Black Sea Journal of Agriculture
doi: 10.47115/bsagriculture.1563531

Open Access Journal
e-ISSN: 2618 – 6578

Research Article
Volume 7 - Issue 6: 750-757 / November 2024

# ASSESSING SUSTAINABILITY DISPARITIES AMONG TYPOLOGIES OF SHEEP FARMING IN TÜRKİYE

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**Abstract:** This research aims to empirically examine the relationship between sustainability level and typological differences among Turkish sheep farms and the success of policy implications. Farm level research data were collected from randomly selected 328 sheep farms in Diyarbakır, Şanlıurfa, Mersin, Antalya, Konya, and Ankara through a structured questionnaire. Farm level sustainability was explored based on a composite sustainability index was created based on the selected 28 indicators attributed to productivity, resilience, adaptability, self-sufficiency, and equity under economic, social, and environmental pillars of sustainability. Research results revealed that the sustainability level of sheep farms varied from 36.54% to 41.19% associated with typology. Sheep farms in Type III (semi-intensive dairy sheep farms) and 5 (intensive dairy sheep farms) had the highest economic sustainability, while sheep farms in Type VI (multi-purpose sheep farms with large land) had the highest social sustainability and sheep farms in Type IV (extensive multi-purpose farms with small land) had the highest environmental sustainability. Sheep farms in Type V (intensive dairy sheep farms) were better performers than others in resilience and productivity. The research results also showed that there had been a gap between current policy implications and the real needs of sheep farms to achieve sustainability and it varied associated with typology. The study suggests considering sustainability level differences by typology when designing and practicing policy related to sheep farming. Reducing the gap between the real needs of sheep farms and current policy implications may increase the efficiency and impact of policy measures related to sheep farming.

**Keywords:** Sheep farms, Typological characterization, Sustainability assessment, Policy gap

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**Received:** October 08, 2024
**Accepted:** November 02, 2024
**Published:** November 15, 2024
**Cite as:** Canan S, Ocak Yetişgin S. 2024. Assessing sustainability disparities among typologies of sheep farming in Türkiye. BSJ Agri, 7(6): 750-757.

## 1. Introduction

Sustainable sheep farming can contribute to food security by producing high-quality, healthy meat and milk products. Sustainable sheep farming can improve the long-term economic viability of the farm by reducing costs, improving soil fertility, and reducing dependence on inputs. Therefore, several policy measures have been designed and implemented to address these issues and enhance the overall performance and sustainability of sheep farming worldwide. However, the effectiveness and success of implemented policies are unsatisfactory due to ignoring the heterogeneity and diversity among sheep farms. Sheep farms exhibit varying characteristics, such as farm size, production systems, geographical location, and resource endowments. The typological differences among sheep farms can significantly influence their performance, responsiveness to policies, and overall sustainability outcomes. Enhancing the sustainability and economic performance of sheep farms requires eliciting the typologies of sheep farms. Up to now some previous studies conducted in different parts of the world have focused on the characterization of sheep farm typology (Ion et al., 2015; Rolesu et al., 2018; Silveria et al., 2021, Pappa et al., 2021) On the other dimension, some previous research assessed the sustainability of the sheep farms (Ronchi and Nardone, 2003; Peacock and Shearman, 2010; Toro-Mujica et al., 2015; Paraskevopoulou et al., 2020; McCoart et al., 2020). Because examining sheep farm typology and sustainability in different zones without tying each other causes some important information to be overlooked, integrating the sustainability assessment with the sheep farm typology is crucial to formulating policy measures for directing the sheep farming sector. Some pioneering studies have been conducted worldwide to reduce the information gap (Ripoll-Bosh et al., 2012; Toro-Mujica et al., 2014; Styliannou et al., 2020; Barron et al., 2021). However, there still is an information gap on the link between sheep farm and their typology. Since the characteristics of sheep farming vary associated with geographical location, sheep breed, feed sources, farming culture, etc., there has been in need to reveal the link between sheep farm typology and their sustainability in different parts of the world to generalize the scientific findings. Therefore, this research revolves around the question of whether the consideration of typological differences among Turkish sheep farms during the design and implementation of policies can enhance the success



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of adopted policies related to sheep farming. By considering the typological differences among Turkish sheep farms when formulating and implementing policies, it is hypothesized that policymakers can better tailor measures to meet the specific needs and characteristics of different sheep farm types. This approach holds the potential to unlock untapped opportunities, optimize resource allocation, and enhance the overall success of policies related to sheep farming.
This research aims to empirically examine the relationship between sustainability level and typological differences among Turkish sheep farms and the success of policy implications in the sheep sector. Through a comprehensive analysis of relevant data, including farm surveys, policy documents, and performance indicators, this study will investigate the extent to which policy outcomes are influenced by the incorporation of typological considerations. By evaluating the effectiveness of different policy approaches in light of typological diversity, this research seeks to provide valuable insights and recommendations for policymakers, practitioners, and stakeholders involved in the sheep farming sector. Ultimately, the aim is to provide evidence-based recommendations that can inform future policy design and implementation strategies, leading to a more resilient, efficient and prosperous sheep farming sector in Türkiye.

## 2. Materials and Methods

### 2.1. Research Data

Türkiye is one of the most important sheep producers in the world. In Türkiye, sheep constitute 25% and 5% of domestic meat and milk production, respectively (TSI, 2022). Sheep production is conventional and characterized by low productivity and efficiency (Gürsoy, 2006). The study focused on sheep farms in Diyarbakır, Şanlıurfa, Mersin, Antalya, Konya, and Ankara provinces of Türkiye, which are among the top ten provinces in Türkiye. These provinces have the 23% of the total number of sheep in Türkiye (TSI, 2022). Farm level research data were collected from randomly selected 328 sheep farms through a structured questionnaire. Sample sizes for Diyarbakır, Şanlıurfa, Mersin, Antalya, Konya, and Ankara were 55, 57, 63, 52, 36, and 65, respectively.

### 2.2. Typological Characterization of the Sheep Farms

Typologies of sheep farms characterized by Canan et al. (2022) were adopted in the study when examining the link between the sheep farm typology and sustainability. Canan et al. (2023) elicited six different sheep farm typologies. 14% of the sample sheep farms were the members of Type I, which was called extensive-traditional-replacement farms with low input. Replacement breeding was the main activity of this type of sheep farm characterized by small herd size, on average 190 sheep, low family labor, and owner of small farmland (5.4 ha).
The second sheep farm typology was multi-purpose sheep farms with the lowest family labor use. Nearly, 17% of the sample sheep farms were assigned to the Type II. They generated their income from the sale of meat, milk, and livestock. These sheep farms had the lowest family labor by 1.48 LU. They had also a relatively smaller herd size with an average of 183 animals, smaller sheep barns, and larger farmland (13.56 ha) compared to others. The percentage of income generated by sheep in total income was lower. Sheep farms in this typology tended to balance crop production and animal husbandry activities.
Type III was called semi-intensive dairy sheep farms. 8% of the sample sheep farms were assigned to this typology. They specialized in sheep farming. They had the largest flock size, an average of 737 sheep, and the highest fertility. Their sheep barns were relatively larger. They partially benefited from pasture and their outside input use was high. The technology level of sheep farms in Type III was satisfactory. Although family labor use of sheep farms in Type III was relatively high (3.44 LU) compared to the others, their labor use per sheep was lower due to the highest herd size. 15% of the sheep farms that took place in typology benefited from grazing.
Extensive multi-purpose farms with the smallest land (Type IV) were the most common typology in Türkiye. Approximately, 37% of the sample sheep farms took place in this typology group. Income generated sheep production of sheep farms in this typology had the largest share in overall farm income by 95.1% due to having the smallest farmland. Family labor use (2.61LU) was generally low and their average flock size was 291. The main distinction between Type II and Type IV is that the highest share of income is generated by sheep production.
Sample sheep farms included in Type V were called intensive dairy sheep farms and they constituted 13% of sample sheep farms. They had the highest labor use per sheep, the largest sheep barns, and the smallest herd size with 621 sheep. The fertility of sheep farms in Type V was moderate. Their farmland was relatively small and they did not benefit from grazing.
Type VI was named multi-purpose sheep farms having large farmland. 11% of sample sheep farms were included in this group. They had a low level of income generated by sheep production and their fertility rate and labor use per sheep was low. Herd size was 249 sheep in these farms.

### 2.3. Sustainability Assessment

Farm level sustainability was explored by using a site-specific classification method considering the physical, social, and economic characteristics of sample sheep farms. Basic factors were developed based on the site-specific characteristics and previous literature to obtain basic information on the indicators representing the characteristics of the research area concerning sheep farming. Since an indicator has limited applicability spatially, the approach of typological characterization based on sheep farm level indicators was adopted in the study. The list of possible indicators was prepared by using the results of previous studies focused on the sustainability assessment of sheep farms worldwide (Masera et al., 2000; Lopez-Ridaura et al., 2002). Then the final set of indicators was created by confirming the selection criteria. Scientific validity, data availability, measurability, easily interpretable, clarity, and sensitivity were used as the selection criteria based on the suggestion of Pannell and Glenn (2000) and Reed et al. (2006) in the study. After checking the adaptability of the indicators, the 3S approach suggested by Cloquell-Ballester et al. (2006), which is self, scientific, and social authorization, was adopted when checking the validity of the indicators for determining the final set of indicators. 28 final indicators were assigned to the 3-sustainability pillars such as economic, social, and environmental. Five distinct attributes such as productivity, resilience, adaptability, self-sufficiency, and equity were also used for assigning sheep farms (Masera et al., 2000; Lopez-Ridaura et al., 2002). Economic efficiency, food conversation rate, and animal productivity were attributed to the productivity of sheep farms. Farm continuity, satisfaction, farm structure aspect of biodiversity, working capital, technical efficiency, income risk, net farm income per capita, and carbon emission were attributed to the resilience of farms to competitive markets and climate change. The adaptability of farms to a lack of economic and environmental resources included the variables of number of incomes, communal grazing area, farmers' training on sheep production, education and experience, residue management, distance to city, veterinary cost, and off-farm income. The variables of property of land, salary level, stocking rate, and hired labor were attributed to the equity of sheep farms. Contrary to previous studies conducted by López-Ridaura et al. (2002), Vilain (2008), Ripoll-Bosh et al. (2012), Lebacq et al. (2015) and Barron et al. (2021), the fact that the farms produce their own feed, use their own workforce and land was not used as a self-sufficiency indicator in this study. If the farms' use of their own resources is costlier than purchasing or leasing from outside, then the farms cannot be self-sufficient and sustainable in economic terms. Therefore, using one's own resources does not always mean self-sufficiency. Whether the inputs used by the farms in production are self-sufficient should be evaluated economically, not physically. Therefore, subsidy rate, current ratio, rate of return equity, profit margin ratio, and debt ratio were attributed to the self-sufficiency of farms in this study (Table 1).

**Table 1.** List of final indicators and definition

| Sustainability pillar | Indicators | Attribute* | Unit/definition |
|---|---|---|---|
| Economic | Economic efficiency | Productivity | Agricultural income/Total costs (%) |
| | Food conversion rate | Productivity | Livestock income/Feed cost (%) |
| | Animal productivity | Productivity | Lamb/Sheep |
| | Operating capital | Resilience | USD/farm (thousand USD) |
| | Income risk[1] | Resilience | Deviation of agricultural income (thousand USD) |
| | Net farm income per capita | Resilience | USD/person (thousand USD) |
| | Off-farm income | Adaptability | Off-farm income/Total income (%) |
| | Subsidies | Self-sufficiency | Total subsidies/Net margin (%) |
| | Current ratio | Self-sufficiency | Current assets/Current debt (%) |
| | Profit margin ratio | Self-sufficiency | Return on capital/Total operating income (%) |
| | Risk tolerance | Self-sufficiency | Equity/Total capital (%) |
| | Debt ratio | Self-sufficiency | Debt/Total capital (%) |
| Social | Farm continuity | Resilience | Presence of children intend to continue sheep farm (yes/no) |
| | Satisfaction | Resilience | yes/no |
| | Farmers' training in sheep production | Adaptability | yes/no |
| | Farmer operator's experience | Adaptability | Year |
| | Distance to city | Adaptability | km |
| | The percentage of owned land | Equity | Own area/Total area (%) |
| | Farmers operator's education | Adaptability | Scale (1:primary school, 2:secondary school, 3:high school, 4:bachelor 5:master |
| | Salary level[2] | Equity | Family income/Reference salary (%) |
| | Hired labor | Equity | Hired labor unit/Total labor unit (%) |
| Environmental | Income diversity [3] | Adaptability | Number of income sources |
| | Technical efficiency | Resilience | Stochastic frontier analysis (0-1) |
| | Stocking rate | Equity | Animal Unit/Forage area (AU/ha)) |
| | Carbon emission | Resilience | Carbon dioxide equivalent or $CO_2$e (kg/farm) |
| | Communal grazing area | Adaptability | yes/no |
| | Residue management | Adaptability | Pesticide cost/ha (USD/ha) |
| | Veterinary cost | Adaptability | Vet cost/Animal Unit (USD/AU) |

[1] Income risk means expected mean absolute agricultural income deviation. When the expected mean absolute agricultural income deviation was calculated 10 years of historical data covering yields and prices of production activities, input quantities, and input prices from 2012 to 2021 was used, [2] The poverty line for 2021 was taken as the reference salary (TSI 2022), [3] Income diversity refers to the number of alternative income sources including the number of crops, the number of animal activity, and non-agricultural income.

Quantitative and qualitative data to calculate the values of final sustainability indicators were obtained from sample sheep farms through well designed and structured questionnaires. The scores of technical efficiency and economic efficiency were estimated by using stochastic frontier analysis. The production and cost functions were estimated by using a maximum likelihood estimator. To calculate the technical efficiency score was the ratio of the actual productivity achieved by the sheep farm to the maximum achievable productivity. The observed cost of the sheep farm was divided by the minimum cost to calculate the economic efficiency score. When determining the carbon emission, the default emission factors for methane from enteric fermentation in lambs and adult sheep, which are kilograms of methane per year per lamb/sheep (in carbon dioxide equivalent or $CO_2e$), were used.

**2.4. Linking Typological Characterization and Sustainability of Sheep Farms with the Policy Measures**

When exploring the link between typological characterization and sustainability of sheep farms with the policy measures, the Turkish government's current policy measures were considered. The gap between current policy implications and normative policy measures was revealed. Current policy implications were based on Ministry of Agriculture and Forestry (MoAF) policy instruments in 2022. Normative policy measures were created based on the previous research findings.

## 3. Results and Discussion

### 3.1. Sustainability of the Sheep Farms by Typology

Based on the results of the sustainability assessment, the sustainability index of sheep farms in Type I -VI were 36.70%, 41.19%, 38.55%, 36.54%, 38.48%, and 41.16%, respectively. The sustainability index of sheep farms varies associated with the pillars of sustainability. Type I did not have the best or worst scores in terms of sustainability scores, but it had the second-best scores in each category of sustainability. This meant that this type of sheep farm had achieved a certain status in terms of sustainability. The highest productivity score and the lowest scores of adaptability score were in sheep farms in Type II (Figure 1). While the self-sufficiency score of the sheep farms in Type III was the lowest, they had the highest economic sustainability score (Table 2). When glancing at the adaptability attribute, it was clear that the adaptability score of the sheep farms in Type IV scoring was also better than the rest. However environmental sustainability scoring and equity scoring of sheep farms in Type IV was the lowest (Figure 1). Sheep farms in Type V had the highest economic sustainability score (Table 2). They had also the highest resilience score. But, the lowest score of productivity was in Type V (Figure 1). The index of social sustainability showed that sheep farms in Type VI had the highest score. However, sheep farms in Type VI had the lowest environmental sustainability score. At the same time, the lowest scores of resilience were in Type VI (Figure 1).

The typologies identified in this study exhibit distinct characteristics and varying sustainability scores across economic, social, and environmental pillars. Comparing these findings with previous literature, we can observe both similarities and differences, shedding light on the consistency and context-specific nature of sustainability in sheep farming.

**Table 2.** Composite sheep farm level sustainability index associated with a pillar of sustainability and typology

| Pillars | Indicators | Type I | | Type II | | Type III | | Type IV | | Type V | | Type VI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Value | Index | Value | Index | Value | Index | Value | Index | Value | Index | Value | Index |
| | Economic efficiency | 0.06 | 0.35 | 0.49 | 0.42 | -0.17 | 0.31 | 0.05 | 0.34 | -0.18 | 0.31 | 0.83 | 0.47 |
| | Feed conversation ratio | 0.32 | 0.03 | 0.56 | 0.06 | 0.67 | 0.07 | 0.43 | 0.04 | 0.22 | 0.02 | 0.27 | 0.03 |
| | Animal productivity | 1.39 | 0.18 | 1.68 | 0.21 | 2.07 | 0.26 | 1.47 | 0.19 | 1.48 | 0.19 | 1.18 | 0.15 |
| | Operating capital | 47.27 | 0.08 | 59.18 | 0.05 | 59.92 | 0.04 | 67.43 | 0.09 | 53.85 | 0.05 | 78.60 | 0.02 |
| | Income risk | 12.39 | 0.40 | 3.21 | 0.48 | 10.04 | 0.43 | 13.63 | 0.39 | 11.57 | 0.42 | 6.15 | 0.48 |
| Economic | Net farm income per capita | 9.75 | 0.17 | -1.00 | 0.11 | -1.35 | 0.11 | 7.86 | 0.16 | -0.87 | 0.11 | -0.89 | 0.11 |
| | Off-farm income | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | Subsidies | 3.48 | 0.58 | -16.32 | 0.58 | 4.38 | 0.58 | -13.61 | 0.58 | 67.95 | 0.56 | 5.94 | 0.58 |
| | Current ratio | 0.41 | 0.41 | 0.70 | 0.70 | 0.79 | 0.79 | 0.53 | 0.53 | 0.77 | 0.77 | 0.54 | 0.54 |
| | Profit margin ratio | -52.86 | 0.93 | 5.51 | 0.96 | -78.96 | 0.92 | -109.37 | 0.90 | -188.42 | 0.90 | 8.62 | 0.97 |
| | Risk tolerance | 0.83 | 0.83 | 0.87 | 0.87 | 0.93 | 0.93 | 0.87 | 0.87 | 0.94 | 0.94 | 0.91 | 0.91 |
| | Debt ratio | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 |
| | Farm continuity | 27.08 | 0.27 | 32.73 | 0.32 | 55.56 | 0.55 | 30.58 | 0.30 | 73.81 | 0.73 | 48.57 | 0.48 |
| | Satisfaction | 45.83 | 0.45 | 34.55 | 0.34 | 29.63 | 0.29 | 38.02 | 0.38 | 26.19 | 0.26 | 48.57 | 0.48 |
| | Participation in training (%) | 64.58 | 0.58 | 29.09 | 0.18 | 18.52 | 0.17 | 38.84 | 0.43 | 14.29 | 0.16 | 31.43 | 0.30 |
| | Experience | 29.42 | 0.44 | 24.89 | 0.43 | 32.59 | 0.57 | 31.09 | 0.52 | 31.63 | 0.55 | 17.60 | 0.41 |
| Social | Distance to city | 90.61 | 0.53 | 66.45 | 0.65 | 34.75 | 0.82 | 59.18 | 0.69 | 77.66 | 0.59 | 58.06 | 0.70 |
| | Land ownership (%) | 44.62 | 0.44 | 92.60 | 0.92 | 25.93 | 0.25 | 10.65 | 0.10 | 71.43 | 0.71 | 95.75 | 0.95 |
| | Education | 1.33 | 0.26 | 1.31 | 0.26 | 1.07 | 0.21 | 1.41 | 0.28 | 1.04 | 0.20 | 1.00 | 0.20 |
| | Salary level[1] | 7.95 | 0.47 | -1.95 | 0.42 | -6.21 | 0.40 | 8.64 | 0.48 | -7.23 | 0.39 | -3.86 | 0.41 |
| | Hired labor (%) | 11.48 | 0.11 | 32.11 | 0.32 | 23.21 | 0.23 | 10.92 | 0.10 | 6.16 | 0.06 | 36.26 | 0.36 |
| | Income diversity | 2.95 | 0.32 | 2.56 | 0.26 | 2.52 | 0.25 | 3.33 | 0.38 | 2.36 | 0.22 | 2.48 | 0.24 |
| | Technical efficiency | 0.52 | 0.52 | 0.99 | 0.99 | 0.61 | 0.61 | 0.80 | 0.80 | 0.71 | 0.71 | 0.61 | 0.61 |
| | Stocking rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.02 |
| Environmental | Carbon emission[2] | 6038.73 | 0.85 | 4660.43 | 0.88 | 8503.77 | 0.79 | 6808.12 | 0.83 | 8464.36 | 0.79 | 4985.98 | 0.88 |
| | Grazing | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.07 | 0.02 | 0.02 | 0.03 | 0.03 |
| | Residue management | 7.59 | 0.88 | 3.70 | 0.94 | 1.56 | 0.97 | 8.80 | 0.86 | 1.59 | 0.97 | 2.27 | 0.96 |
| | Veterinary cost | 4.98 | 0.13 | 4.57 | 0.12 | 5.87 | 0.15 | 5.33 | 0.14 | 4.11 | 0.10 | 7.53 | 0.20 |
| Sustainability index (%) | | 36,70 | | 41.19 | | 38.55 | | 36.54 | | 38.48 | | 41.16 | |

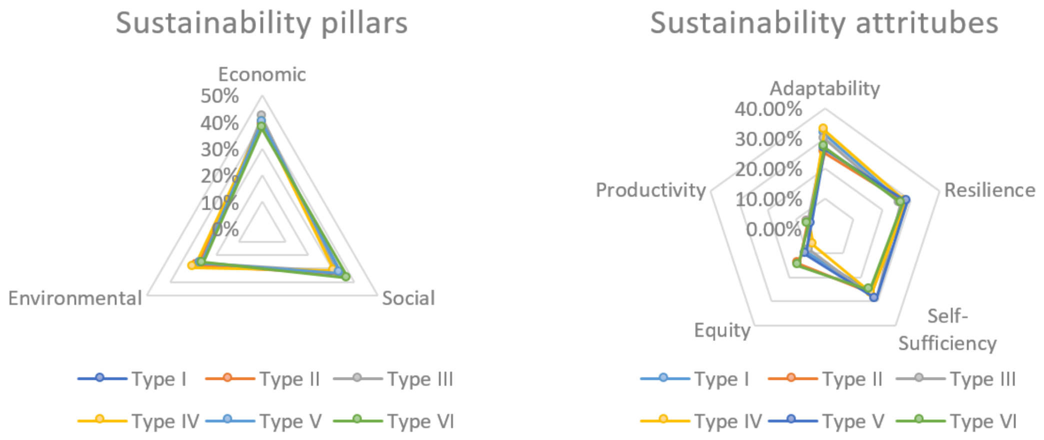


**Figure 1.** The spider graphics of the composite sustainability index by pillars of sustainability and attributes.

In terms of economic sustainability, previous studies emphasized the importance of optimizing income generation and profitability in farming systems (Ripoll-Bosh et al. 2012; Stylianou et al. 2020). Type III and V, which scored highest in economic sustainability, aligned with the literature's focus on factors such as higher livestock income, intensive inputs, and technology use. However, it was noteworthy that the other typologies received lower scores, suggesting potential challenges in achieving economic sustainability. Factors such as lower income from animals, smaller land areas, and different production focuses contributed to these lower scores. This finding resonated with studies that highlight the economic difficulties faced by small-scale and extensive farming systems (Lebacq et al. 2015). Regarding social sustainability, this study identified Type VI as the best-performing typology. This typology had larger land, a lower livestock income ratio, and a higher labor force per animal unit. This is aligned with literature that emphasizes the significance of equitable labor force utilization and land distribution for promoting social sustainability (Madelrieux et al. 2009; Ryschawy et al. 2012). However, Type IV scored the lowest in social sustainability, indicating potential concerns in terms of equity and social well-being. It was important to investigate factors such as family labor utilization and workforce dynamics to better understand the reasons behind these scores. These findings echoed previous research that has identified social inequities and labor-related challenges in farming communities (Ryschawy et al. 2012). Environmental sustainability showcased Type IV as the highest-scoring typology. This typology, despite having the smallest land area, has implemented practices that promote environmental conservation and resource management. This finding aligned with studies emphasizing the importance of environmental stewardship and resource management. However, Type VI received the lowest score, suggesting the need for improved environmental practices. Factors such as land size, fertility rate, and animal unit per farm influenced these scores. This finding corresponded to literature highlighting the potential environmental impacts of large land sizes and intensive farming practices (Ryschawy et al., 2012; Lebacq et al., 2015).

Comparing the adaptability attributes, Type I, and IV were identified as better performers, aligning with previous research that highlights the adaptability of traditional and extensive farming systems. These findings suggested that lower input and traditional approaches can contribute to the resilience and adaptability of farming operations. This implies that these typologies may be more capable of adjusting to changing circumstances, potentially due to their lower input and traditional approaches (Toro-Mujica et al., 2014). The current study identified Type V as the best performer in terms of resilience. This typology adopted measures to mitigate risks and maintain stable production, despite having the smallest flock size. It also exploited the advantages of the small flock, such as reducing carbon dioxide emissions and economically managing the small capacity farm. It was worth comparing these findings with previous literature to gain a comprehensive understanding. Previous studies emphasized various factors contributing to resilience, such as diversification of income sources, risk management strategies, and adaptive capacity (Bernués et al., 2011; Toro-Mujica, 2014; Barron et al., 2021). Self-sufficiency, another attribute of sustainability, aligned with the findings of Type III, had the highest score. This typology, with its intensive use of labor and technology, large flock size, and potential grazing practices, established a self-sufficient production system and had the best solvency with its current assets and the capacity to take risks with its equity capital. The literature emphasized the significance of self-sufficiency in reducing dependency on external resources and enhancing farm viability (López-Ridaura et al., 2002; Ripoll-Bosh et al., 2012; Lebacq et al., 2015; Barron et al., 2021). However, in this study, self-sufficiency was evaluated not from a physical point of view but from an economic point of view. Productivity, an important aspect of sustainability, showed Type II as the best performer in the current study. This typology, characterized by multi-purpose farms with a balanced focus on crop production and animal husbandry, achieved higher productivity scores. Type V scored the lowest in productivity, indicating potential areas for improvement. While the factors contributing to productivity in Type II were animal production value despite food costs and agricultural income despite total costs, Type V failed in these factors. Moreover, Type V faced the challenge of lamb production. Comparing this finding with previous literature, studies emphasized the significance of efficient production processes, balanced farm activities, and optimized resource utilization for achieving higher productivity (Veysset et al., 2005; Ryschawy et al., 2012; Toro-Mujica, 2014; Stylianou et al., 2020). Lastly, this study identified Type VI as the best performer in terms of equity. This typology, characterized by large land size and low livestock income ratio, implemented practices that promote fairness and equal distribution of resources. The factors contributing to equity in Type VI were the rate of land ownership and hired labor. Although Type IV had a good salary level, it had the lowest equity score because it was not good at other equity factors. Comparing this finding with previous literature, studies highlighted the importance of equitable resource distribution, fair labor practices, and equal access to opportunities for promoting equity in agricultural systems (Ryschawy et al., 2012).

### 3.2. Policy Implication

The gap analysis showed that there had been a gap between current policy implications and the real needs of sheep farms to achieve sustainability and it varied associated with typology, except Type I. Sheep farms included in Type II did not require benefiting from policy instruments of productivity, equity, and environmental measures. However, they benefited from this government support, resulting in decreasing in policy efficiency. Sheep farms in Type III benefited from government support related to productivity, resilience, and self-sufficiency, even if this support was unnecessary. Although government support was not necessary for sheep farms in Type IV related to adaptability, self-sufficiency, and environment, they benefited from this support. Sheep farms in Type V benefited from government support on self-sufficiency measures and environmental measures even if this support was unnecessary (Table3).

In conclusion, the findings from this study aligned with previous literature in some aspects, highlighting the importance of factors such as income generation, labor utilization, resource management, and equity for achieving sustainability in sheep farming. However, the study also revealed context-specific differences among the typologies, emphasizing the need for tailored approaches.

**Table 3.** Current policy implication and real needs of sheep farms for sustainability associated with typological characterization

| Possible policy measures set | Type I | | Type II | | Type III | | Type IV | | Type V | | Type VI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current | Real need | Current | Real need | Current | Real need | Current | Real need | Current | Real need | Current | Real need |
| Biosecurity measures | + | + | + | + | + | + | + | + | + | + | + | + |
| Productivity measures (breed support, input subsidies, training, knowledge transfer, improvement, herd management) | + | + | + | - | + | - | + | + | + | + | + | + |
| Adaptability measures (technology adoption support, infrastructure investment for pasture accessing, supporting organic farming, GAP) | + | + | + | + | + | + | + | - | + | + | + | + |
| Resilience measures (market measures, intensification, diversification, modernization, interest rate subsidies) | + | + | + | + | + | - | + | + | + | + | + | + |
| Self-sufficiency measures (insurance subsidies, supporting farmers' unions, generational renewal | + | + | + | + | + | - | + | - | + | - | + | + |
| Equity measures | - | - | - | - | - | - | - | + | - | + | - | - |
| Environmental measures | + | + | + | - | + | + | + | - | + | - | + | + |

## 4. Conclusion

This study underscores the importance of considering the unique characteristics and resource utilization patterns of different typologies when designing policies and strategies to promote sustainability. By adopting tailored approaches and addressing the specific needs of each typology, policymakers, researchers, and farmers can work towards fostering a more sustainable and resilient sheep farming sector. Stakeholders can utilize these findings to develop targeted strategies and interventions that promote sustainable practices within the sheep farming sector.

**Author Contributions**

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

| | S.C. | S.O.Y. |
|---|---|---|
| C | 50 | 50 |
| D | 50 | 50 |
| S | 100 | |
| DCP | 50 | 50 |
| DAI | 100 | |
| L | 50 | 50 |
| W | 80 | 20 |
| CR | 80 | 20 |
| SR | 100 | |
| PM | 100 | |
| FA | 100 | |

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

**Conflict of Interest**

The authors declared that there is no conflict of interest.

**Ethical Consideration**

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. The experimental procedures were approved by the Social and Human Sciences Research Ethics Committee of Ondokuz Mayis University (Approve date: March 15, 2021 and protocol code: 2021/592).

**Acknowledgments**

This work was supported by The Scientific and Technological Research Council of Türkiye [Grant no: 121K711].

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