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Determining factors that affect the sustainability of forage crop production

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ABSTRACT: This study identified the fundamental factors determining the sustainability of forage crop production. Sustainability is a concept directed towards the balanced utilization of natural resources, ensuring the fulfillment of future generations' needs. Conducted using data from 306 farms in the Erzurum province, Turkey, this research investigated the impact of factors such as producers' age, income levels, non-agricultural earnings, and education levels on the desire to continue forage crop production. The regression analysis was performed in the R program with probit model. The findings notably demonstrate the influence of age, non-agricultural income, agricultural support, and educational attainment on forage crop production. Overall, this study delineated key elements shaping sustainability in forage crop production, offering crucial guidance for future endeavors.
Key words: agriculture production, forage crops, probit model, sustainability.

Determinando os fatores que afetam a sustentabilidade da produção de culturas forrageiras

RESUMO: Este estudo tem como objetivo identificar os fatores fundamentais que determinam a sustentabilidade da produção de culturas forrageiras. A sustentabilidade é um conceito direcionado para a utilização equilibrada dos recursos naturais, assegurando o atendimento das necessidades das gerações futuras. Conduzida com dados de 306 fazendas na província de Erzurum, na Turquia, esta pesquisa investiga o impacto de fatores como a idade dos produtores, níveis de renda, ganhos não agrícolas e níveis de educação sobre o desejo de continuar a produção de culturas forrageiras. A análise de regressão foi realizada no programa R com o modelo probit. Os resultados demonstram de maneira significativa a influência da idade, renda não agrícola, suporte agrícola e nível educacional na produção de culturas forrageiras. De maneira geral, este estudo delineia elementos-chave que moldam a sustentabilidade na produção de culturas forrageiras, oferecendo orientações cruciais para empreendimentos futuros.
Palavras-chave: produção agrícola, culturas forrageiras, modelo probit, sustentabilidade.

INTRODUCTION

Sustainability is a concept that utilize natural resources and environmental factors in a balanced manner to meet needs while allowing future generations to fulfill their own needs. In this regard, it encompasses global-level social, economic, and environmental components. Achieving sustainability requires maintaining a balance among these components. The social dimension of sustainability encompasses a society's well-being, equality, and justice. Environmental sustainability targets the conservation of natural resources and ecosystems. Economic sustainability signifies the continuity of economic activities and the persistence of development. Sustainable animal production can be defined as production that meets current needs without compromising the ability of future generations to meet their needs. For instance, the production of fodder crops is essential for sustainable animal production (OLTJEN & BECKET, 1996; VAVRA, 1996). Globally, particularly in agriculturally advanced countries, substantial agricultural land is allocated for the cultivation of fodder crops. Perennial fodder crops cover 36% of cultivated lands in Eastern Canada and 43% in Northeastern United States (THIVIERGE, 2023).

In the context of sustainable animal husbandry in Turkey, the significance of fodder crop production resources stands out prominently. Fodder crop production holds vital importance for the development of animal husbandry. Fodder crop agriculture among agricultural activities is considered the cornerstone of both plant and animal production (SOYA et al., 2004; AÇIKGÖZ et al., 2005; AKMAN et al., 2007).

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Similar to other countries around the world, pasture lands in Turkey hold great importance both in terms of animal feeding and as elements of natural balance (ÇOMAKLI, 2021). Turkey possesses 14.6 million hectares of meadow-pasture land, with the Eastern Anatolia and Central Anatolia regions having the most extensive pasture areas (TURKSTAT, 2023). However, the condition of pastures that are grazed beyond their capacity is gradually deteriorating. With the increasing grazing pressure, pastures have largely lost their original vegetation (SAYAR et al., 2015). This situation underscores the significant role of forage crop production. In Turkey, the rates of fulfilling the needs of animal production from fodder crops are 24% from alfalfa, 4% from sainfoin, and 14% from vetch. Moreover, considering the livestock population in Turkey, there exists a deficit of 27 million tons of roughage, which is attempted to be compensated for by low-quality feeds such as straw (TAGEM, 2022). To address the roughage deficit and increase production, specific products are supported by the Ministry of Agriculture and Forestry." However, supporting fodder crop production solely through agricultural support policies is insufficient to bridge the production deficit. The sustainability of fodder crop production holds significance in evaluating the status and necessary future measures.

The hypothesis of this study is that demographic and socio-economic factors, such as the age of the producers, their income levels, non-agricultural earnings, and educational attainment, significantly influence the sustainability of forage crop production. Specifically, it is posited that younger producers, higher income levels, additional non-agricultural income, and higher education levels positively correlate with a greater inclination to continue and sustain forage crop production. Furthermore, it is hypothesized that agricultural support plays a crucial role in enhancing the sustainability of these practices.

The primary purpose of this study is to systematically identify and analyze the key determinants that influence the sustainability of forage crop production. By examining various factors such as age, income levels, non-agricultural earnings, and education levels of producers, the study seeks to provide a comprehensive understanding of how these elements contribute to or hinder the continuation and sustainability of forage crop production. This analysis offered insights and recommendations for policymakers and stakeholders to foster sustainable agricultural practices in the forage crop sector. Additionally, it contributes to literature by providing a new perspective through its methodological approach and findings, laying the groundwork for future research.

MATERIALS AND METHODS

Description of the Study Area

Erzurum province, located in Turkey's coldest and highest region, predominantly consists of highlands. The plateaus reach elevations of 2000 meters above sea level, while the mountains above them exceed 3000 meters. The province is characterized by a continental climate. Considering the late spring frosts and early autumn frosts in Erzurum, the vegetation period is quite short. Additionally, its extensive pastures and fertile meadows are well-suited for livestock farming (ELKOCA & ÇINAR, 2015; TURKSTAT, 2023).

Erzurum was selected as the study area due to its extensive pasture lands and its significance in forage crop production. The study determined the impact of demographic and socio-economic characteristics of local farmers on their willingness to continue forage crop production. Specifically, the effects of factors such as producers' age, income levels, non-agricultural income sources, and educational attainment on the sustainability of forage crop production were analyzed. In this context, the Erzurum province provides an appropriate sample for identifying the key elements that influence the sustainability of forage crop production.

In the study, the primary population was identified through consultations with engineers from the Ministry of Agriculture and Forestry and district organizations in Erzurum province. Villages where forage crops are intensively cultivated were specifically selected (34 in total), and farms engaged in forage crop cultivation in these villages constituted the main universe of the study.

Sampling and Data Collection

In the selection of samples from the farms included in the main population, the simple random sampling method was employed. The number of farms to be included in the sample was determined using the following formula, considering a 10% margin of error and 90% confidence limits (ÇIÇEK & ERKAN, 1996):

$$n = \frac{N * \sigma^2}{(N-1) * D + \sigma^2}$$

n = Number of farms to be surveyed.

N = Number of farms in the population, with a value of 9457.

σ^2 = The variance value for the size of forage crop

land owned by the farms constituting the population is 825.8.
D = Calculated as (d^2 / z^2) with a value of 2.7.
d = Permissible error amount from the sample mean ($\bar{x} * 0{,}10$) with a value of 2.71.
$\bar{x}$ = Average land area per farm, with a value of 27.1 da.
z = Represents the z value in the standard normal distribution table according to the error rate, with a value of 1.65.

$$n = \frac{N * \sigma^2}{(N-1) * D + \sigma^2} = \frac{9457 * 825.8}{9456 * 2.7 + 825.8} = 305.45 \sim 306$$

When the values are plugged into the formula, we obtain 305.45, and the survey count is determined as 306. A total of 306 surveys were conducted through face-to-face interviews with farms engaged in forage crop cultivation, both those receiving support and those not receiving support. Tabular data from the survey were formatted appropriately for analysis in Excel.

Statistical Analysis of Data: Probit Model

To demonstrate the sustainability of production, a probit model was established to identify the factors affecting production. The probit model is a qualitative regression model based on the normal distribution, where the variables take values of 1 or 0. In our study, the producers' response to the question "Do you want to continue forage crop production?" was coded as 1 for yes and 0 for no, forming our dependent variable. The independent variables included in the model were the producer's age (quantitative), gross production value of farm (GPV) value of each farm (taking values of 1, 2, or 3), livestock farming activity (1 if yes, 0 if no), receiving forage crop support (1 if yes, 0 if no), desire to increase cultivation area (1 if yes, 0 if no), non-agricultural income (1 if yes, 0 if no), education level (taking values of 1, 2, 3, or 4), and the ratio of experience to age (quantitative). To determine if the categories of X and Y variables are dependent on each other, binary choice models as suggested by GUJARATI (1995) and GREENE (2003) are used.

For the probit model, the cumulative distribution function needs to be appropriately selected. The probit model, derived from the normal cumulative distribution function, is mathematically expressed as follows (DÜZGÜNEŞ et al., 1993; AKKAYA & PAZARLIOĞLU, 1998):

$$F(x) = \int_{-\infty}^{x_0} \frac{1}{\sqrt{2\sigma^2 \Pi}} e^{-(x-\mu)^2/2\sigma^2}$$

The probit analysis uses utility theory to explain the model. With $Y_i = \alpha + \beta X_i + £i$ probit analysis provides information about the unobservable Y_i utility index, allowing estimation of the α and β parameters. The index Y_i or the producer's desire to continue or not continue production, and the independent variables are represented by X_i In this context, with $Y_i = F(X_i)$,
X_1: Producer's age.
X_2: Experience-to-age ratio.
X_3: Receiving forage crop support.
X_4: Livestock farming activity of the farms.
X_5: Producers' desire to increase cultivation area.
X_6: Presence of non-agricultural income for producers.
X_7: Probability of GPV < 50.000 (GPV ≥ 500.000 is taken as reference).
X_8: Probability of 50.000 ≤ GPV < 200.000 (GPV ≥ 500.000 is taken as reference).
X_9: Probability of 200.000 ≤ GPV < 500.000 (GPV ≥ 500.000 is taken as reference).
X_{10}: Probability of being a primary school graduate (with non-literate individuals as the reference group).
X_{11}: Probability of being a secondary school graduate (with non-literate individuals as the reference group).
X_{12}: Probability of higher education graduate (with non-literate individuals as the reference group).

A total of 12 independent variables were included in the model. In determining the factors influencing production, numerous model attempts were made, and decisions regarding the most suitable model were based on Pseudo R^2, Wald Chi^2, Log-likelihood statistics. Robust standard errors and the Newton-Raphson algorithm were employed in the model estimation process.

The accurate estimation of error term standard deviations is crucial during the prediction of a statistical model. In this context, Robust Standard Errors serve as a method used to compute error term standard deviations based on the model's predictions. This methodprovided more reliable results when assumptions about the distribution of error terms in the model are not met (HOECHLE, 2007).

The Newton-Raphson algorithm is an optimization algorithm used in models estimated by methods such as maximum likelihood or least squares. Furthermore, the Newton-Raphson algorithm is known for its effectiveness in terms of convergence speed and efficiency (BÖHNING, 1999).

RESULTS AND DISCUSSION

The probit model established with the variables included according to the test was analyzed

using the R statistical program. Consequently, based on the analysis results, factors influencing the continuation of production, their effect sizes, and marginal effects were determined.

Descriptive statistics for the variables are presented in table 1. The mean value for the dependent variable, the decision to continue production, was determined to be 0.8790.

The results of the regression analysis are presented in table 2. The Wald Chi-Square value, a statistical measure used to test the significance of independent variables in the probit regression model, is notably high at 654.54. Consequently, the effects of the independent variables in our model are statistically significant. The Pseudo R Squared value stands at 0.1933, measuring the compatibility of data with the model, akin to McFadden R Squared.

In analogous studies, AYYILDIZ & ÇIÇEK (2023) reported a McFadden R Squared value of 0.20, ALTINTAŞ et al. (2017) indicated a McFadden R Squared value of 0.38, while ALTINTAŞ et al. (2018) determined a McFadden R Squared value of 0.35.

Analysis revealed that factors influencing the sustainability of fodder crop cultivation included the desire to increase cultivation area, education levels in terms of elementary, secondary, and higher education compared to non-literate farmers at a 1% significance level, age, experience relative to age, receiving fodder crop subsidies, and engagement in livestock farming at a 5% significance level. Additionally, non-agricultural income and the probability of having an income less than GPV < 50,000 ₺ compared to those within the range 50,000 ≤ GPV < 200,000 also demonstrated significance at a 10% level. Notably, the decision-making process in fodder crop production is not only influenced by individual and farm-specific characteristics but also by economic factors (YAVUZ, 2004).

As producers' ages increase, the likelihood of continuing fodder crop cultivation also increases. The increasing age of farmers is expected to enhance the sustainability of forage crop production. As farmers age, they perceive agriculture as a necessary profession and livelihood to sustain their lives. They optimized the use of fields that cannot be allocated to alternative crop production besides forage crops. Forage crop production is crucial not only for its cost advantages, especially for enterprises involved in livestock farming, but also as a means for forage producers to benefit from government subsidies. This reality is better understood by older producers. Analysis indicated that for every one-year increase in a producer's age, the probability of continuing fodder crop cultivation increases by 0.3%. Similarly, in CEVHER et al. (2012) and BESHIR (2014) studies,

Table 1 - Descriptive statistics of variables influencing the sfstainability of sorage crop production.

	--Minimum Value--	--Maksimum Value--	----------Mean----------	--Standard Deviation--
Dependent Variables				
Y (Yes = 1, No = 0)	0	1	0.8790	0.3265
Independent Variables				
X_1 (Qualitatively Acquired)	18	81	48.12	0.6810
X_2 (Experience/Age)	0.06	0.98	0.6574	0.1817
X_3 (If Receives = 1, Not = 0)	0	1	0.8269	0.3790
X_4 (If Present = 1; If Absent = 0)	0	1	0.4640	0.4995
X_5 (If Desires = 1; Not = 0)	0	1	0.5751	0.4951
X_6 (Present = 1; If Absent = 0)	0	1	0.3366	0.4733
X_7 (GPV < 50.000)*	0	1	0.1928	0.3951
X_8 (50.000 ≤ GPV < 200.000)*	0	1	0.4019	0.4910
X_9 (200.000 ≤ GPV < 500.000)*	0	1	0.2745	0.4469
X_{10} (Primary School Graduate)**	0	1	0.6764	0.4685
X_{11} (Secondary School Graduate)**	0	1	0.2875	0.4533
X_{12} (Higher Education Graduate)**	0	1	0.0163	0.1269

*GPV ≥ 500.000 is taken as reference.
**with non-literate individuals as the reference group.

Table 2 - Probit pegression results on factors influencing the sustainability of forage crop production.

Independent Variables	------Coefficients------	------Standard Error-----	----------z-value----------	-----Marginal Effect----
X_1	0.0256**	0.0115	2.22	0.0032**
X_5	-1.7447**	0.7282	-2.40	-0.2197**
X_3	-0.6780**	0.2925	-2.32	-0.0617***
X_4	0.4552**	0.2090	2.18	0.0565**
X_5	1.2259***	0.2098	5.85	0.1874***
X_6	0.3460*	0.2120	1.63	0.0402*
X_7	-0.7679*	0.4563	-1.68	-0.1366
X_8	-0.7989*	0.4264	-1.87	-0.1160*
X_9	-0.6455	0.4441	-1.45	-0.1018
X_{10}	-3.4809***	0.2845	-12.23	-0.3473***
X_{11}	-3.5131***	0.3231	-10.87	-0.8317***
X_{12}	-4.6108***	0.7090	-6.57	-0.9432***

Pseudo R Squared: 0.1933; Wald chisquare; 654.74 Prob (chisquare): 0.000000; Log pseudolikehood: -91.02819.
The values of ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 probability levels, respectively.

age was positively associated with the sustainability of production.

Conversely, experience relative to age exhibits an inverse relationship with the decision to continue production. Age-related experience affected forage crop sustainability negatively, as emphasized in the previous paragraph, related to the factor of age. Farming appears less attractive as an activity for young producers. Therefore, even if young producers are experienced in forage crop production or other agricultural sectors, they tend to exhibit a propensity to change jobs and switch to different sectors. This situation results from the economic and social conditions of those engaged in agricultural activities in Turkey being generally lower compared to the population in other sectors (US & AKBIYIK, 2023). As per analysis, for every one-unit increase in a producer's experience relative to their age, the likelihood of continuing fodder crop cultivation decreases by 21.97%.

Furthermore, a negative relationship exists between receiving fodder crop subsidies and the decision to continue production. The decisions of recipients of forage crop support to discontinue forage crop production stem from the perceived inadequacy of the support amount received by the producers. This indicated that producers are not satisfied with the levels of forage crop subsidies. Analysis suggested that those receiving subsidies are 6.1% less likely to perceive fodder crop production as sustainable compared to those not receiving support. Although, research in the U.S. has conflicting opinions, with no conclusive evidence that the removal of U.S. support payments either reduced production or elevated prices (WISE, 2005), this discrepancy might be attributed to the existence of other factors, such as engagement in livestock farming, influencing the decision to continue production. Additionally, in AYYILDIZ & CIÇEK (2023) study, dissatisfaction with fodder crop subsidies was found, aligning with our findings that satisfaction with support payments was generally low. Therefore, the negative impact of fodder crop support on the decision to continue production is anticipated.

Engagement in livestock farming positively influences the decision to continue production. In enterprises engaged in livestock farming, there is an expected tendency to continue forage crop production. It is crucial to reduce feed costs, which constitute the highest cost factor in animal production. Enterprises that produce their own feed alongside their livestock have a greater cost advantage compared to others. As a result, these enterprises achieve sustainable forage crop production along with more profitable production compared to others. Analysis indicated that those engaged in livestock farming are 5.65% more likely to continue fodder crop cultivation. Similarly, INAN et al. (2022) reported a positive relationship between the area cultivated with fodder crops and the presence of livestock in the operation.

In cases where businesses face liquidity or capital constraints, the likelihood of willingness to produce fodder crops decreases (LAPAR & EHUI, 2003). Our analysis also indicated that non-agricultural income positively influences the decision to continue production. Enterprises with a strong capital structure are observed to be more willing to undertake forage crop production, fulfilling both their own needs and those of other enterprises, without relying heavily on agricultural subsidies. This is an expected scenario.

The probability of continuing fodder crop cultivation is 4.02% higher for those with non-agricultural income compared to those without. Likewise, ALTINTAŞ et al. (2017) reported a positive correlation between fodder crop sustainability and non-agricultural income.

Farms with a GPV < 50,000 have a 13.66% lower probability of continuing production compared to farms with GPV 500,000. Similarly, farms falling within the range 50,000 ≤ GPV < 200,000 have probabilities of continuing production 11.60% lower than farms with a GPV 500,000. This finding indicated that an increase in gross income derived from agricultural activities enables enterprises to continue forage crop production. This outcome is expected. The increase in income from agricultural activities for forage-producing enterprises signifies that they profit from forage crop production, and this profit satisfies the producers.

Education levels significantly affect the likelihood of continuing fodder crop cultivation, with elementary, secondary, and higher education graduates being respectively 34.73%, 83.17%, and 94.32% less likely to continue production compared to non-literate farmers. The findings indicated that an increase in education levels enhances the willingness to engage in forage crop cultivation. This suggested that for farmers, forage crop cultivation is perceived as a reasonable activity. Likewise, ALTINTAŞ et al. (2017) observed a negative correlation between education and fodder crop sustainability.

CONCLUSION

The study's limitations encompass its restricted geographical focus on Erzurum province, Turkey, which restricts the generalizability of findings to regions characterized by diverse climatic, economic, and social conditions. While data from 306 farms offer a representative sample of Erzurum, broader applicability could be enhanced through larger, more heterogeneous samples. The method of data collection via surveys and farmer interviews introduces potential biases contingent upon respondent honesty and recall capabilities. The temporal specificity of the data implies that findings may not capture evolving trends over time attributable to economic, environmental, or policy changes, necessitating longitudinal investigations. Furthermore, the study's emphasis on specific demographic and socio-economic factors excludes potentially influential variables such as technological adoption and environmental considerations. Additionally, it overlooks broader policy and economic contexts that could impact the sustainability of forage crop production, such as trade policies and market dynamics. Subsequent research endeavors should address these constraints by employing larger and more diverse samples, incorporating additional variables, and adopting longitudinal methodologies to comprehensively elucidate the dynamics of sustainable forage crop production.

Analysis from the established model concerning factors affecting fodder crop sustainability indicated that producer age, engagement in livestock farming, the desire to increase cultivation area, and the presence of non-agricultural income positively influence sustainability. However, educational level, experience relative to age, receiving fodder crop subsidies, and GPV exert a negative influence on sustainability.

The positive effect of advancing age on the decision to continue production aligns with the perception of farming as a lucrative and less physically demanding profession. Similarly, engaging in livestock farming positively influences the desire to continue production, as these farms aim to produce fodder crops at lower costs. Those seeking to increase cultivation area also exhibit a desire to continue production. Fodder crop producers with non-agricultural income tend to perceive the production process as less burdensome and thus aspire to continue for additional income.

Conversely producers with experience relative to age tend to shift their focus to products with higher support and income. Educated producers, regardless of the degree, are less inclined to continue production, possibly due to considering alternative professions. The negative impact of receiving subsidies on the decision to continue production indicates dissatisfaction among fodder crop producers, potentially arising from perceiving the support as inadequate. The disparity in GPV values reflects a preference among farms for more profitable business ventures, considering the opportunity cost.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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