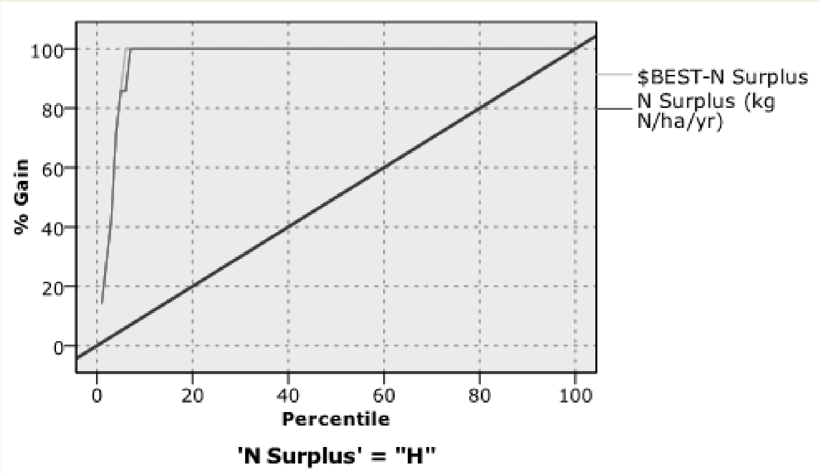

Figure 1: Evaluation graph indicating the accuracy of the model.

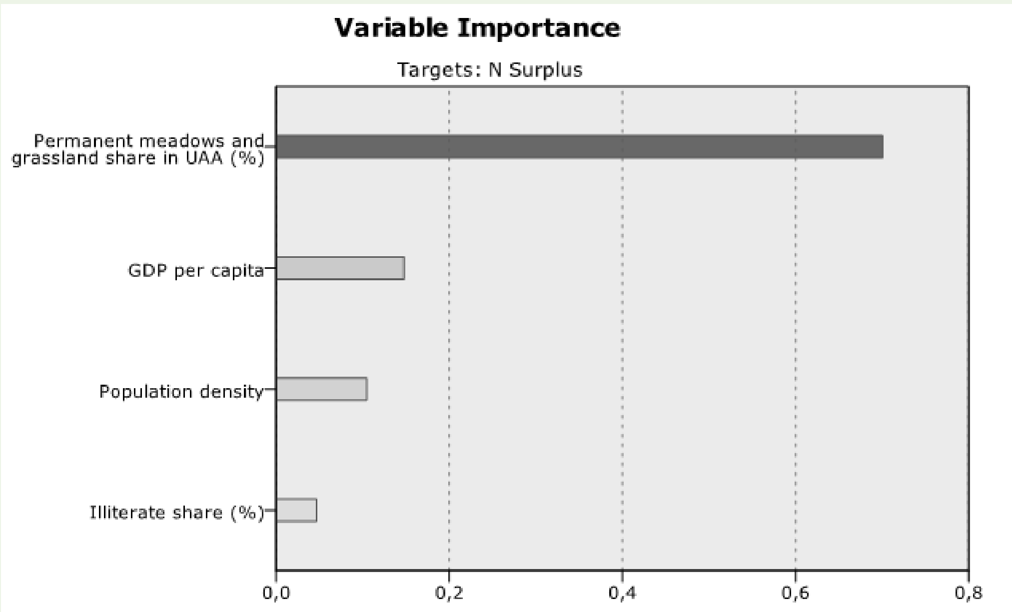

Figure 2: Important variables determined by the model.

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high. Therefore, mineral fertilizer usage was low; it was observed that NS values of these regions were relatively low.

It was shown that the relationship between environmental degradation and income level was the form of inverted U. The relationship between N surplus and GDP per capitain this study was similar to that curve (Figure 3). This indicates us that the relationship between N surplus and GDP per capita ensures EKC curve similar to some environmental issues (eg. SO_2 emission [22]; suspended particulate matter, total deforestation etc. [11]. This result is also parallel to the study made by Shen et al. [15] and Zhang et al. [16] showed the pollution from NS and economic growth relationship followed an inverse-U shape.

All the regions with permanent meadows and grassland shares in UAA were higher than 27% in the group of low NS or low medium NS. This indicates us that the regions / countries with high permanent meadows and grassland shares have relatively lower NS. 12 of EU countries with permanent meadows and grassland shares in UAA was higher than 27% had low or low medium NS [23] similar to the model results in this study (Figure 4). But, 5 of EU countries had upper medium or high NS. It is a fact that the regionalisation of NS estimations gives more sound results compared to the non-regionalisation estimations. Therefore, the most important reason for the bias is the non-regionalisation of NS estimations in Eurostat methodology. The model shows us that the more GDP per capita the more NS for the regions. The GDP per capita has increased in TR in recent years [24]. It was speculated that in the future if current trends in GDP growth continue the environmental risks related to NS can increase.

Although the effect of population density and illiterate share on the NS were relatively low compared to the effect of permanent meadows and grassland share in UAA and GDP per capita, some indirect relationships were observed between these properties and NS. According to the model results, the NS values of the regions with

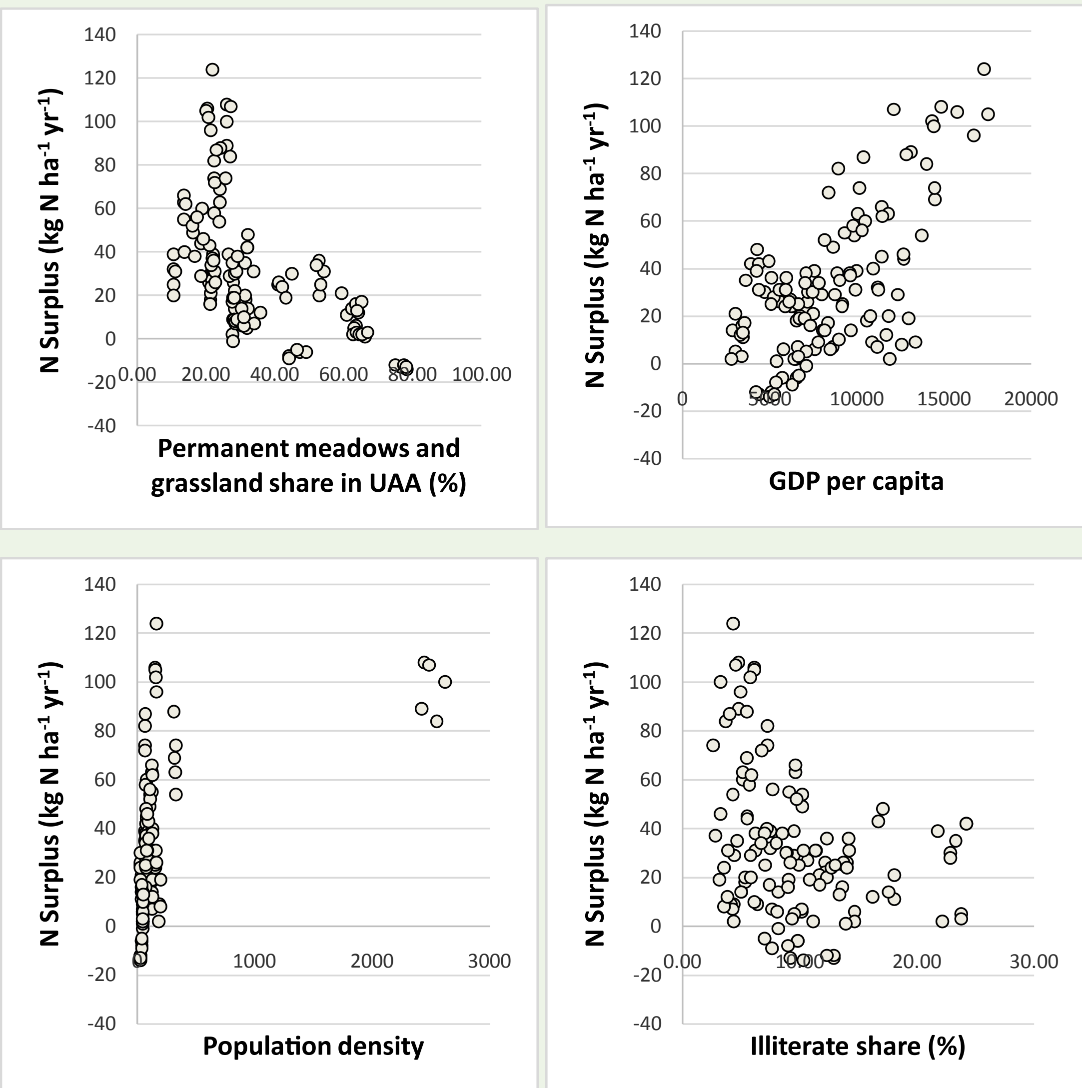

Figure 3: Scatter pilot diagrams of the important variables and nitrogen surplus for agriculture.

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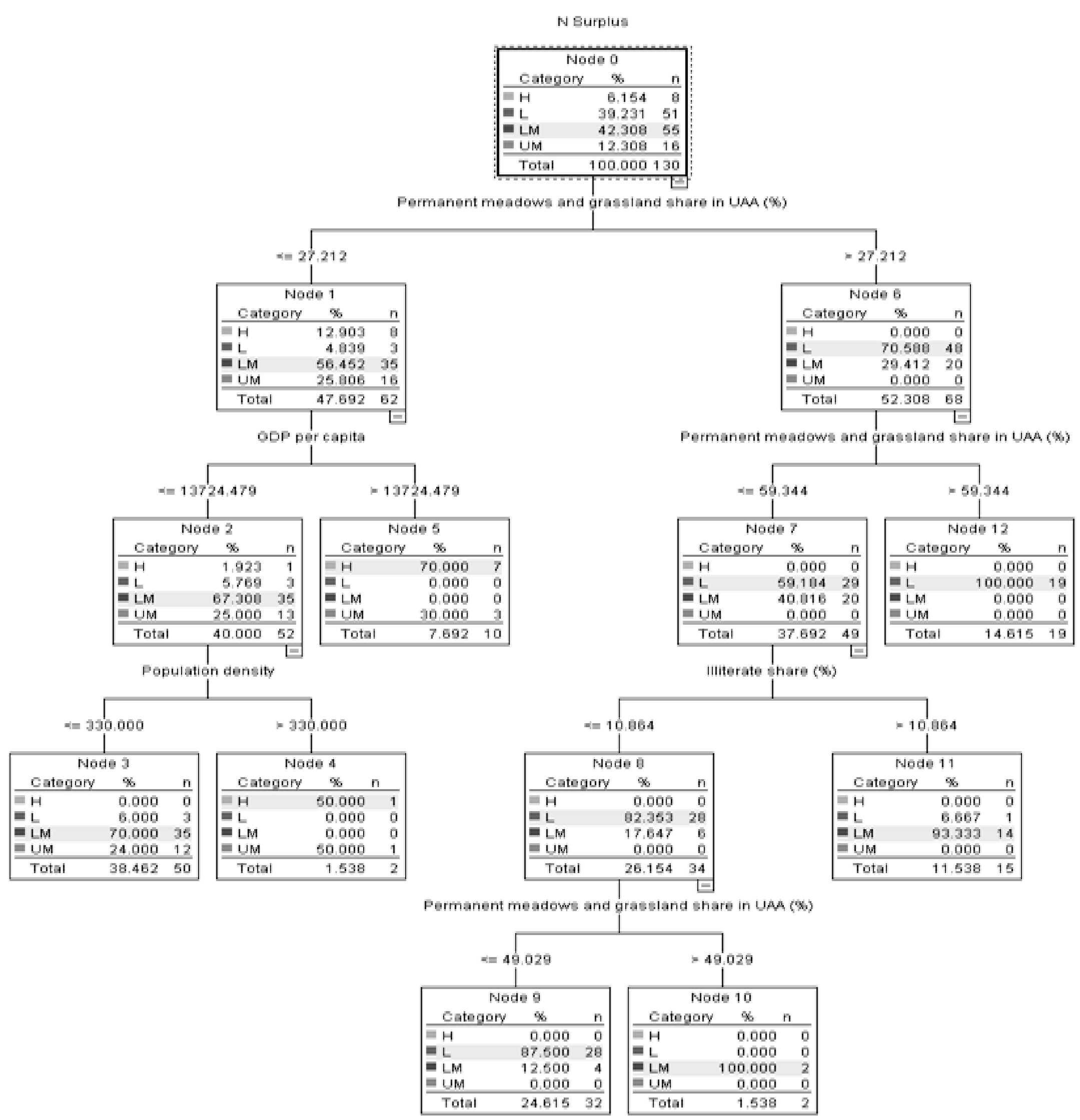

Figure 4: Decision tree diagram of the model.

higher illiterate shares and lower population density were higher than the NS of the regions with lower illiterate share and higher population density. It was also observed from the model that the more population density the more NS for the regions (Figure 4). The direct relationship of NS with population density and the inverse relationship of NS with illiterate share can be explained as follows; in the regions where population densities were low and illiterate shares were high, the extensification level in agriculture was also high and consequently low mineral fertilizer usage, hence NS values of these regions were relatively low [18]. It was therefore speculated that the regions with low population densities and high illiterate shares have a low risk for environmental degradation related to NS in comparison to other regions.

Although NS is not only one or main indicator for measuring environmental degradation, it is well known that nitrogen surplus can cause important problems that affect environmental quality and human welfare [25]. It can therefore be concluded that the permanent meadows and grassland shares in UAA and GDP per capita are the main socio-economic properties having the noticeable effect on the environmental quality and human welfare related to NS.

References

1. Ozbek FS, Leip A (2015) Estimating the gross nitrogen budget under soil nitrogen stock changes: a case study for Turkey. Agric Ecosyst Environ 205: 48-56.

2. Sutton MA, Bleeker A, Howard CM, Bekunda M, Grizzetti B, et al. (2013) Our Nutrient World: The challenge to produce more food and energy with

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less pollution. Centre for Ecology and Hydrology, Edinburgh on behalf of the Global Partnership on Nutrient Management and the International Nitrogen Initiative.

3. Sutton MA, Howard CM, Erisman JW, Billen G, Bleeker A, et al. (2011a) The European Nitrogen Assessment: Sources, effects and policy perspectives. Cambridge, Cambridge University Press.
4. Sutton MA, Oenema O, Erisman JW, Leip A, van Grinsven H, et al. (2011b) Too much of a good thing. Nature 472: 159-61.
5. Smil V (2011) Nitrogen cycle and world food production. World Agriculture 2: 9-13.
6. Bouwman AF, Van Drecht G, Van der Hoek KW (2005) Global and regional surface nitrogen balances in intensive agricultural production systems for the period 1970-2030. Pedosphere 15: 137-155.
7. Carpenter SR, Caraco NF, Correll DL, Howarth RW, Sharpley AN, et al. (1998) Non-point pollution of surface waters with phosphorus and nitrogen. Ecological applications 8: 559-568.
8. Mosier A, Kroeze C, Nevison C, Oenema O, Seitzinger S, et al. (1998). Closing the global N_2O budget: Nitrous oxide emissions through the agricultural nitrogen cycle. Nutrient Cycling in Agroecosystems 52: 225-248.
9. OECD (2001) Environmental Indicators for Agriculture: Methods and Results. OECD, Paris.
10. Bassanino M, Grignani C, Sacco D, Allisiardi E (2007) Nitrogen balances at the crop and farm-gate scale in livestock farms in Italy. Agric Ecosyst Environ 122: 282-294.
11. Shafik N, Bandyopadhyay S (1992) Economic Growth and Environmental Quality Time-Series and Cross-Country Evidence. Working Papers (WPS 904). The World Bank.
12. Panayotou T (1997) Demystifying the Environmental Kuznets Curve: Turning a Black Box into a Policy Tool. Environment and Development Economics 2: 465-484.
13. Dasgupta S, Laplante B, Wang H, Wheeler D (2002) Confronting the Environmental Kuznets Curve. Journal of Economic Perspectives 16: 147-168.
14. Managi S (2006) Pollution, Natural Resource and Economic Growth: an Econometric Analysis. International Journal of Global Environmental Issues 6: 73-88.
15. Shen RP, Sun B, Zhao QG (2005) Spatial and temporal variability of N, P and K balances for agroecosystems in China. Pedosphere 15: 347-355.
16. Zhang H, Yu Y, Hu H (2011) Economy Growth and Agricultural Non-point Source Pollution: An Empirical Analysis: Based on Provincial Paneldata (1990-2007). Energy Procedia 5: 545-549.
17. Eurostat (2012) Methodology and Handbook Eurostat/OECD Nutrient Budgets EU-27, NO, CH. Luxembourg, Eurostat.
18. Ozbek FS (2014): Estimation of National and Regional Phosphorus Budgets For Agriculture In Turkey, Spanish Journal Of Agricultural Research 12: 52-60.
19. Kotsiantis SB (2007) Supervised Machine Learning: A review of classification techniques. Infromatica 31: 249-268.
20. Zhang L, Chen Y, Liang Y, Li N (2008) Application of data mining classification for Customer Membership Card Model. College of transportation and management China.
21. Moore AW (2003) Information gain.
22. Stern D, Common MS, Barbier EB (1996) Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development. World Development 24: 1151-1160.
23. Eurostat (2013) Gross Nutrient Balance.
24. Turkstat (2014) Turkish Statistical Institute.
25. Vitousek PM, Naylor R, Crews T, David MB, Drinkwater LE, et al. (2009) Nutrient Imbalances in Agricultural Development. Science 324: 1519-1520.

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