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Agricultural Engineers as Alternative Producers in the Reuse of Abandoned Agricultural Land

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ABSTRACT
The aim of this study is to determine whether agricultural engineers would be willing to engage in agricultural production if agricultural lands that have become idle for various reasons were allocated to them, and to identify the criteria that would influence their production decisions. In this context, a survey was conducted with 134 agricultural engineers. Factors that could influence agricultural engineers' decisions to produce on idle lands were analyzed using the Fuzzy Pairwise Comparison method. The study found that the most important factors influencing engineers' decisions to produce on idle lands were grant support and marketing/purchase guarantees. Engineers indicated that the most critical services in the region where the land is allocated, for production to take place, are agricultural support and irrigation services. According to the results, costs are significant for agricultural engineers. Accordingly, minimizing the costs of establishing operations, providing marketing-related support, and intensifying agricultural support and infrastructure in the region where the land is located could enhance the effectiveness of allocating idle agricultural lands to agricultural engineers.

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Terk Edilmiş Tarım Arazilerinin Yeniden Kullanımında Ziraat Mühendislerinin Alternatif Üretici Olması

ÖZET
Çalışmanın amacı çeşitli nedenlerle âtıl hale gelmiş tarımsal arazilerin üretime kazandırılması amacıyla ziraat mühendislerine verilmesi durumunda tarımsal üretimde rol alıp almayacaklarını, hangi kriterlerin üretim kararı vermelerinde etkili olacağını belirlemektir. Bu kapsamda 134 ziraat mühendisi ile anket yoluyla görüşme sağlanmıştır. Ziraat mühendislerinin âtıl arazilerde üretim yapmalarında etkili olabilecek faktörler Bulanık Eşli Karşılaştırma yöntemiyle analiz edilmiştir. Araştırmada ziraat mühendislerinin âtıl arazilerde üretim kararı almalarında etkili olabilecek en önemli faktörlerin hibe desteği ve pazarlama/alım garantisi olduğu saptanmıştır. Mühendisler, tahsis edilecek arazide üretim yapılabilmesi için arazinin olduğu bölgede en önemli hizmetlerin tarımsal destekler ve sulama hizmetleri olduğunu belirtmiştir. Sonuçlara göre; ziraat mühendisleri için maliyetler önem arz etmektedir. Bu doğrultuda işletme kurulumu için maliyetlerin minimize edilmesi, pazarlamaya yönelik desteklerin sağlanması, arazinin olduğu bölgede tarımsal desteklerin ve alt yapının yoğunlaştırılması yoluyla âtıl arazilerin ziraat mühendislerine tahsis edilmesinin âtıl tarım arazilerinin etkinliğini arttırabileceğini göstermektedir.

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INTRODUCTION

Agriculture is expanding and intensifying in many parts of the world, but agricultural abandonment is also commonly increasing. Unfortunately, there is a lack of data and methods to accurately monitor abandoned agricultural land over large areas (Alcantara et al., 2012). Land abandonment has both negative and positive impacts; it can adversely affect biodiversity, rural livelihoods, and communities, while simultaneously enhancing local biodiversity, providing ecosystem services, and facilitating the restoration of natural landscapes (Subedi et al., 2022a).

Soils, a non-renewable resource, are being fragmented due to various factors, leading to irreversible productivity losses and economic damage. The causes of land fragmentation, which reduces the efficiency of agricultural enterprises, include inheritance and succession, partitioned and shared sales, public investments crossing agricultural lands such as irrigation, highways, and railways, partial leasing and sharecropping due to insufficient capital and labor, natural disasters like floods and landslides, and the pressure from high population density in the agricultural sector (Küsek, 2014). In Türkiye, the inability to utilize resources efficiently in agriculture often leads to the abandonment of lands.

The share of idle lands within total agricultural land is increasing as stakeholders abandon production on inherited lands whose ownership has not been fully transferred. Many producers sell their shares, contributing to the rise in idle land (Tanrıvermis et al., 2024). The Ministry of Agriculture and Forestry has attempted to address land fragmentation and ensure minimum agricultural land sizes through regulations such as the "Regulation on the Transfer of Ownership of Agricultural Lands," published in the Official Gazette No. 29222, which includes provisions on land transfer, inheritance, and economically viable land size and integrity. Additionally, the Ministry of Environment and Urbanization has taken steps to reintegrate idle public lands into productive sectors, while the Ministry of Agriculture and Forestry organized a workshop titled "Reintegrating Idle Agricultural Lands into Production and Establishing Institutional Infrastructure for Land Banking" on January 14-17, 2019. During the workshop, various definitions of land types were provided (GDAR, 2019):

- Agricultural land that is viable for production but left unused for at least three consecutive production cycles (October 1 to September 30) due to social, economic, technical, legal, environmental, or other reasons by the owner(s).
- Idle agricultural land: Land that, although technically and economically suitable for agricultural production, is not currently being utilized.
- Idle agricultural land (Unused Agricultural Land): Areas with negative conditions that degrade the land's characteristics and impact its use, left out of production during the rotation period.

The literature also provides varying definitions of idle land. Abandonment is understood as the transition of land use from cultivation to other uses without making any normative judgment on the desirability of this change (Sikor et al., 2009). Abandoned land refers to areas that were previously used for agriculture (either for crops or grazing) and have not been used or have been minimally used for more than three years (Grădinaru et al., 2019).

It is suggested that making idle lands suitable for production will lead to the formation of agricultural enterprises that align with economies of scale, ensuring that agricultural production becomes safer and more reliable in terms of quantity and quality. This approach will also facilitate the transferability of lands to maintain their agricultural characteristics, enhancing the features of agricultural lands, such as buying, selling, and leasing, thereby enabling more efficient use of these lands by their users. Moreover, balancing supply and demand in the agricultural land market could bring approximately 2 million hectares of idle agricultural land back into production (GDAR, 2019).

According to the "Regulation on the Leasing of Unused Agricultural Lands for Agricultural Purposes," published in the Official Gazette No. 32640 by the Ministry of Agriculture and Forestry, it has been decided that agricultural lands, excluding those under the private ownership of the Treasury or the control of the State, that belong to individuals and legal entities and have not been cultivated for two consecutive years, may be leased seasonally for agricultural purposes. The regulation states that priority in leasing will be given to residents of the locality where the agricultural land is located, as well as to non-governmental organizations and professional chambers. If no interested parties emerge from these priority groups, the lands will be leased to other applicants.

Studies examining the causes of land abandonment reveal various factors. Many studies attribute this situation to migration movements (Pazarlıoğlu, 2007; Sikor et al., 2009; Mut & Ayan, 2011; Çelik & Taşçı, 2016; Beilin et al., 2014). The factors driving migration also vary; the new job opportunities created by industrialization have intensified urban migration (Xie et al., 2014), leading younger generations to distance themselves from agriculture (Yılmaz et al., 2020). Population growth pressures on land lead to the fragmentation of agricultural lands, reduced expectations of yield and profit, and abandonment of land (Aliağaoğlu & Aslantekin, 2018). Additionally, farmer age and access to land play significant roles in land abandonment. An aging farming population struggles with

agricultural production; older producers tend to work on nearby fields and abandon distant ones (Chaudhary et al., 2018; KC & Race, 2020), continuing production on accessible and fertile lands (Zhou et al., 2020; Subedi et al., 2021).

High input costs (Blair et al., 2018), insufficient employment opportunities (Muñoz-Rios et al., 2020; Li et al., 2023), and household incomes dependent on factors such as wages, pensions (Chaudhary et al., 2018), and non-agricultural employment (Kolecka et al., 2017; Wang et al., 2024) are seen as economic reasons for land abandonment.

Physical conditions, climate, and access to technology are critical factors influencing the productivity of agricultural lands and the sustainability of production. The small scale, fragmented nature, and multiple ownerships of lands restrict production (Uzun & Yomralıoğlu, 2005; Karadağ, 2015; Yan et al., 2016; Peker & Dağdelen, 2016; Sav & Sayın, 2018). Research conducted in various regions found higher rates of land abandonment in areas with inadequate physical conditions (Beilin et al., 2014). Many studies have shown that declining parcel size leads to land abandonment (Shi et al., 2016; Levers et al., 2018; Perpiña Castillo et al., 2020). Similarly, a significant relationship between low land productivity and abandonment has been identified (Prishchepov et al., 2013; Meyfroidt et al., 2016; Ojha et al., 2017; Khanal, 2018).

While negative production conditions lead to land abandonment, positive conditions increase production intensity on the land. Sloping terrain, frost, and water scarcity have altered production patterns and led to land abandonment, yet fertile soils in some areas have facilitated concentrated production (Sikor et al., 2009). The connection between production and soil quality is well recognized, with poor and low-yield lands being more prone to abandonment (Bakker et al., 2011; Pazúr et al., 2014). Conversely, infrastructure availability and access to technology have been found to prevent land abandonment (Yu et al., 2017; Deng et al., 2019; Rajpar et al., 2019). Studies indicate that as elevation increases, abandonment rates decrease, although rates vary with slope inclination (Kolecka et al., 2017; Baumann et al., 2011). Producers are inclined to abandon agricultural lands in high flood-prone areas (Nguyen et al., 2022). Changing climate conditions are also seen as influential factors in agricultural land abandonment due to their negative effects on production (Blair et al., 2018; Levers et al., 2018; KC & Race, 2020).

The distance of agricultural lands from the producer's residence and urban centers affects land abandonment. According to Kolecka et al. (2017), agricultural lands near urban centers are more likely to be abandoned. Factors influencing this include the employment opportunities outside agriculture and the conversion of land for residential use due to urban expansion (Grădinaru et al., 2015). Distant and mountainous lands have higher abandonment rates (Yu et al., 2017). Some studies have found that as the distance from settlements increases, so does land abandonment (Zhang et al., 2016; Wang et al., 2020). Other factors contributing to abandonment include landowners residing outside the region where their land is located, the perception that non-agricultural land uses will be more valuable in the future, and financial constraints (Abolina & Luzadis, 2015).

While public policies aim to regulate agricultural production and improve rural welfare, some policies may have unintended negative effects or fail to keep producers in rural areas. A household survey in Colombia found that 39.7% of respondents cited insufficient public support as a reason for leaving rural areas (Muñoz-Rios et al., 2020). In some studies, certain public policies designed to promote nature conservation were found to contribute to land abandonment (Beilin et al., 2014). Similarly, Murua et al. (2013) found that certain ineffective policies of the Common Agricultural Policy (CAP) have led to land abandonment. In Türkiye, the opening of agricultural lands in coastal regions to tourism has led producers to abandon agriculture (Çelik Ateş et al., 2017). Between 2000 and 2008, cultivated agricultural land in Türkiye decreased by 1.9 million hectares. This decline is attributed to agricultural policies that caused some producers to suffer losses, leading them to abandon production or migrate to urban areas, leaving no one to work the lands (Özkaya et al., 2010).

Armed conflicts and regime changes worldwide also play a role in land abandonment. In Western Ukraine, the rate of agricultural land abandonment increased after the post-socialist era (Baumann et al., 2011). Abandonment rates in areas close to conflict zones were found to decrease as distance from the region increased (Baumann et al., 2015; Yin et al., 2019). In Türkiye, especially in the Eastern and Southeastern Anatolia regions, the PKK issue and the state's counter-terrorism efforts have led to mass migration (Alp, 2013; Şen, 2015; Şimşek & Özkaya, 2018; Gümüş, 2024). This has resulted in significant agricultural land abandonment and a marked reduction in agricultural production, particularly in livestock. Additionally, lands along borders with neighboring countries remain idle due to being heavily mined. In the GAP region, 216,000 hectares are idle due to minefields and security zones surrounding these areas (Öztürkmen, 2010).

The abandonment of agricultural lands can have significant consequences, both positive and negative, as identified in various studies (Beilin et al., 2014; Li & Li, 2017). Abandoned agricultural lands have shown mixed effects on bird populations, with both positive and negative impacts observed (Herrando et al., 2014; Suárez-Seoane et al.,

2002). According to Chaudhary et al. (2018), land abandonment has benefited certain rural practices' cessation but has adversely affected social cohesion within communities. Newly emerging vegetation on abandoned lands can provide habitats for wildlife, potentially damaging nearby agricultural areas (Blair et al., 2018; KC & Race, 2020).

The abandonment of agricultural lands directly and indirectly affects rural populations and economies (Perpiña Castillo et al., 2020). A reduction in arable land negatively impacts food production and income levels (Ojha et al., 2017). Widespread abandonment of agricultural lands is expected to heighten the risk of national-level food insecurity (KC & Race, 2020).

The most noticeable outcome of abandoned lands is the growth of shrubs and forests (Arnaez et al., 2011; Hou et al., 2014; Chaudhary et al., 2018), creating new ecological environments (Blair et al., 2018). However, abandoned traditional agricultural lands have been linked to soil erosion (Arnaez et al., 2011; Chaudhary et al., 2018), with the initial period of abandonment posing the highest erosion risks (Brandolini et al., 2018; Pepe et al., 2019). Another study found that while land abandonment initially increases soil loss due to erosion, these losses decrease over time (Cerdà et al., 2018). If preventive measures against new vegetative growth on abandoned lands are not taken, the extent of abandonment is expected to increase in the coming years (Kolecka et al., 2017). According to Sil et al. (2019), land abandonment leads to the expansion of forested areas and the formation of flammable vegetation, increasing the risk of wildfires. Additionally, the proliferation of scrub and heather vegetation due to abandonment reduces arable land (Bielsa et al., 2005), and structures such as drainage systems and water channels deteriorate over time (Moreira & Russo, 2007).

Abandoned lands positively influence soil organic matter (Novara et al., 2017; Liu et al., 2020; Bell et al., 2020) and increase soil moisture (Yamanaka et al., 2017). Some studies suggest that land abandonment enhances carbon sequestration (Van Der Zanden et al., 2017; Voicu et al., 2017; Wertebach et al., 2017). Abandoned agricultural lands have been found to host more nitrogen-fixing bacteria than semi-natural grasslands, depending on the duration of abandonment (Huhe et al., 2016).

The reuse of abandoned agricultural lands is crucial for meeting the growing global demand for food (Subedi et al., 2022a) and supporting neglected rural communities' development (Corbelle-Rico et al., 2022). Factors contributing to land abandonment were discussed earlier in this text. As seen in the literature, the most influential factors driving land abandonment occur at the farm level, with traditional farming methods often reducing productivity. Studies have proposed various strategies for the effective reuse of abandoned lands. Subedi et al. (2022b) suggest that farmers should be provided with household labor, infrastructure development, government incentives, training on crops with comparative advantages, and access to good markets (Levers et al., 2018) to reintegrate abandoned lands into production. Other studies recommend using abandoned lands for perennial crops or forage plants for animal feed (Guo & Song, 2019) or grazing pastures (Smaliychuk et al., 2016).

Enhanced agroforestry systems could offer adequate income for producers (Blair et al., 2018; Rai et al., 2019; Chaudhary et al., 2019). Some research highlights that in mountainous regions, cultivating tea, fruits (Yan et al., 2016), and high-value crops (Chaudhary et al., 2018; Rajpar et al., 2019) can be viable solutions for reusing abandoned lands. Abandoned lands can also be repurposed for agricultural production to promote food and nutritional security and support rural development (Khanal, 2018). Community-based farming practices aimed at large-scale agricultural production are seen as a crucial approach to revitalizing abandoned lands (KC and Race, 2020).

Artificial interventions in abandoned lands can restore vegetation, enhance plant-soil interactions, improve soil texture and microbial functions, increase carbon capture and storage capacity, and create sustainable pasture ecosystems (Yu et al., 2023). Lands unsuitable for agricultural production can be left in their natural state to enhance ecosystem services (Zhang et al., 2018) or used for energy wood production (Ruskule et al., 2013). Abandoned lands could be reforested for environmental and ecological benefits (Visockienė et al., 2019; Doelman et al., 2020) or utilized for renewable energy production by cultivating short-rotation woody crops (Abolina & Luzadis, 2015).

As shown in the literature, many factors contribute to the abandonment of agricultural lands. Despite regional differences, similar causes of land abandonment are observed in many places, and the resulting impacts often resemble each other. However, due to economic, environmental, and social differences among regions, it is not feasible to generalize the methods for reusing abandoned lands. Policymakers must promote the most appropriate methods based on specific conditions (Subedi et al., 2022a).

Countries must achieve self-sufficiency in agricultural production. Political issues or pandemics may disrupt import routes, posing significant challenges for countries reliant on external sources. Therefore, countries should optimize their agricultural lands for maximum production efficiency and maintain adequate food stocks. Considering the limitations on expanding agricultural areas, protecting and sustainably using existing lands is crucial.

In small family farms, the inadequacy and inefficient use of land are priority issues that need to be addressed. To this end, efforts should be made to establish optimal farm sizes. According to the National Real Estate General Communiqué, published in the Official Gazette No. 31246 by the Ministry of Environment and Urbanization, it is aimed to lease immovable properties under the private ownership of the Treasury or under the jurisdiction and disposal of the State for agricultural production. These properties are intended to be leased primarily to landless or insufficiently landed farmers who are registered in the population of the village/neighborhood where the property is located or reside there. In the absence of such demands, the properties may be leased to other natural or legal persons.

Expanding operational agricultural lands through the allocation of state-owned lands to farmers could contribute to addressing this issue (Kumbasaroğlu & Dağdemir, 2007). However, in recent years, farmers have increasingly distanced themselves from production, and the number of individuals willing to continue agricultural activities in subsequent generations has diminished. A study by Yılmaz et al. (2020) found that 56% of farmers did not wish to continue agricultural activities, and the agricultural sector was not seen as a promising future for their children. Economic reasons have been identified as one of the primary factors influencing this attitude among farmers regarding the continuity of the agricultural sector.

This situation is expected to lead to increased migration of the younger population to urban areas, greater employment in non-agricultural sectors, a decline in rural populations, and an increased demand for labor in agricultural production. The significant amount of idle land under public ownership, coupled with the ongoing idling of land owned by farmers due to the aforementioned reasons, has necessitated the search for alternative producer profiles.

The number of agricultural faculties in Türkiye is continuously growing. As of 2024, there are 40 agricultural faculties admitting students, with thousands of students graduating from these institutions each year. A very small proportion of these agricultural engineering graduates are employed in their field within the public sector, while some find employment opportunities in the private sector. Agricultural engineers who are unable to find jobs within their field are often compelled to work in unrelated occupations.

The primary objective of this study is to determine whether agricultural engineers would engage in agricultural production if idle agricultural lands were allocated to them and to identify the conditions under which they would be willing to participate in agricultural production. Additionally, the study aims to assess agricultural engineers' perspectives on the factors that could affect agricultural production and their views on the utilization of idle lands for production.

MATERIALS AND METHODS

The data for this study were collected through surveys conducted with agricultural engineers residing in Izmir. The survey form was developed based on a review of national and international literature, with a focus on identifying the current problems leading to the idleness of agricultural lands. Due to the COVID-19 pandemic occurring during the survey period, the questionnaires were distributed via Google Forms and reached participants through email and social media channels.

The data set utilized in this study is defined as the " Survey Data of Agricultural Engineers Residing in İzmir." In determining the sample size, the total of 5.255 registered members of the Izmir Chamber of Agricultural Engineers as of December 2021 was taken as the sampling frame. Based on a 90% confidence level and a 10% margin of error, a sample of 67 members was selected.

In addition, to expand the scope of the study and to include perspectives beyond Chamber members, 67 agricultural engineers who actively practice in İzmir but are not registered members of the Chamber were also included in the study. Equal representation of member and non-member groups aimed to enable comparative analyses and minimize sampling bias. As a result, data obtained from a total of 134 agricultural engineers were used in the analyses.

The survey data were analyzed using SPSS and Excel software packages. The opinions of agricultural engineers were statistically tested, and the chi-squared test was applied to compare groups of more than two. A five-point Likert scale was employed to assess factors that could impact agricultural production and to gather opinions on the utilization of idle lands for production. The Likert scale was structured as follows: "1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree."

The importance levels of factors influencing agricultural engineers' decisions to engage in production on idle lands, as well as the importance of services in the region of the allocated land that could affect production, were analyzed using the Fuzzy Pairwise Comparison Method. This method shows similarities to the simple pairwise comparison

method, where agricultural engineers compare two factors. In this method, a preference degree of one criterion over another is determined, and engineers are also allowed to remain indifferent between two factors. Unlike traditional numerical estimation methods, the numerical value of each objective is based on the set of compared objectives. Partial membership is a central concept of fuzzy set theory. In classical set theory, a set is well-defined if each element of the universal set either belongs (i.e., 1) or does not belong (i.e., 0) to the set. In partial membership, however, a fuzzy set is defined within the closed interval [0,1], assigning each element a value between 0 and 1. Fuzzy set theory is grounded in uncertain preferences, with fuzzy sets characterized by non-sharp boundaries (Tanaka, 1997).

The concept of fuzzy sets includes membership degrees that range between 0 and 1. In classical sets, the membership degree indicates whether an element belongs to the set, whereas in fuzzy sets, it expresses the value of variation between 0 and 1 for each element (Ross, 2005; Klir & Yuan, 1995; Pedrycz & Gomide, 1998). The first stage of the method is data collection.

The number of pairwise comparisons for the objectives is determined as follows:

$$K = \frac{n*(n-1)}{2} \quad (1)$$

Here, n represents the number of objectives. For each pairwise comparison, Rij (Where i≠j) is obtained. The measurement of the preference degree of j with respect to i is given by: Rij= 1-Rij. The second stage involves the construction of the fuzzy preference matrix. After data collection and processing as described above, the fuzzy preference matrix for agricultural engineers can be established. The following expression is used for this purpose:

$$Gcr = \begin{cases} 0 \text{ if } c = r \,\forall\, c, r = 1, \dots n \\ gcr \text{ if } c \neq r \,\forall\, c, r = 1, \dots n \end{cases} \quad (2)$$

The method can be explained using an i×j dimensional fuzzy preference matrix (R).

$$R = \begin{bmatrix} 0 & r_{12} & r_{13} & . & . & . & r_{1j} \\ r_{21} & 0 & r_{23} & . & . & . & r_{2j} \\ r_{31} & r_{32} & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & 0 & r_{i-1j} \\ r_{i1} & r_{i2} & . & . & . & r_{ij-1} & 0 \end{bmatrix} \quad (3)$$

The third stage of the method involves measuring the fuzzy weights. It is possible to calculate the degree of preference associated with each objective (i) from the preference matrix of agricultural engineers. The following formula is utilized to assess the preference intensity for each individual objective.

$$İj = 1 - \left(\sum_{i-1}^{n} R_{ij}^2 / (n-1) \right)^2 \quad (4)$$

The final stage involves ranking the factors. The values of Ij range between 0 and 1, with values closer to 1 indicating a greater intensity of preference for the respective factor. Once the Ij values are obtained, the factors are ranked from most important to least important (Günden & Miran, 2007).

In the methodology, the analysis of the agreement among the preferences of agricultural engineers was conducted using the Friedman and Kendall's W tests. The Friedman test is employed to determine whether the treatment effects obtained from data collected from a group are statistically significant (Günden & Miran, 2007).

On the other hand, Kendall's W test is utilized to measure the degree of concordance within a ranking of items in a block (Legendre, 2005). This statistic is often used as a substitute for Kendall's coefficient of concordance and can be applied in contexts where the Friedman test has been executed. Essentially, Kendall's W is a modified version of the Friedman test. The values of Kendall's W, which can range from 0.1 to 0.9 (0.1, 0.3, 0.5, 0.7,0.9), correspond to levels of agreement classified as very weak, weak, moderate, strong, and very strong, respectively (Günden & Miran, 2007).

RESULTS

Of the agricultural engineers participating in the study, 53.7% are male and 46.3% are female, with an average age of 35.75. While 69.4% of agricultural engineers reside in central districts of Izmir, 21.6% live in other district centers, 3.0% in rural areas such as towns or villages, and 6.0% in rural areas like neighborhoods/villages.

While 49.3% of agricultural engineers or their families own agricultural land, 50.7% do not possess any land assets. Looking at the percentage of those whose livelihood depends on agriculture in their families, it is determined that 25.4% derive their livelihood from agriculture, while 74.6% do not. The number of those earning a living from agriculture is 34 people (25.4%), and 67.7% operate their own property. Of those who earn a living from agriculture, 70.6% are involved in crop production, 8.8% in animal production, and 20.6% in mixed farming.

When examining the employment status of agricultural engineers, it is found that 31.3% are unemployed or working outside their profession, while 29.9% are practicing their profession in public institutions, and 38.8% are employed in their field within the private sector. Only 68.7% are employed in their respective professions. Of the interviewed agricultural engineers, 87.3% have expressed their desire to engage in agricultural production, while 12.7% have stated that they do not want to engage in production.

The average values of the degrees of participation in factors that may affect agricultural production and opinions on bringing idle lands into production by agricultural engineers are provided in Table 1. The factors identified by the agricultural engineers participating in the study in the top three positions are as follows; disputes (disagreement, conflict) arising over land ownership negatively affect production (4.26), fragmented and scattered lands negatively affect production and therefore income (4.20), and the ongoing fragmentation and reduction of lands day by day is a significant problem (4.19). The results indicate that agricultural lands owned by the treasury can be rented out to large companies (2.51), that sanctions should be imposed on the owners of uncultivated lands (3.01), and that the size of the land to be rented should be determined based on the number of family members engaged in agriculture (3.07); however, the agreement rates for these statements were found to be lower compared to others.

The research also revealed a significant inclination among non-member participants regarding the notion that treasury-owned agricultural lands should be leased exclusively to farmers $\chi 2(4, N=134) =7.98$, $p=.075$. However, no significant difference was identified concerning the opinions that lands should only be rented to landless individuals or agricultural engineers. A substantial portion of the participants expressed strong agreement with the idea that treasury-owned agricultural lands could be leased to agricultural engineers.

The results demonstrate a significant difference between non-member and member participants regarding the statement that treasury-owned agricultural lands should be rented to large companies $\chi 2(4, N=134) =7.50$, $p=.078$. Consequently, non-members showed greater agreement with the idea of renting lands to large companies.

Considering the existing economic, social, and cultural constraints, it would be inadequate to solely direct agricultural engineers toward agricultural production through land leasing. In this regard, certain criteria were established for agricultural engineers, and they were asked to compare these criteria among themselves. Table 2 presents complementary statistics regarding the results of the Fuzzy Pairwise Comparison method. Based on the obtained weights, the effective factors are ranked from most to least significant. According to the results, the most prioritized factor influencing engineers' decisions to engage in production on uncultivated lands is grant support. The other prioritized factors, in order, include marketing/purchase guarantees, labor support, agricultural insurance premium support, credit, and accommodation. The results of the Friedman test indicate a statistically significant difference among preferences.

This result indicates that agricultural engineers do not evaluate all factors equally in their decision-making process; certain support elements have a more decisive influence on their choices. In particular, the prioritization of grant support demonstrates that economic incentives strongly affect engineers' willingness to engage in production on idle lands. The high prioritization of other factors, such as marketing and labor support, further highlights the critical importance, from the engineers' perspective, of securing market access after production and ensuring sufficient labor availability during the production process.

It can be stated that some factors influencing engineers' production decisions are preferred over others. Based on the values obtained from Kendall's W test, the agreement can be categorized as very weak (0.1), weak (0.3), moderate (0.5), strong (0.7), and very strong (0.9). In this study, the Kendall's W value was determined to be 0.333. This suggests that there is a weak level of agreement among engineers regarding the weights of the criteria deemed important by the survey participants.

Table 3 presents the importance levels of the services required for agricultural production on leased lands, categorized by the region where the land is located. Utilizing the Fuzzy Pairwise Comparison method, the effective services have been ranked in descending order based on their assigned weights. The study identified agricultural support services as the most significant service essential for facilitating production on leased lands. Other prioritized services, in order of importance, include irrigation services, land consolidation, transportation services, healthcare services, and educational services. Notably, social services were found to be the least prioritized. The results of the Friedman test indicate a statistically significant difference among the preferences. This suggests that certain factors are preferred over others when it comes to enabling production on leased lands.

Table 1. Opinions of agricultural engineers on factors that may affect agricultural production and the idle land for production

Çizelge 1. Ziraat mühendislerinin tarımsal üretimi etkileyebilecek faktörler ve atıl arazilerin üretime kazandırılması konusunda görüşleri

Faktörler (*Factors)*	Ortalama/ *Mean*	Std Sapma/ *St. Dev.*
Disputes over land ownership (disagreement, dispute) negatively affect production.	4.26	1.011
The fact that the lands are very fragmented and dispersed negatively affects production and, therefore, income.	4.20	1.095
The fragmentation and shrinkage of land is a major problem.	4.19	1.114
The distribution of agricultural lands belonging to the treasury positively affects production.	3.99	1.069
Agricultural lands belonging to the treasury can be leased to Agricultural Engineers.	3.93	1.045
An association/union can be established for the purpose of land utilisation.	3.78	1.193
The idle land can be rented or sold to another producer with land nearby.	3.78	1.140
Small, scattered, fragmented, and unused lands should be gathered under a professional roof with no profit margin, acting only as a bridge, and brought into production, provided that the right of ownership remains with the individual.	3.77	1.169
Lands belonging to one person but scattered should be brought together through land consolidation work.	3.76	1.203
Agricultural lands belonging to the treasury can be leased to cooperatives/unions.	3.69	1.171
The land to be rented out should be located where the requester wants, easily accessible, and, if possible, in bulk.	3.63	1.206
Having one of the shareholders of the shared lands prevents the lands from remaining idle.	3.62	1.046
The land to be leased must be given from the place of residence of the requester.	3.57	1.271
Agricultural lands belonging to the treasury should be leased only to farmers.	3.52	1.330
The small scale of agricultural enterprises has a negative impact on income.	3.45	1.341
The size of land to be leased should be determined according to the production data of the family in recent years.	3.25	1.306
Uncultivated land belonging to individuals can be transferred to a land office to be established by the state at a cost.	3.22	1.294
Agricultural lands belonging to the treasury should be leased only to landless people.	3.22	1.266
Leaving the land fallow negatively affects the profitability of the enterprise.	3.10	1.207
The size of the land to be leased should be determined according to the number of people working in agriculture.	3.07	1.246
Sanctions should be imposed on the owners of uncultivated land.	3.01	1.301
Agricultural lands belonging to the treasury may be leased to large companies.	2.51	1.347

Table 2. Importance levels of factors influencing agricultural engineers' decisions on production in idle lands

Çizelge 2. Ziraat mühendislerinin atıl arazilerde üretim kararı almalarında etkili olan faktörlerin önem dereceleri

Faktörler/ *Factors*	Ortalama/ *Mean*	Std. Sapma/ *Std. Deviation*	*En Küçük/ Minimum*	En Büyük/ *Maximum*
Grant	0.624	0.225	0.000	1.000
Marketing/Purchase Guarantee	0.572	0.215	0.106	1.000
Labor Support	0.425	0.160	0.000	0.684
Agricultural Insurance Premium Subsidy	0.330	0.187	0.000	1.000
Credit	0.301	0.209	0.000	0.776
Accommodation	0.261	0.209	0.000	1.000

*Friedman test is significant at $p<0.01$. Kendall's W: 0.333

Table 3. Importance levels of services required in the area for production on leased lands
Çizelge 3. Kiralanacak arazilerde üretim yapılabilmesi bakımından etkili olabilecek faktörlerin önem dereceleri

Faktörler/ *Factors*	Ortalama/ *Mean*	Std. Sapma/ *Std. Deviation*	*En Küçük/ Minimum*	En Büyük/ *Maximum*
Agricultural Support	0.544	0.147	0.236	1.000
Irrigation Services	0.541	0.146	0.087	1.000
Land Consolidation	0.454	0.216	0.000	1.000
Transportation Services	0.434	0.156	0.065	1.000
Healthcare Services	0.409	0.198	0.000	1.000
Educational Services	0.394	0.213	0.000	1.000
Social Services	0.258	0.204	0.000	0.711

The Friedman test is significant at $p<0.01$. Kendall's W: 0.237

This result reveals that certain services are perceived as significantly more critical than others for enabling production on leased lands. In particular, the prioritization of agricultural support services highlights the importance of supporting initial investments and ensuring production sustainability. Moreover, the high prioritization of physical infrastructure services such as irrigation and land consolidation indicates the necessity of improving production efficiency. The fact that social services are ranked at the bottom suggests that agricultural engineers primarily adopt a production-oriented perspective, prioritizing production infrastructure over aspects of social life.

Based on the values obtained from the Kendall's W test, the degree of agreement can be categorized as very weak (0.1), weak (0.3), moderate (0.5), strong (0.7), and very strong (0.9). In this study, the Kendall's W value was determined to be 0.237, indicating that the agreement among the engineers regarding the weights assigned to the criteria deemed important by the survey participants is at a weak level.

DISCUSSION

The reasons for land remaining idle include high input costs, inefficiency, fragmented and dispersed land structure, multiple ownerships, disputes over land, rural-to-urban migration, aging rural population, reluctance of young individuals to work in agriculture, family feuds, terrorism, and border issues with neighboring countries. Agricultural engineers have indicated that disputes arising from land ownership (conflicts, disagreements) and the fragmentation and dispersion of lands negatively impact agricultural production and, consequently, income. This assertion is supported by previous studies (Uzun & Yomralıoğlu, 2005; Küsek, 2014; Karadağ & Özdemir, 2015; Yan et al., 2016; Peker & Dağdelen, 2016; Aliağaoğlu & Aslantekin, 2018; Sav & Sayın, 2018).

The literature reveals a lack of a clear definition for idle land. In response to the question, "What is your definition of idle land?" posed to agricultural engineers, we developed two definitions of idle land. The first definition states that idle land refers to "land that, despite having suitable climate and soil conditions for agricultural production factors without a specific time limit, is left vacant due to physical, political, social, and particularly economic reasons, and on which no agricultural production occurs." The second definition describes idle land as "land on which agricultural production potential is not utilized, despite the possibility of conducting plant and/or animal activities through any agricultural system or method." (Sevim & Bostan Budak, 2022).

The high volume of idle land owned by the public sector, alongside the continuous idleness of lands owned by farmers for the aforementioned reasons, has necessitated the search for alternative producer profiles. Each year, thousands of agricultural engineers graduate from numerous universities in Türkiye, but only a small fraction are employed in their field. This situation leads to either unemployment or employment in different sectors for individuals who have received agricultural training. In our study, this rate was found to be 31.3%.

Corbelle-Rico et al. (2022) determined that reintroducing abandoned lands into agricultural production could significantly increase the gross value added of the agricultural sector and predicted that the increase in production within the agricultural sector would create a multiplier effect on other sectors, leading to a greater overall economic impact. In our study, 87.3% of the participating agricultural engineers expressed a willingness to engage in agricultural production. Although there may not be a direct correlation with the project initiated by the Ministry of Agriculture and Forestry, known as the "Uzman Eller" it has been observed that this project aims to direct this producer profile towards individuals graduating from associate and bachelor's degree programs in agricultural education. Participants in these programs receive grant support of up to 250.000 TL. In our study, agricultural engineers indicated that, in addition to leasing land, the provision of grant support is the most influential factor

in their production decision-making. The intention to lease idle public lands to individuals without access to land, due to insufficient investment opportunities arising from costs that do not yield adequate income, will enhance the effectiveness of the proposed project. Additionally, the regulation published in the Official Gazette No. 32640, concerning the leasing of uncultivated agricultural lands for agricultural purposes, prioritizes professional groups within the agricultural sector, further emphasizing these needs.

In the statistical analyses conducted, the relationship between agricultural engineers' willingness to engage in agricultural production and several key socio-economic variables was comprehensively examined. For this purpose, both parametric and non-parametric hypothesis tests were applied to variables such as the presence of family members engaged in agriculture, ownership of agricultural land by the individual or their family, membership in the Chamber of Agricultural Engineers, employment status, field of graduation, age, and household income. The results revealed that agricultural engineers' orientation toward agricultural production was not significantly associated with these demographic variables. Although no statistically significant differences were found, it is noteworthy that the willingness to engage in production exceeded 80% across all demographic groups. This finding suggests that the motivation of agricultural engineers to participate in agricultural production cannot be solely explained by demographic characteristics. Therefore, in order to better understand the underlying reasons for this willingness, it is essential to investigate psychosocial and structural factors in greater depth—such as the desire to participate in production, inclination to return to rural areas, access to public support mechanisms, trust in agricultural policies, career orientation, and employment opportunities.

Among the participants, we posit that the reason why non-member agricultural engineers show greater support for the leasing of treasury lands to large companies compared to members may be related to the institutional stance of the Chamber of Agricultural Engineers. The Chamber has long opposed policies that delegate agricultural production to corporate control and advocates for the protection and sustainability of small family farms. This institutional perspective is thought to influence the attitudes of member agricultural engineers, leading them to adopt a more cautious or critical approach toward the role of companies in utilizing treasury lands. The continuation of livestock production and the enhancement of tourism opportunities positively impact the preservation of agricultural lands (Cocca et al., 2012). The re-utilization of abandoned agricultural lands for market-oriented agriculture can provide financial security for farmers and promote new job opportunities for younger generations (Magagula & Tsvakirai, 2020). However, traditional agricultural production methods are challenging, which can trigger abandonment of production (Todde et al., 2024). Therefore, new producer profiles that can more rapidly adopt innovation are essential. In this context, increasing capital and technology opportunities in rural areas and creating e-commerce-supported market opportunities will have a positive impact (Wang et al., 2023).

The new agricultural support model implemented in Türkiye in 2024 presents significant opportunities for bringing idle agricultural lands back into productive use. The system, simplified under three main categories—Planned Production Support, Basic Support, and Production Development Support—aims to guide agricultural production through the promotion of strategic crops, adherence to crop rotation rules, and product-based incentives in water-scarce regions (Official Gazette, 2024). In particular, provisions that withhold support from lands left fallow for consecutive years and that encourage the reutilization of long-term idle plots are regulations that could directly influence land-use decisions. In particular, provisions that withhold support from lands left fallow for consecutive years and that encourage the reutilization of long-term idle plots are regulations that could directly influence land-use decisions.

Current national policies on the efficient use of agricultural lands in Türkiye include recent regulations targeting the revitalization of unprocessed or abandoned lands. In accordance with amendments to Law No. 5403 on Soil Conservation and Land Use introduced via Law No. 6537, it is now possible to lease agricultural lands that have remained uncultivated for two consecutive years on a seasonal basis in favor of public interest. These regulations prioritize leasing rights to local residents, civil society organizations, and professional chambers, and also allow lessees to benefit from agricultural subsidies. Furthermore, with this legal framework, public mechanisms are being developed to address structural issues—such as ownership disputes, land fragmentation, and migration—that prevent land from being cultivated.

In this context, the land allocation proposal for agricultural engineers, as introduced in this study, emerges not only as a tool to respond to individual production motivations but also as a policy instrument aligned with current governmental strategies. The active involvement of agricultural engineers in the reclamation of idle lands can contribute both to the efficient use of professional capacity and to the planned and sustainable enhancement of agricultural production. Accordingly, the study underscores the necessity of designing structural solutions that integrate policy implementation with the actors directly involved in agricultural development.

CONCLUSION

Land ownership disputes, land fragmentation, and the continuous reduction of parcel sizes have been identified by agricultural engineers as the most significant structural problems negatively affecting agricultural production. These issues emerge as major obstacles to enhancing productivity and ensuring sustainable land use.

Directing agricultural engineers towards agricultural production is of great importance to ensure a more secure agricultural investment, production, and export process, as well as the continuity of agricultural production in Türkiye. Leasing abandoned lands to agricultural engineers is of critical importance for the planning and management of agricultural production. Agricultural engineers, who have a better understanding of the supply-demand balance, can effectively conduct agricultural production on these lands.

It has been observed that financial and production-related supports directly influencing decision-making processes are prioritized by agricultural engineers when considering the rehabilitation of fallow lands. The prioritization of grant support indicates that reducing the initial financial burden is decisive in both starting production and maintaining sustainable production. The fact that marketing/purchasing guarantees rank second highlights producers' concerns about securing market access and emphasizes their expectations for income stability. The importance attached to labor support points to the challenges in accessing sufficient and qualified labor, especially in rural areas. In terms of essential services required for sustainable production on leased lands, the prominence of basic infrastructure and technical supports (agricultural support services, irrigation, land consolidation, and transportation) underscores the necessity of improving physical production conditions. Conversely, the lower priority assigned to social services suggests that producers initially focus on production and income, while quality of life-related services may gain importance at later stages.

It is evident that the integration of agricultural engineers into the agricultural sector should not rely solely on land allocation but must also be supported by mechanisms that ensure long-term economic sustainability. In this context, grant and financial support programs should be expanded to encourage the utilization of idle lands for production, and startup packages aimed at reducing initial investment costs should be developed. Mechanisms providing marketing and purchasing guarantees (such as contract farming and state purchase guarantees) should be widely implemented to minimize market risks faced by producers. Incentives that facilitate labor supply should be introduced. Infrastructure investments (irrigation systems, transportation routes, and land consolidation projects) must be prioritized to ensure long-term production on leased lands.

The analyses indicate that the willingness of agricultural engineers to engage in agricultural production cannot be sufficiently explained by demographic variables. This finding underscores the necessity for policymakers to consider deeper structural factors, rather than relying solely on surface-level characteristics when developing agricultural policies. Given that the preferences and expectations of agricultural engineers may vary across regions, conducting similar studies in different provinces or on a national scale would provide a valuable comparative framework for both the academic literature and policy development.

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Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

Conflict of Interest

All authors declare that there are no financial or other material conflicts of interest in their manuscripts that could influence the results or interpretations.

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