sustainability

MDPI

Article

The Risk of Agricultural Land Abandonment as a Socioeconomic Challenge for the Development of Agriculture in the European Union

Adam Pawlewicz [1,*] and Katarzyna Pawlewicz [2,*]

[1] Department of Agrotechnology and Agribusiness, Faculty of Agriculture and Forestry, University of Warmia and Mazury in Olsztyn, ul. Oczapowskiego 8, 10-719 Olsztyn, Poland
[2] Department of Socio-Economic Geography, Institute of Spatial Management and Geography, Faculty of Geoengineering, University of Warmia and Mazury in Olsztyn, ul. Prawocheńskiego 15, 10-720 Olsztyn, Poland
* Correspondence: adampawl@uwm.edu.pl (A.P.); katarzyna.pawlewicz@uwm.edu.pl (K.P.)

Abstract: In this article, the risk of agricultural farmland abandonment was assessed with the use of a synthetic measure of socioeconomic problems as challenges to the quality of life in rural areas in the European Union. To determine the direction and dynamics of changes in farmland abandonment in the EU countries, variables based on EUROSTAT and FADN data were analyzed using Hellwig's method, and data for 2010, 2013, 2016, and 2019 were compared. The EUROSTAT methodology for the agri-environmental indicator "risk of land abandonment" was adapted for the needs of this study. Agricultural land is abandoned for many reasons, including conversion to other uses, but also abandonment of farming. The results of the analysis indicate that the risk of farmland abandonment was highest in countries with difficult farming conditions, such as Greece, Spain, Portugal, Romania, and Finland. In turn, Belgium, Denmark, Germany, and the Netherlands, i.e., the most economically developed countries, were most resilient to this risk. An analysis of the factors that contribute to farmland abandonment demonstrated that the likelihood of this risk decreases with a rise in agricultural investments, farm income, population density, prices of agricultural land, road quality, and density. A high proportion of ageing farm owners was the only factor that increased the risk of agricultural land abandonment.

Keywords: agricultural land abandonment; farmland abandonment; quality of life; socioeconomic challenges; European Union

check for updates

Citation: Pawlewicz, A.; Pawlewicz, K. The Risk of Agricultural Land Abandonment as a Socioeconomic Challenge for the Development of Agriculture in the European Union. *Sustainability* **2023**, *15*, 3233. https://doi.org/10.3390/su15043233

Academic Editor: John McDonagh

Received: 15 January 2023
Revised: 7 February 2023
Accepted: 9 February 2023
Published: 10 February 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Over the centuries, rapid population growth has led to the conversion of natural habitats to farmland [1] to increase food production and ensure food security. Agricultural production was intensified to improve the efficiency of farming operations and decrease costs [2]. However, these practices led to the abandonment of farmland because rent prices failed to generate profits, expenses exceeded profits, and high productivity in the remaining farmland compensated for the losses generated by the exclusion of land that was more expensive to maintain. For this reason, agricultural intensification is often regarded as one of the main drivers of farmland abandonment [3], next to state policies and cheap imports of agricultural commodities [4]. Land abandonment is also driven by socioeconomic factors such as migration from rural to urban areas in search of work and economic incentives, as well as negative demographic phenomena [5]. Agricultural land abandonment can be a consequence of social, economic, political, and environmental marginalization, which decreases the profitability of agricultural production in the existing land use structure and the socioeconomic system [6]. Farmland abandonment and its causes continue to attract considerable research interest because this phenomenon remains

insufficiently investigated [5–11]. The problems associated with the definition of land abandonment [8,12,13], data collection [11–14], and the identification of the complex mechanisms that drive land abandonment, in particular in the social dimension [15], have been recognized by numerous researchers. To better understand the discussed phenomenon, it should be noted that previous research focused on factors that contribute to farmland abandonment, as well as the spatial relationships between these factors. The applied methods were based mainly on sets of geographic data that support reliable identification of land cover. Such data are obtained by remote sensing [16] and they are used to develop territorial models. Despite the fact that the main drivers of farmland abandonment and their spatial relationships have been extensively studied, most research relied on local and static variables. Analyses of spatial patterns revealed that farmland abandonment was strongly determined by spatial factors, in particular environmental and geological conditions, as well as socioeconomic factors [17,18]. At the same time, very few attempts have been made to describe agricultural land abandonment with a dynamic approach [19]. Variables relating to the financial situation of rural households were also rarely analyzed, and most studies where these factors were considered had a local character [20]. Therefore, the present study was undertaken to fill in this knowledge gap, and the socioeconomic consequences of farmland abandonment in the EU were analyzed with the use of synthetic variables.

In the present study, agricultural land abandonment was defined as complete cessation of farming activity. However, this phenomenon is very difficult to analyze due to the absence of a concise definition of the term, lack of cohesive data about the spatial and temporal distribution of abandoned land, and considerable influence of local factors. Therefore, land abandonment is a complex, multidimensional phenomenon that cannot be measured and expressed with the use of a single parameter, such as the area of land that was abandoned temporarily or permanently. Therefore, the aim of this study was to evaluate agricultural land abandonment in the EU with the use of a composite (synthetic) index representing the key drivers of this process so as to relate the observed changes to socioeconomic problems. The present study was undertaken to: (1) analyze the evolution of farmland abandonment in the EU in the socioeconomic dimension; (2) analyze the spatial distribution of socioeconomic factors that contribute to farmland abandonment and affect the quality of life in rural areas in the EU; (3) identify potential socioeconomic changes that can minimize the risk of farmland abandonment.

2. Literature Review

At present, agriculture occupies more than 36%, and cropland—more than 10% of the global land surface, which has important implications for sustainable development [21]. In recent decades, specialization, intensification, and technological progress have contributed to an increase in agricultural productivity and competitiveness [9]. Agricultural land abandonment is a process that accompanies economic growth around the world [12]. This complex, multidimensional phenomenon is driven by social, economic, technological, and political factors [22]. Farmland abandonment can also exert negative environmental impacts by contributing to ecosystem degradation [9]. Sustainable land management represents Goal 15 ("Life on land") of the 17 Sustainable Development Goals adopted by the United Nations. The aim of Goal 15 is to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and to achieve a land degradation-neutral world. Agricultural land abandonment is one of the key threats to sustainable land management. Farmland abandonment compromises sustainable development because land degradation and land abandonment decrease the quality of life, reduce agricultural income, and undermine poverty reduction strategies. Therefore, sustainable land management is a key priority for all countries in the world.

Agricultural land abandonment is difficult to analyze due to the absence of a concise definition of the term and the lack of cohesive data about the spatial and temporal distribution of abandoned land [12,13,19]. This phenomenon can have different definitions in the environmental, institutional, social, and economic context, as well as in the local

context [23]. Farmland can be abandoned temporarily or permanently, which additionally complicates the analysis [24]. Land abandonment is a process whereby human control over land (such as agriculture or forestry) is given up, and land is left to nature. Depending on ecological and climatic conditions, land can be regarded as completely "abandoned" after several years if it cannot be restored for legal (e.g., forestry laws) or environmental (e.g., desertification and forest expansion) reasons or if restoration costs are very high [3,25]. Farmland abandonment is most often defined as the complete cessation of agricultural activity [6]. The above definition applies to land that was previously used to grow crops or graze livestock, but presently does not serve any agricultural functions (complete cessation of farming activity), has not been converted to woodlands or artificial areas [12], and is managed to some degree, possibly to ensure that it remains available for agricultural use in the future [13]. In the literature, farmland abandonment has been frequently analyzed by comparing land-use data and agricultural statistics [9]. However, this approach is incorrect because it does not account for the causes and consequences of land abandonment or land zoning requirements.

According to the literature, agricultural land abandonment is a multidimensional process which is driven by diverse factors that may occur simultaneously, including environmental constraints, socioeconomic factors, land degradation, demographic structure, and the institutional framework [3,8,9,25–27]. The Joint Research Center has classified recurring determinants of farmland abandonment in the EU into three blocks [9,27]:

- poor environmental/biophysical suitability for agricultural activity;
- low farm stability and viability;
- negative drivers in the regional context.

Agricultural land abandonment has been researched extensively, and the results indicate that farmland abandonment indicators and patterns differ considerably around the world because "exogenous" factors can affect the direction of changes in farmland use [28]. Various multidimensional drivers of farmland abandonment have been analyzed, and the following factors have been most often identified in the literature:

- small-scale production, closure of family farms, slow economic growth, low population growth, low land mobility on the farmland market [3,24,29];
- rural to urban migration for economic, social, and cultural reasons [30–32];
- migration caused by military conflict, political instability, or large-scale natural disasters such as hurricanes [30];
- subsidies under the EU's Common Agricultural Policy (CAP), low levels of investment in agricultural farms, ageing farm owners, low farmer qualifications, and low demand for land [8,27,33–36].
- environmental factors, including elevation above sea level, farmland geology, land slope, soil fertility, soil depth profile for agricultural use, climate change, water and wind erosion, and land degradation resulting from improper land use or overexploitation [5,37,38];
- increased agricultural productivity which leads to the abandonment of less productive land; import of agricultural commodities from other regions [4,11];
- decrease in agricultural profits, for example when higher production costs are not compensated by an increase in the prices of agricultural products, which prevents small-scale farms from competing on the market [6,30];
- strict environmental protection policies which decrease the performance of conventional farms, combined with the absence or low levels of public support for alternative farming solutions [4,35,38];
- new production technologies, rapid industrialization, monopoly on land ownership, safety, availability of infrastructure, distance from potential markets [5];
- decrease in the biodiversity of agricultural landscapes and crop homogeneity associated with, for example, a higher risk of agricultural fires [3];
- depletion of water resources, loss of biodiversity, decrease in the population of species adapted to the local environmental conditions, loss of cultural and aesthetic values [3];

- historical events, such as the transition from a centrally planned to a market economy and the collapse of agriculture in Eastern European countries between 1990 and 2004; national and EU policies; problems with renewing agri-environmental contracts after five years; new sanitary requirements imposed on agricultural producers in Eastern Europe in 2004; decoupled payments that are not linked with production [8,24,31];
- urbanization and economic growth that can lead to the marginalization of neighboring agricultural areas [39,40] and migration of the local population [28].

Agricultural land abandonment affects social welfare and the environment. Farmland abandonment can have diverse consequences, both positive and negative, depending on the context. An increase in biodiversity and ecosystem restoration are undoubtedly positive changes in the environmental dimension, but not necessarily in the socioeconomic context. Without institutional support, farmland abandonment can compromise the local standard of living and decrease local incomes, including in agriculture. For this reason, research into agricultural land abandonment should examine not only the environmental impact of this phenomenon, but also its socioeconomic consequences. The positive and negative consequences of land abandonment continue to stir a heated debate [23]. In general, farmland abandonment has negative implications for socioeconomic development, the environment, and the landscape [41]. It can lead to the loss of biodiversity [5–7,42], landscape homogenization [3,5,7,42,43], higher risk of fire [6,7,42,44,45], soil erosion, desertification, land degradation [5–7,42], increase in land area under intensive agriculture [41], changes in ecosystem processes [26], loss of nature conservation areas (e.g., Natura 2000) [6], lower water availability, and loss of cultural values [5]. In the economic context, agricultural land abandonment can significantly compromise food security [46] and lead to the loss of local agricultural practices and knowledge [47].

Land abandonment has positive implications mainly in the environmental context. Above all, it promotes the restoration of natural habitats, ecosystem services, and biodiversity [6,30], including all consequences of this process. Soil is regenerated, the nutrient cycle is restored, and soil moisture and aeration are improved [5]. Abandoned lands can sequester more carbon [32], and they are not exposed to the harmful effects of agricultural chemicals [8]. Spontaneous revegetation and forest regrowth [5] contribute to the restoration of native flora [26]. However, land abandonment also leads to depopulation, which is difficult to control. Therefore, various instruments are being offered under the CAP to prevent land abandonment, including decoupled payments that are not linked with production and compensatory payments in areas with natural constraints [3]. Responsible policy-making plays a very important role in this context.

Agriculture Land Changes

Abandoned farmland or agricultural land that is at risk of abandonment is difficult to identify because changes in land use are not always unambiguous and apparent [8]. Land abandonment can be roughly estimated based on long-term statistical data published by the Food and Agriculture Organization (FAO) [21]. The area occupied by agricultural land continued to increase globally until 2001. A reverse trend was noted after 2001, and agricultural land area began to decrease, with several short-term increases in 2005, 2010, 2011, and 2017 (Figure A1). An analysis of the relevant data indicates that global agricultural land area has been decreasing steadily since 2001 at an annual rate of nearly 7 million ha. Similar results were reported by Zanden et al. [19]. These changes have contributed to a long-term global trend. In many regions of the world, land abandonment was one of the key processes that led to changes in land use [6,19]. However, despite the steady increase in the area of abandoned agricultural land since the 1950s [26], competition on the global farmland market continues to rise, and the struggle to acquire more land for agricultural production became known as "hunger for land" in many countries around the world. Farmland abandonment has both negative and positive consequences, and the socioeconomic and environmental drivers of land abandonment need to be considered to find a satisfactory solution to the problem.

The restoration of abandoned farmland is not always a priority in the EU. Abandoned land with high conservation value may be protected to promote habitat restoration. The demand for farmland is driven by numerous factors, but above all, agricultural land is regarded as a source of additional income. For example, the present conflict in Ukraine has significantly decreased food supply and increased food prices on the global market. In consequence, in some regions of the world, including Europe, efforts are being made to restore abandoned farmland for agricultural production (Figure A2).

In developing regions, agricultural land area continued to increase between 1961 and 2020, including in Asia (by 1,346,600 ha per year), Africa (by 2,284,000 ha per year), South America (by 1,307,000 ha per year), and Central America (by 169,000 ha per year) (Figure A3, Table A1). A reverse trend was reported in developed regions, including North America (annual decrease of 756,000 ha), Oceania (2,630,000 ha), and Europe (7,785,000 ha, including 406,000 ha in the EU). In general, in developed regions, changes in land use are fueled mainly by economic growth, and the abandonment or conversion of agricultural land in high-income regions has been chiefly responsible for the steady decrease in farmland area since 1960 [23]. Abandoned farmland area is difficult to estimate on a global scale due to the lack of accurate data, but this process is observed mainly in marginal areas where the conditions for agricultural production are unfavorable and farm income is low.

Utilized agricultural areas account for more than 50% of the EU's total area. Agricultural production contributes to food security, but it also affects the availability of natural resources as well as socioeconomic growth and the quality of rural life. In Europe, farmland abandonment is an important land-use change process that has been observed since the mid-19th century [48,49] to the present [7–9,12]. This process is expected to continue in the coming decades [13,50], and the area of abandoned farmland will reach 7,127,700 ha or even 21,181,400 ha in 2040 [19,51]. Utilized agricultural area continues to decrease in the EU, excluding in Luxembourg and Slovenia where this parameter increased significantly, and in Estonia and Latvia, where significant ($p > 0.05$) changes in farmland area could not be confirmed (Figure A4a–c, Table A2).

3. Materials and Methods

Data Collection

The directions and rate of agricultural land abandonment in the EU were determined by analyzing and comparing EUROSTAT and Farm Accountancy Data Network (FADN) data for 2010, 2013, 2016, and 2019 with the use of Hellwig's taxonomic method. Only data that were available for all EU countries in the examined years were selected for the analysis. Malta was not included in the study due to the absence of complete data in the analyzed years. The definitions, measurement methods, and the context for the correct interpretation of data were consistent with the EUROSTAT agri-environmental indicator—risk of land abandonment [52].

Farmland abandonment is a complex phenomenon that should be characterized with the use of synthetic variables so as to combine various indicators into a composite index [53–58]. The taxonomic method developed by Zdzisław Henryk Hellwig is often applied to generate synthetic variables [59–61].

The study was carried out in the following stages:

1. Choosing a set of variables

The selection of diagnostic variables is made from a set of potential variables characterizing the studied phenomenon. The risk of farmland abandonment is estimated based on a statistical analysis of the main factors grouped into a composite index. Factors that increase this risk were regarded as destimulants, and factors that decrease this risk were regarded as stimulants. The variables adopted to build a synthetic measure of the risk of agricultural land abandonment are included in Table A3.

The "remoteness" variable was not available for all analyzed years; therefore, it was used interchangeably with the "road networks" variable. Rural roads are an important part of the road network. They connect motorways and transport routes with cities, villages, and

tourist destinations. Rural roads are used directly by farmers and rural businesses. They promote the transfer of people, goods, and information in rural areas. The construction of rural roads contributes to the transfer of labor and capital between urban and rural areas, and it plays an important role in agricultural production and rural revival and renewal [17,62].

2. Construction of the taxonomic measure of risk using the Hellwig measurement method

The starting point when constructing synthetic variables is the observation matrix, which we can present in the form:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix}, \quad (1)$$

where x_{ij} ($i = 1,2, \dots, n$; $j = 1,2, \dots, m$)—denotes the value of the j-th feature (in this case, a variable characterizing risk of abandonment) for the i-th object.

Due to the fact that diagnostic variables usually have different measures, it is not possible to directly compare them. Therefore, in order to make the features comparable, normalization should be carried out, i.e., the effect of units of measurement should be eliminated. Features were normalized by standardizing them according to the formula:

$$z_{ij} = \frac{(x_{ij} - \overline{x}_j)}{S_j}, \quad (j = 1, 2, \dots, m), \quad (2)$$

where: $\overline{x}_j = \frac{1}{n} \sum_{i=1}^{n} x_{ij}$, $s_j = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x_{ij} - \overline{x}_j)^2}$

The result of the transformations was a matrix of standardized property values—Z:

$$Z = \begin{bmatrix} z_{11} & z_{12} & \dots & z_{1m} \\ z_{21} & z_{22} & \dots & z_{2m} \\ \dots & \dots & \dots & \dots \\ z_{n1} & z_{n2} & \dots & z_{nm} \end{bmatrix}, \quad (3)$$

Based on the obtained matrix, the "pattern", i.e., an abstract object (country) with the coordinates: $P_0 = [z_{01}, z_{02}, \dots, z_{0j}]$, where: $z_{0j} = \max \{z_{ij}\}$, when Z_j is a stimulant, and $z_{0j} = \min\{z_{ij}\}$, when Z_j is a destimulant. According to the considerations, it should be stated that the "pattern" is a hypothetical country with the most favorable variable values.

The next step is to determine the Euclidean distance of each assessed object (country) P_i from the designated "pattern" according to the formula:

$$q_i = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{0j})^2}, \quad (4)$$

On the basis of the q_i values determined, the value of the synthetic Hellwig risk measure was calculated, which was used to evaluate the countries studied. This value can be represented by the formula:

$$S_i = 1 - \frac{q_i}{q_0}, \quad (i = 1, 2, \dots, n), \quad (5)$$

where: $q_0 = \overline{q}_0 + 2s_0$, $\overline{q}_0 = \frac{1}{n} \sum_{i=1}^{n} q_i$, $s_0 = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (q_i - \overline{q}_0)^2}$.

The synthetic measure of Hellwig Si risk generally takes values between (0.1). The closer its values are to 0, the higher the level of analyzed phenomenon (risk of abandonment) is characterized by the examined object (country). However, the higher the values, the lower the level of risk of abandonment of the surveyed country are. The negative value

of the Si measure may appear when the risk of abandonment in a given country is clearly stronger compared to the others.

3. Building a ranking of countries and their division into classes

The standard deviation and arithmetic mean of the Hellwig synthetic risk measure were used to classify countries by level of risk of abandonment.

Four classes have been identified (four levels of risk of abandonment) [63,64]:

- class I (low risk of farmland abandoning) $S_i \geq \overline{S_i} + 0.5 s_{S_i}$,
- class II (average risk of farmland abandoning) $\overline{S_i} - 0.5 s_{S_i} \leq S_i < \overline{S_i} + 0.5 s_{S_i}$,
- class III (high risk of farmland abandoning) $S_i < \overline{S_i} - 0.5 s_{S_i}$,

where:
S_i—the value of the synthetic measure calculated using the Hellwig risk pattern method,
$\overline{S_i}$—arithmetic average of the synthetic meter S_i,
s_{S_i}—standard deviation of the synthetic meter S_i.

4. Regression

The strength and direction of the interactions between the key drivers of agricultural land abandonment were determined by regression analysis in the Statistica 13 program.

4. Results

A sound knowledge of the location and area of abandoned land is needed to estimate the external effects of land abandonment in the social, economic, and environmental context, and to plan effective political interventions [41]. Low demand for agricultural land decreases prices and increases the risk of farmland abandonment [9,65,66]. Various factors can decrease the demand for agricultural land, including climate change, increase in agricultural productivity, environmental protection policies, pollution, or conflict. These factors decrease agricultural rents and farm income, and they force farmers to search for other sources of income. Various payment schemes have been introduced to maintain agricultural operations in areas characterized by low farming productivity [67]. In the analyzed years, farmland sales and rental prices were very low in Czechia, Romania, Slovenia, Poland, Slovakia, Lithuania, Estonia, and Latvia. Despite the fact that agricultural rents increased considerably in some of these countries between 2010 and 2019 (240.61% in Estonia, 172.91% in Latvia, 138.55% in Bulgaria, 114.12% in Czechia, 103.45% in Slovakia, and 98.00% in Lithuania) and land hunger was observed in this region, the demand for farmland continues to be low, which can contribute to the risk of land abandonment (Figure 1). New EU members had experienced significant problems during the transition from a centrally planned to a market economy, including the collapse of large State-owned farms and land privatization [9].

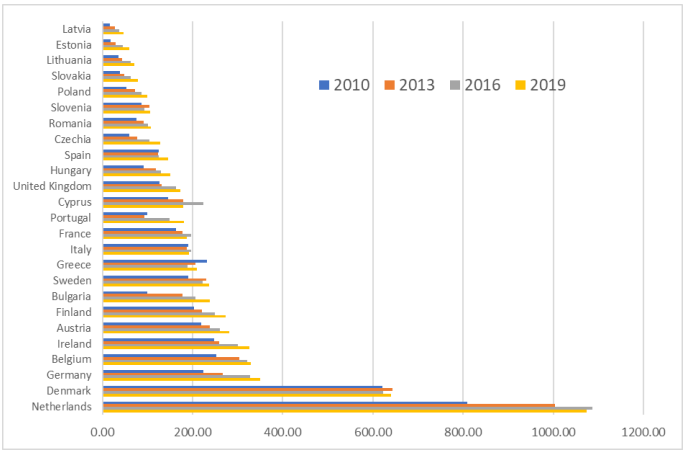


Figure 1. Weak land market (D1; €/ha).

Agricultural profits are determined mainly by a farm's financial situation. The risk of land abandonment increases when farmland ceases to generate sufficient incomes. The financial health of agricultural businesses differs considerably across the EU, and agricultural income has to be compared with income levels in all sectors of the national economy to identify these differences. Farm net value added is compared with the gross domestic product (GDP) per capita to determine the performance of the farming sector in a given country. Large differences indicate that the agricultural sector is not financially stable, which prompts the rural population to abandon farmland and search for new employment opportunities outside the farming sector [9,52,68].

Low farm income significantly contributes to the risk of agricultural land abandonment in Romania, Poland, Austria, Finland, Lithuania, Greece, Cyprus, Ireland, and Slovenia. The greatest decrease in this agri-environmental indicator was noted in Lithuania, Ireland, Poland, and the United Kingdom, whereas the greatest increase was observed in Slovakia, Spain, and Bulgaria (Figure 2). However, these results should be interpreted with caution because the underlying mechanisms can differ across countries [9]. The results are based solely on farm net value added (FAWN SE415), whereas the total income of rural households, including off-farm incomes, can substantially change the picture. Off-farm incomes (tourism, employment in other sectors of the economy) are an important source of livelihood for rural households [52]. Off-farm work enables rural families to diversify their sources of income, and it could decrease the risk of land abandonment. Farmland ownership is a form of investment and capital accumulation that provides rural households with financial security.

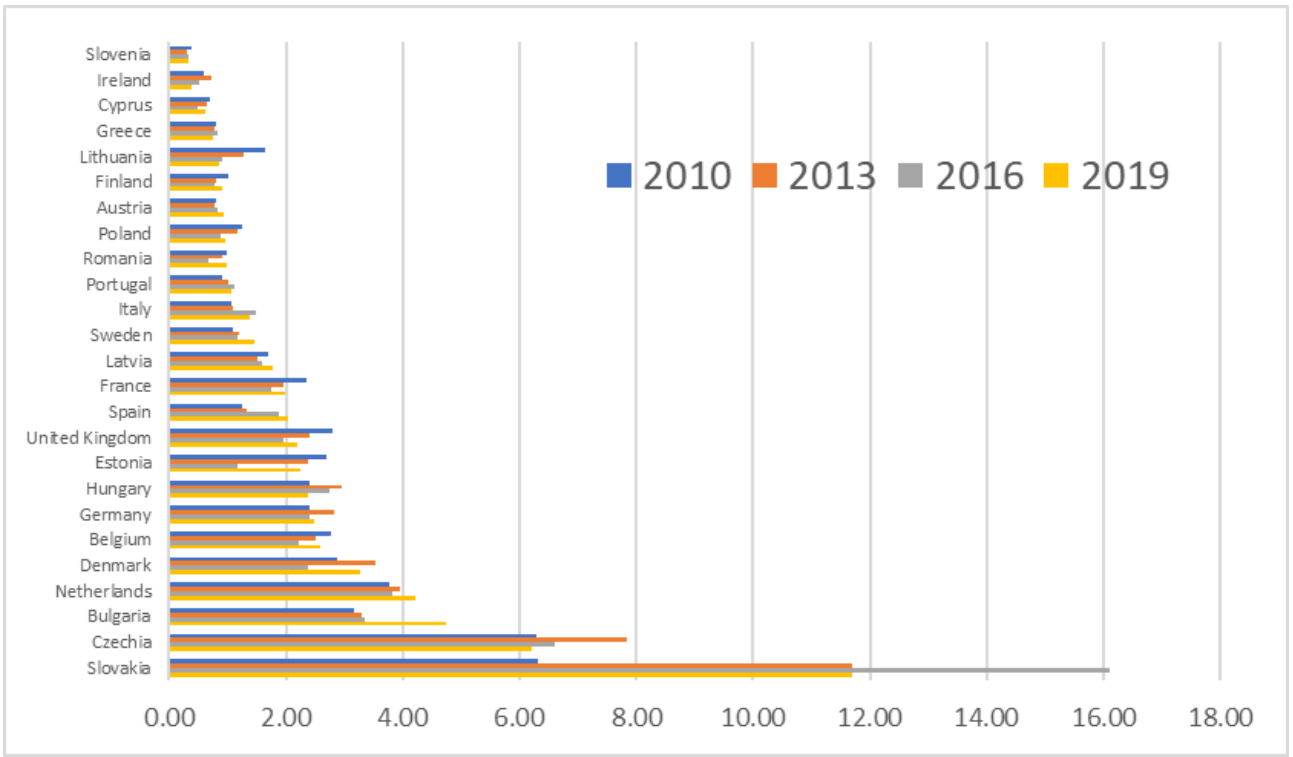


Figure 2. Low farm income (D2; €).

Investment behaviors reflect an agricultural holding's performance, its ability to adapt to market requirements, and expectations about the future. New investments indicate that a farm is willing to continue agricultural operations and has implemented a long-term strategy. Regions with negative long-term investment ratios were identified in Greece, Italy, Romania, Poland, and Spain. The above could be attributed to the fragmentation of agricultural land and a high ratio of small farms that do not invest or implement small

and short-term investment schemes [69]. In turn, the value of long-term investments per hectare of agricultural land was highest in the Netherlands, Belgium, Ireland, Germany, and Sweden (Figure 3).

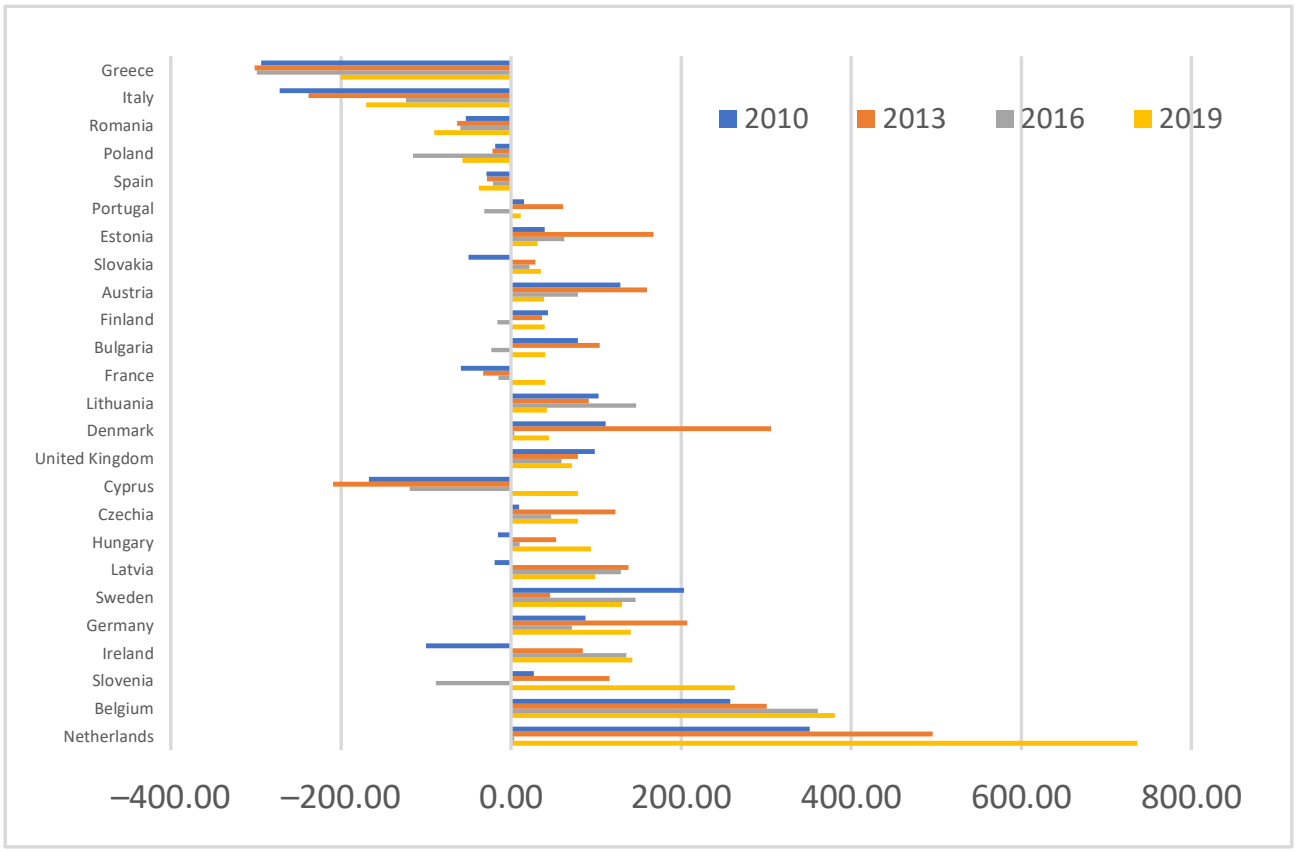


Figure 3. Low investment in the farm (D3; €/ha).

The risk of agricultural land abandonment is higher when most of the farmer population is close to retirement age. The ratio of farm holders older than 65 years to the total number of farm holders was calculated to estimate the distribution of age groups in the farmer population. An unfavorable age ratio which can contribute to land abandonment was noted in Portugal, Sweden, Ireland, the United Kingdom, and Cyprus, where 20% or more farmers were older than 65. This parameter was lowest in Czechia, Poland, Hungary, and Spain where less than 5% of farm holders were close to retirement age (Figure 4).

Agricultural land is more likely to be abandoned in remote, peripheral areas with poor access to basic services such as commerce, healthcare, legal services, and schools. At the same time, population density is generally low in rural areas, and this factor was also considered in the analysis. Population density was highest in the Netherlands, Belgium, the United Kingdom, Germany, and Italy, and lowest in Finland, Sweden, Latvia, Estonia, and Lithuania (Figure 5).

Remoteness, namely the distance from potential markets (such as cities), and the availability and quality of transport infrastructure (such as roads), are also important drivers of farmland abandonment [5]. As previously mentioned, the "remoteness" variable was not available for the analyzed period, and information about road length per 1000 square kilometers was used instead. It was assumed that road density is low in remote and sparsely populated regions, which can lead to the cessation of farming activity. Road density was lowest in Bulgaria, Finland, Greece, Spain, and Romania, and highest in the Netherlands, Belgium, Hungary, France, Slovenia, and Denmark (Figure 6).

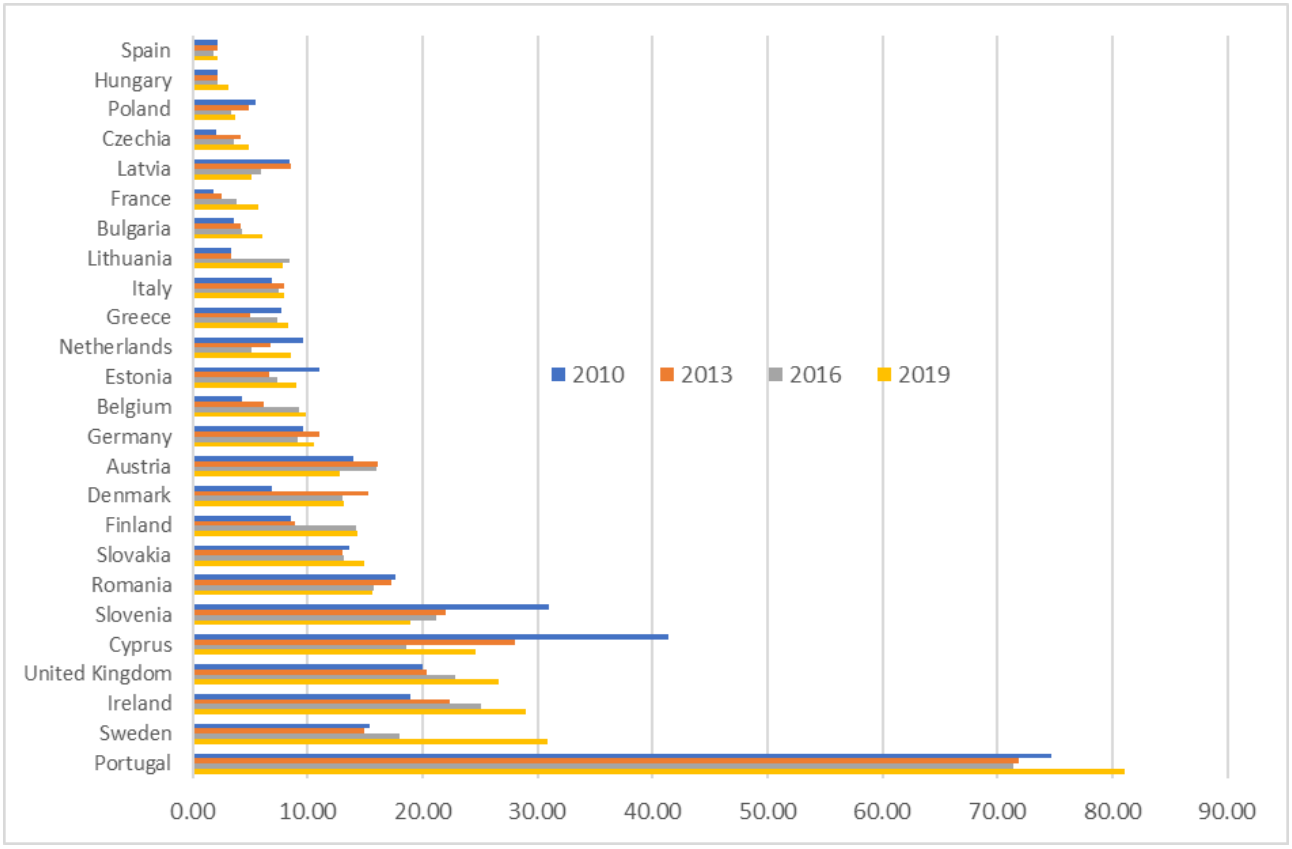


Figure 4. Age of farm holder (D4; %).

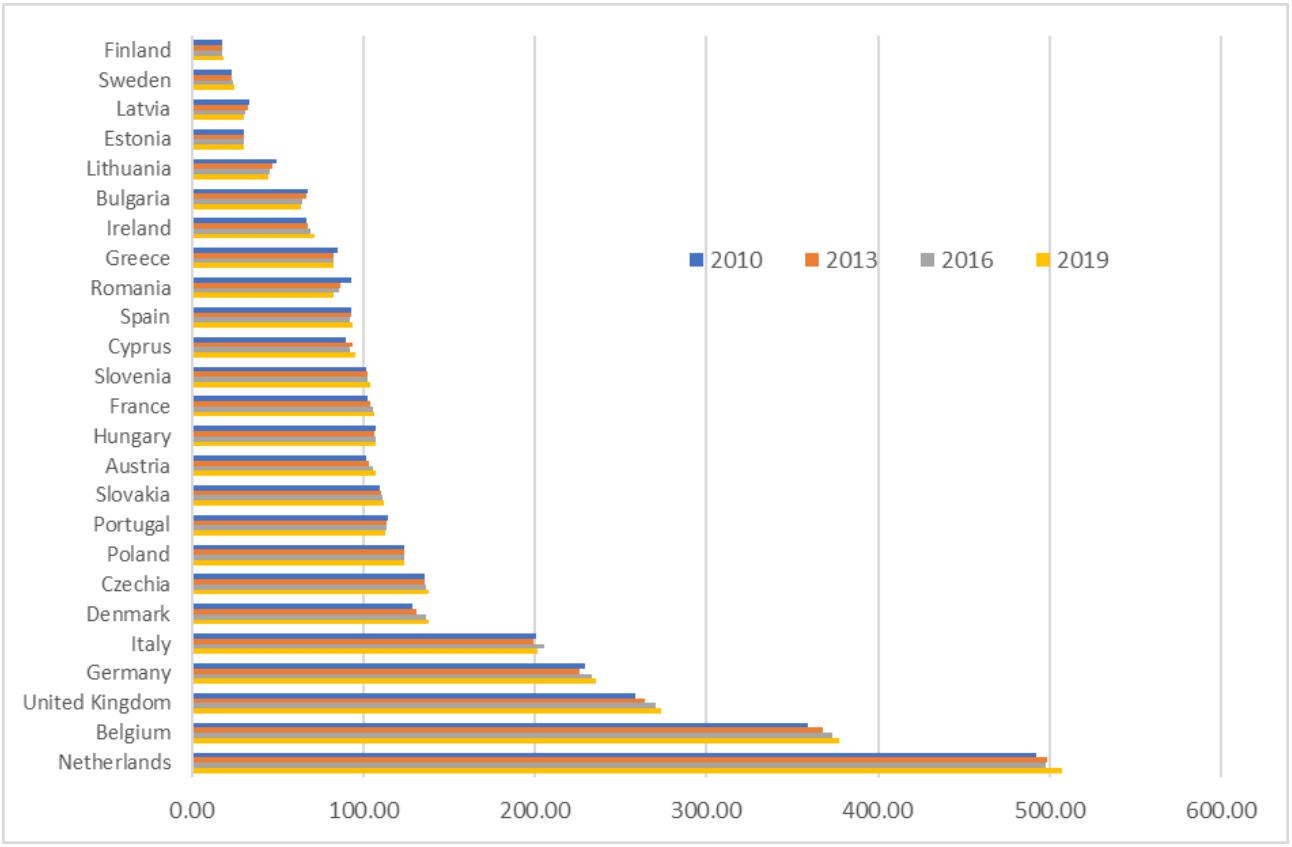


Figure 5. Low population density (D7a; person/km^2).

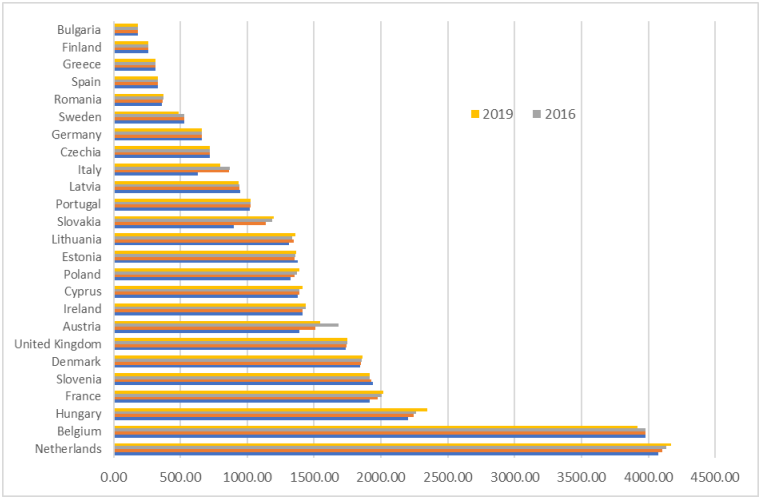


Figure 6. Remoteness (D7b; km/km^2).

Individual factors were combined into a composite index of the risk of farmland abandonment with the use of an empirical framework for building composite indices. Data were normalized at the level of the EU Member states because land abandonment is largely associated with economic, structural, environmental, and political factors in each country. Table 1 presents the ranking of NUTS2 regions in the analyzed years. The risk of farmland abandonment was lowest in Belgium, Denmark, Germany, and the Netherlands, where the highest values of the composite index were noted in the examined period. This result can be attributed mainly to a stable farming sector and a high demand for land for both agricultural activities and non-agricultural investments (such as urban development or road construction). In the United Kingdom and Slovakia, the composite index assumed moderate values, and low values were noted only in 2010 and 2016.

In the analyzed period, the risk of agricultural land abandonment was high in Greece, Spain, Portugal, Romania, and Finland. The composite index also assumed relatively high values in Italy, Cyprus, Latvia, and Sweden. In the remaining countries, the risk of farmland abandonment was moderate, with a growing trend in Estonia, Poland, and Sweden in 2016, and in Lithuania in 2019.

An analysis of the influence (strength and direction) of the examined factors on the risk of agricultural land abandonment produced interesting results. The results of the multiple regression analysis are presented in Table A4. The validation of independent variables revealed that at high adjusted values of the coefficient of determination R^2 (2010—0.99; 2013—0.99; 2016—0.97; 2019—0.99), econometric models explained 99% of the variation in the risk of farmland abandonment in the EU. The results of the regression analysis indicate that population density and farm investments are the key drivers of farmland abandonment. The risk of land abandonment decreases with a rise in these parameters. Farmer ageing was also an important factor, which implies that agricultural land is more likely to be abandoned in areas with a high proportion of farmers who are close to retirement age. However, farm income was a more influential factor in 2016, and the risk of land abandonment was considerably lower in regions with high income. Farmers who derive high income from agricultural production tend to be more satisfied with their land, and they tend to invest in their holdings to expand their operations. The performance of the farmland market was also an important determinant of land abandonment, but it was a less influential contributor than farm income in 2019. A similar trend can be observed in this case—the risk of land abandonment decreases with a rise in farmland prices or rents, or an increase in farm income. The current conflict in Ukraine has decreased the supply of food, mainly cereals, on the global market, which drove the demand for agricultural land (land hunger) in many countries. These processes are responsible for the surge in food and farmland prices.

Table 1. Hellwig measure of risk of farmland abandonment in the EU.

	2010	2013	2016	2019
Belgium	I	I	I	I
Bulgaria	II	II	II	II
Czechia	II	II	II	II
Denmark	I	I	I	I
Germany	I	I	I	I
Estonia	II	II	III	II
Ireland	II	II	II	II
Greece	III	III	III	III
Spain	III	III	III	III
France	II	II	II	II
Italy	III	III	II	III
Cyprus	III	III	III	II
Latvia	III	III	II	III
Lithuania	II	II	II	III
Hungary	II	II	II	II
Netherlands	I	I	I	I
Austria	II	II	II	II
Poland	II	II	III	II
Portugal	III	III	III	III
Romania	III	III	III	III
Slovenia	II	II	III	II
Slovakia	II	II	I	II
Finland	III	III	III	III
Sweden	II	III	II	III
United Kingdom	I	II	I	II
Legend				
Class I (low risk)	Class II (average risk)		Class III (high risk)	

5. Discussion and Conclusions

The supply of agricultural commodities tends to exceed demand. The demand for food is limited, and when the increase in agricultural productivity exceeds the increase in demand, farmland ceases to generate profits and may be abandoned. In addition to agricultural intensification, the risk of land abandonment is also exacerbated by the harmful impacts of agricultural activities, mainly soil degradation which decreases yields and productivity [70]. Other contributing factors include impaired quality of life, depopulation of rural areas, low levels of socioeconomic development, national and international policies, ineffective farm management practices, climate change, environmental degradation, and a growing demand for land for development projects. In many countries, farmland abandonment is a fairly widespread process that not only exerts greater pressure on biodiversity and natural resources, but also decreases agricultural income and employment, leads to the loss of local farming practices and knowledge, and directly contributes to social problems. For this reason, land abandonment poses a significant challenge in the EU. This phenomenon can have varied consequences for different countries and regions, and it can lead to irreversible social, economic, and environmental changes. Reliable information about land abandonment is essential for predicting its consequences and implementing effective policies to address the resulting problems. It should be noted, however, that the global food crisis, perpetuated by military conflict and dwindling food supply, can drive demand for abandoned farmland. High demand leads to a rise in farm income because food is becoming increasingly expensive despite high production inputs.

Sustainable land use is of critical importance in all countries around the world, and it poses a significant challenge for sustainable development. Agricultural land abandonment is one of the greatest threats to sustainable development. Most research studies based on secondary data (such as EUROSTAT or FADN data) focus mainly on unfavorable conditions for agricultural production [8,9]. However, the performance of agricultural holdings can also be undermined by unfavorable farm structure, inadequate farm management, unstable

farm income and low profits [9], as well as socioeconomic factors such as unfavorable demographic changes [5,9,22,28]. Institutional factors such as environmental protection policies and financial support under the CAP also play an important role [24]. Over the years, various measures have been implemented under the CAP with the aim of counteracting farmland abandonment. The direct payment scheme was introduced as the main tool for supporting and stabilizing agricultural incomes and promoting good agricultural practices in line with environmental protection rules. Direct payments provide financial support and generate demand for land, which can reduce the risk of farmland abandonment. In most cases, agricultural land is abandoned or converted to promote far-reaching social goals (such as infrastructure development or environmental protection). The second tool is the Rural Development Program which delivers numerous benefits for rural communities. The risk of farmland abandonment is mitigated by supporting agricultural activities in areas facing significant natural constraints (such as mountainous areas, northern latitudes, areas with reduced soil fertility, extreme climate, low population density) or by preserving rural landscapes and their environmental value. In many cases, these areas have high natural value, which is why extensive agriculture, including organic farming, should be promoted in these regions [67]. Agricultural production is generally unprofitable in areas with significant natural constraints. Support programs for young farmers are also available to prevent depopulation in rural areas.

In the future, the CAP will provide countries and regions with greater freedom in managing direct payments to serve local needs. The CAP will become a more effective tool that decreases the risk of farmland abandonment and promotes interest in farming among young people. It should also be noted that the EU countries can implement various schemes and programs outside the CAP framework. Support programs financed from the central budget or local budgets can be introduced to engage youths in farming and prevent farmland abandonment. The interest in land ownership and agricultural production can be also enhanced through tax incentives, rural investment programs, as well as education.

Land abandonment is associated with numerous challenges, and the choice of the most effective remedy methods is a complex and costly process that is determined not only by regional and local factors, but also by global events. These observations indicate that the survival of rural landscapes in the EU may be at risk. The following key conclusions can be formulated based on the results of this study: (1) An increase in rural population density and farming incomes decreases the risk of farmland abandonment; (2) Agricultural land is more likely to be abandoned in areas with a high proportion of ageing farmers; (3) The risk of land abandonment decreases with a rise in farm incomes because the profitability of food production is encouraging. The concentration of farmland in the hands of land-scale agricultural holdings prevents land fragmentation in the agricultural sector; (4) Excess labor supply should be redistributed according to the forces of supply and demand; (5) The analysis of the socioeconomic determinants of farmland abandonment revealed that the associated risk is highest in Greece, Spain, Portugal, Romania, and Finland; (6) The risk of farmland abandonment is moderately high in Italy, Cyprus, Latvia, and Sweden. In these countries, agricultural land is abandoned mainly in mountainous regions and areas affected by deforestation, desertification, soil degradation, and loss of biodiversity [6,9,70,71]. (7) Demographic problems, mainly ageing rural populations and rural to urban migration in search of new employment opportunities, also increase the risk of land abandonment; (8) The analyzed risk was lowest in Belgium, Denmark, Germany, and the Netherlands, which are highly developed countries with high farm incomes and high concentration of farmland ownership.

Many researchers have postulated that agricultural land abandonment is a local problem and that reliable local data are needed to assess the severity of this risk. This is a valid observation, mainly because NUTS2 regions differ in environmental conditions and economic performance, and they are not equally affected by land abandonment. However, the heterogeneity and diversity of each region cannot be considered in the analysis due to the absence of data and methods for monitoring farmland abandonment in large regions

and across countries. The resolution of input data in European databases (such as FADN and EUROSTAT) varies between the Member States, and it ranges from NUTS3 level in the best-case scenario to NTUS0 level in the worst-case scenario [9]. Due to the heterogeneity of data, the presented results may not be highly accurate at the local level, but these variations do not affect the general analytical framework or the identified directions of land-use changes. Similar conclusions have been formulated by other researchers. The resolution of input data can be improved through the use of remote detection methods [16] and territorial modeling platforms [11]. Therefore, numeric and spatial data have to be monitored, but new variables should also be considered to expand the range of the analyzed interactions. This approach supports decision-making and the implementation of mechanisms and instruments that prevent and minimize adverse phenomena. The described approach also facilitates the introduction of long-term programs and investment schemes in rural areas. As a result, farmers will be able to make well-informed decisions about continuing agricultural operations or abandoning their land, and their choices will contribute to the sustainable development of regions, countries, and groups of countries. Both social and economic drivers of farmland abandonment should be analyzed to prevent this negative phenomenon from occurring in the future.

Author Contributions: Conceptualization, A.P. and K.P.; methodology, A.P. and K.P.; formal analysis, A.P. and K.P.; investigation, A.P. and K.P.; resources, A.P. and K.P.; data curation, A.P.; writing—original draft preparation, A.P. and K.P.; writing—review and editing, A.P. and K.P.; visualization, A.P.; supervision, A.P.; project administration, A.P.; funding acquisition, A.P. All authors have read and agreed to the published version of the manuscript.

Funding: The results presented in this paper were obtained as part of a comprehensive study financed by the University of Warmia and Mazury in Olsztyn (grant No. 30.610.012-110).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

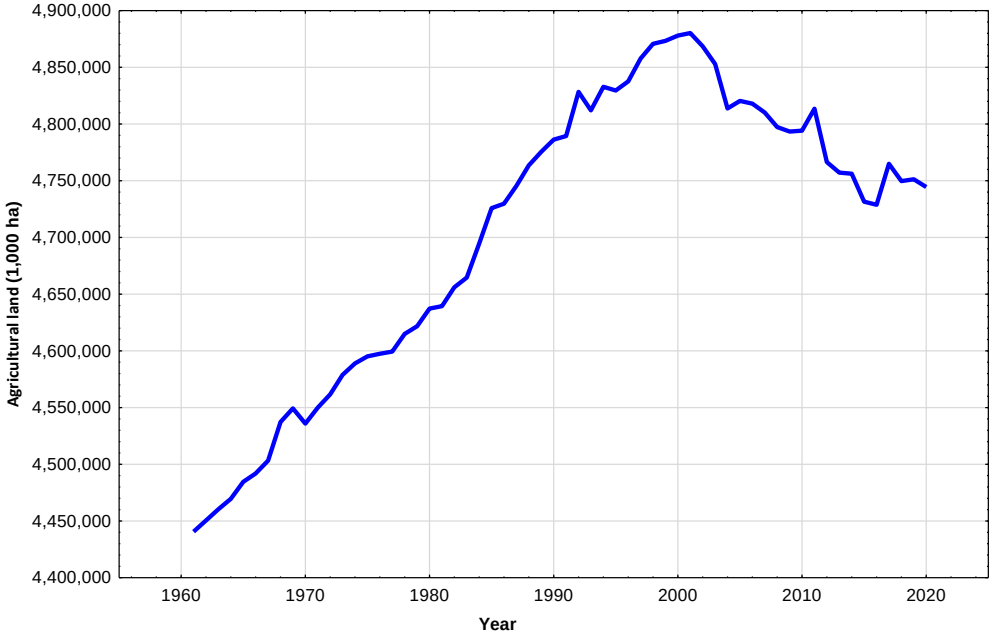


Figure A1. Changes in agricultural land in the world from 1961 to 2020.



Figure A2. Restoration of abandoned farmland for agricultural production in 2012 (Google Maps) and 2022 (author: A. Pawlewicz).

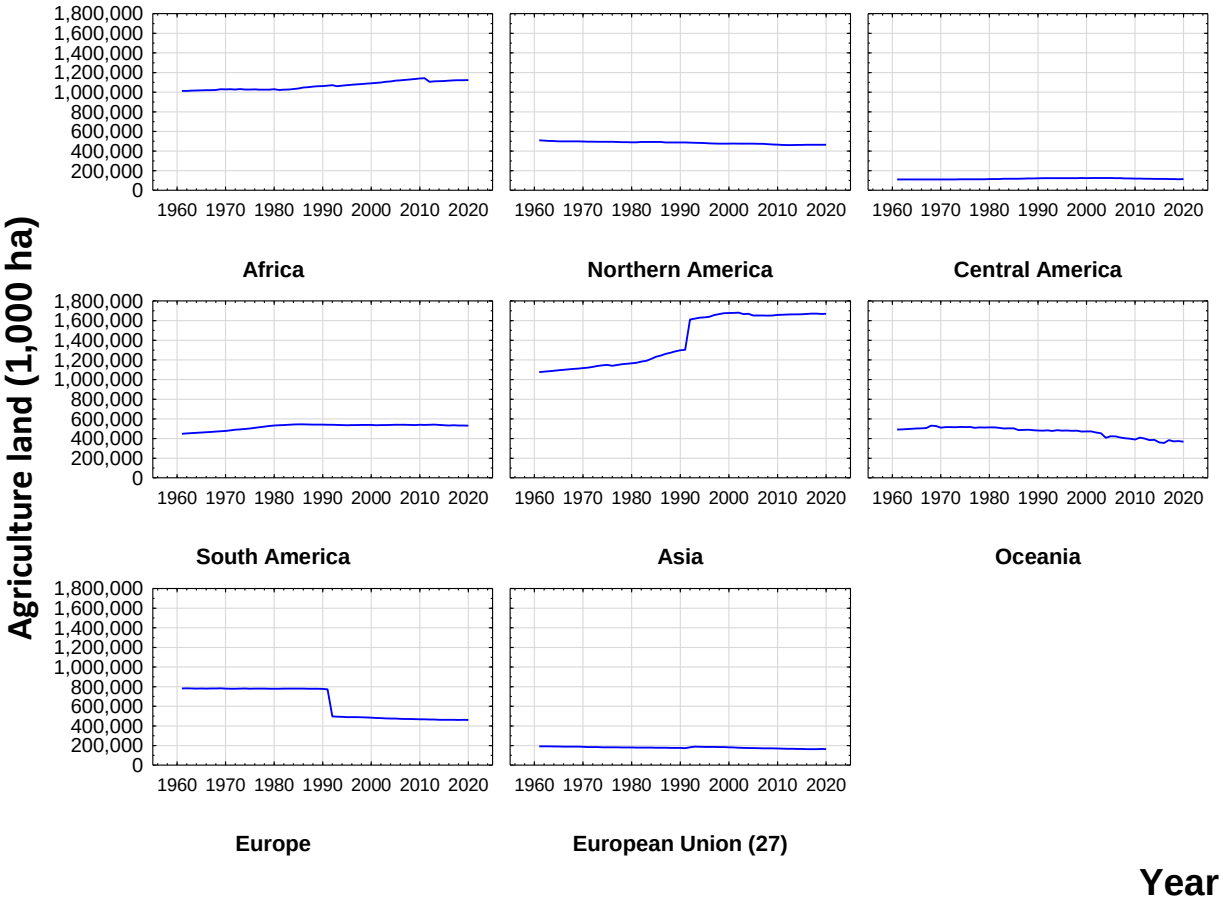
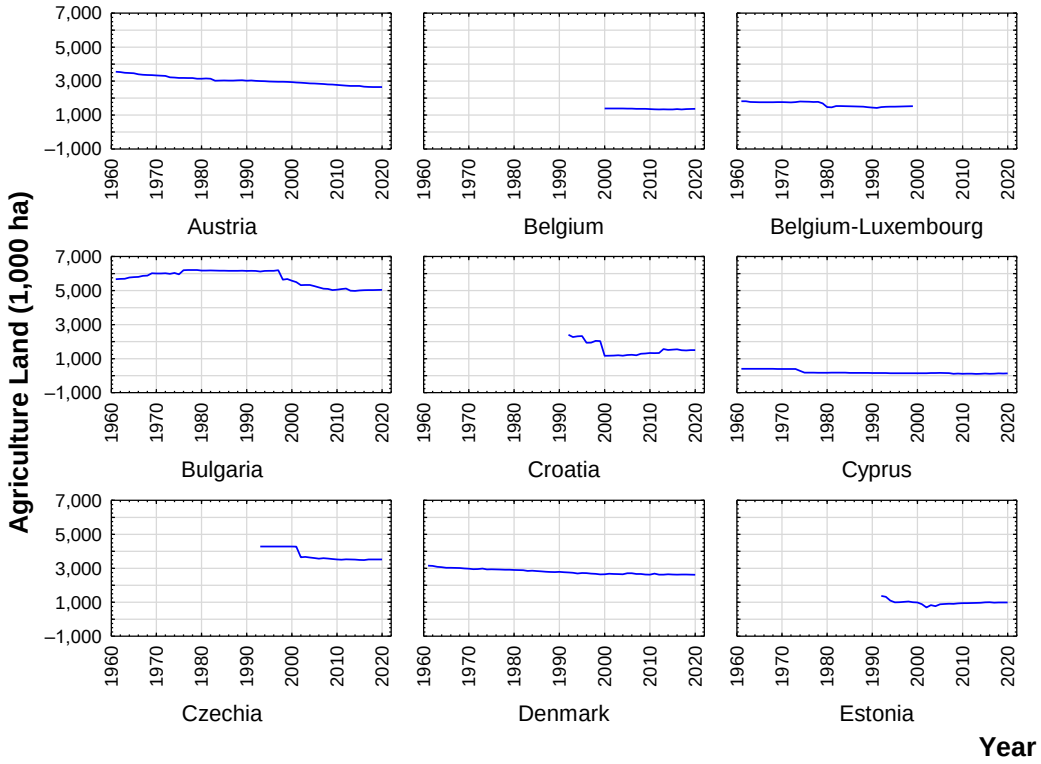
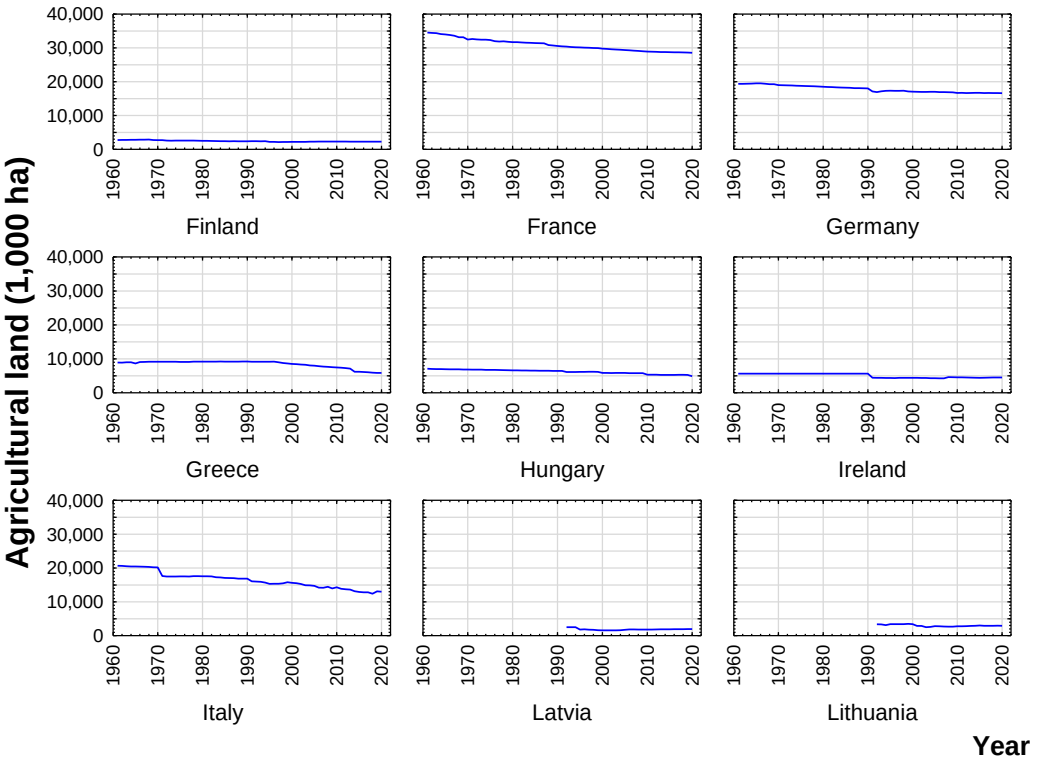


Figure A3. Changes in agricultural land on all continents from 1961 to 2020.

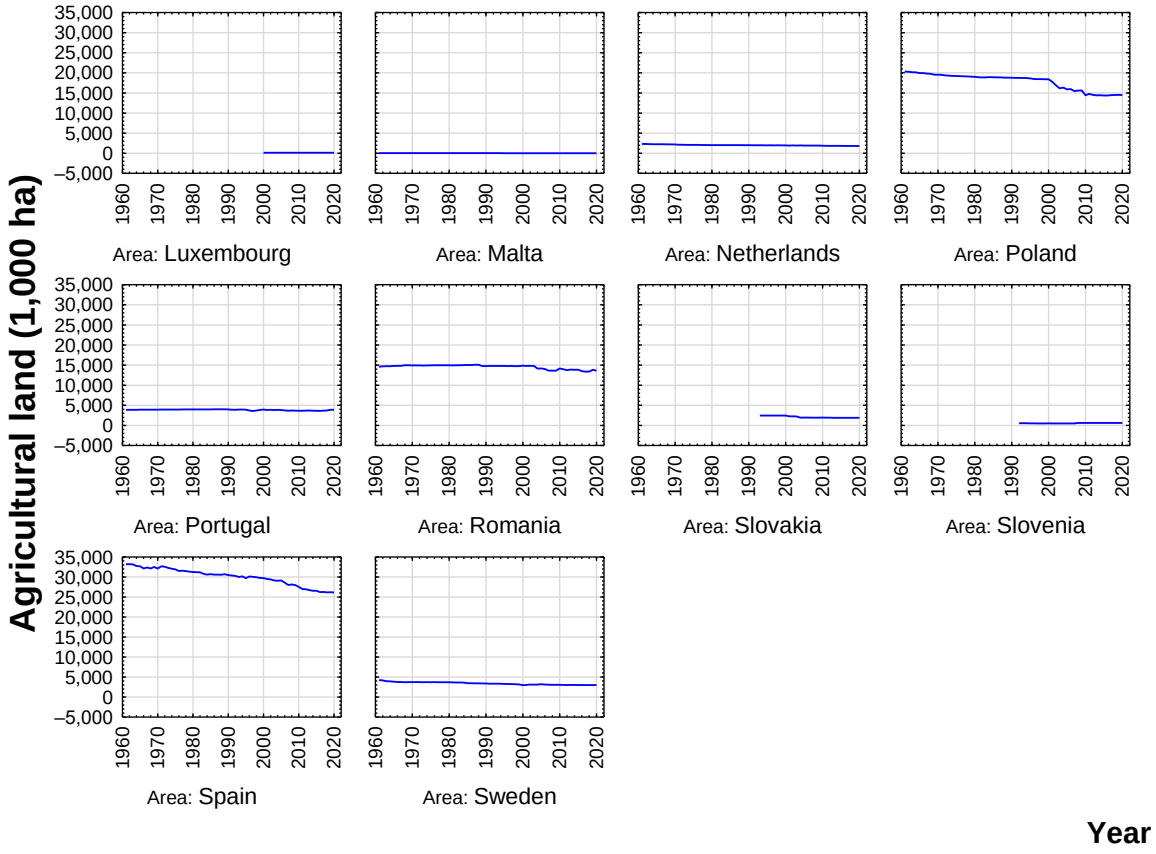


(**a**)



(**b**)

Figure A4. *Cont*.



(**c**)

Figure A4. (**a**–**c**) Changes in agricultural land in the European Union countries from 1961 to 2020.

Table A1. Changes in agricultural land on all continents from 1961 to 2020.

Region	Regression Equation	*p*	r^2
Africa	y = −3,478,144 + 2284x	0.0000	0.9097
Northern America	y = 1,989,462 − 756x	0.0000	0.9583
Central America	y = −217,966 + 169x	0.0000	0.3215
South America	y = −2,080,185 + 1307x	0.0000	0.5928
Asia	y = −25,400,495 + 13,466x	0.0000	0.8568
Oceania	y = 5,701,947 − 2630x	0.0000	0.7947
Europe	y = 16,128,571 − 7785x	0.0000	0.7812
European Union (27)	y = 986,616 − 406x	0.0000	0.7344

Table A2. Changes in agricultural land in the European Union countries from 1961 to 2020.

Country	Regression Equation	*p*	r^2	Change **
Austria	y = 30,785.6714 − 13.9407x	0.0000	0.9702	−25.56
Belgium *	y = 19,679.1905 − 9.116x	0.0000	0.8600	−24.65
Bulgaria	y = 89,659.8084 − 42.0122x	0.0000	0.8765	−18.36
Croatia	y = 54,865.3825 − 26.5677x	0.0015	0.3167	−37.40
Cyprus	y = 10,280.0523 − 5.0613x	0.0000	0.6895	−66.80
Czechia	y = 77,247.8091 − 36.6115x	0.0000	0.7438	−17.71

Table A2. *Cont.*

Country	Regression Equation	*p*	r^2	Change **
Denmark	$y = 20{,}045.4118 - 8.6618x$	0.0000	0.9289	−17.09
Estonia	$y = 11{,}475.1336 - 5.2341x$	0.0703	0.1163	−28.31
Finland	$y = 24{,}068.9314 - 10.8637x$	0.0000	0.8060	−17.92
France	$y = 2.3002 \times 10^5 - 100.0331x$	0.0000	0.9685	−17.33
Germany	$y = 1.2933 \times 10^5 - 55.9978x$	0.0000	0.9474	−14.35
Greece	$y = 1.0456 \times 10^5 - 48.2826x$	0.0000	0.6363	−34.15
Hungary	$y = 72{,}743.1583 - 33.4103x$	0.0000	0.9499	−30.78
Ireland	$y = 64{,}141.9966 - 29.6907x$	0.0000	0.7123	−20.13
Italy	$y = 2.7813 \times 10^5 - 131.4762x$	0.0000	0.9468	−37.15
Latvia	$y = 13{,}756.7232 - 5.9239x$	0.3041	0.0391	−22.17
Lithuania	$y = 41{,}019.231 - 18.9517x$	0.0014	0.3184	−13.17
Luxembourg	$y = -288.8289 + 0.2085x$	0.0000	0.7815	3.23
Malta	$y = 227.9085 - 0.1084x$	0.0000	0.7866	−42.33
Netherlands	$y = 16{,}774.532 - 7.4168x$	0.0000	0.9168	−21.59
Poland	$y = 2.2811 \times 10^5 - 105.6308x$	0.0000	0.8591	−28.84
Portugal	$y = 13{,}105.724 - 4.6431x$	0.0000	0.4343	−0.06
Romania	$y = 60{,}078.3191 - 22.8643x$	0.0000	0.5923	−6.92
Slovakia	$y = 55{,}807.7381 - 26.7671x$	0.0000	0.8086	−23.02
Slovenia	$y = -8235.0307 + 4.3848x$	0.00003	0.4800	8.24
Spain	$y = 2.6407 \times 10^5 - 117.557x$	0.0000	0.9516	−21.33
Sweden	$y = 40{,}440.7114 - 18.5956x$	0.0000	0.9387	−29.06

* until 1999 with Luxembourg; ** change in agricultural land area in % (1982/2020: Bulgaria; 1992/2020: Croatia, Estonia, Latvia, Lithuania, Slovenia; 1993/2022: Czechia, Slovakia; 2000/2020: Luxemburg).

Table A3. Description of diagnostic variables.

Variable Code	Name	Data Source	Unit	Description	Role
D1	Weak land market	[72] SE375/SE030	€/ha	SE375. Rent paid for farm land and buildings and rental charges SE030. Utilized agricultural areas rented by the holder under a tenancy agreement for a period of at least one year (remuneration in cash or in kind); in hectares. High land sale and lease prices are generally associated with high demand for agricultural land, and thus with a lower risk of abandonment (the higher, the lower the risk of abandonment).	stimulant
D2	Low farm income	[72,73] SE415/DGP per capita	€	SE451. Farm Net Value Added; Remuneration to the fixed factors of production (work, land and capital), whether they be external or family factors. As a result, holdings can be compared irrespective of their family/non-family nature of the factors of production employed. This indicator is sensitive, however, to the production methods employed: the ratio (intermediate consumption + depreciation)/fixed factors may vary and therefore influence the FNVA level. For example, in the livestock sector, if production is mostly without the use of land (purchased feed) or extensive (purchase and renting of forage land). SE415 is a weighted mean (average) calculated as a [sum of sample farm incomes x sample farm weights]/[sum of sample farm weights]. DGP per capita—Gross domestic product at market prices, Current prices, euro per capita. Agricultural land is at greater risk of abandonment when it ceases to generate sufficient income (the higher, the lower the risk of abandonment).	stimulant
D3	Low investment in the farm	[72] SE521/SE025	€/ha	SE521. Net Investment on fixed assets. Gross Investment on fixed assets—Depreciation. SE025. Total Utilized Agricultural Area. Total utilized agricultural area of holding. Does not include areas used for mushrooms, land rented for less than one year on an occasional basis, woodland and other farm areas (roads, ponds, non-farmed areas, etc.). It consists of land in owner occupation, rented land, land in share-cropping (remuneration linked to output from land made available). It includes agricultural land temporarily not under cultivation for agricultural reasons or being withdrawn from production as part of agricultural policy measures. It is expressed in hectares (10,000 m^2). As from 2014, it includes kitchen gardens. Investment behavior reflects the dynamics of the farm, its adaptability and expectations for the future. New investments signal a medium/long-term strategy and can be an indicator of the desire to continue farming (the higher, the lower the risk of abandonment).	stimulant

Table A3. *Cont.*

Variable Code	Name	Data Source	Unit	Description	Role
D4	Age of farm holder	[74] Age 65 and more/Total age	%	The ratio between farm holders above 65 years and the total number of farm holders has been calculated. Abandonment of farmland is more likely when the farmer population is older, close to retirement (the higher, the greater the risk of abandonment).	destimulant
D7a	Low population density	[75] Population density	person/km^2	Scarcely populated areas are identified from population statistics and were defined as areas with a population density below 50 inhabitants/km^2. The higher the population density, the less likely agricultural land is to be abandoned	stimulant
D7b	Remoteness	[76] Road networks	km/km^2	Motorways and other roads per thousand square kilometers. Abandonment of agricultural land is likely to occur in remote areas with inadequate access to basic services (health care, school and other services) and fewer marketing opportunities (the higher up, the lower the risk of abandonment).	stimulant

Table A4. Summary of dependent variable regression.

N = 25	b *	Std. Error with b *	b	Std. Error with b	t(23)	*p*
2010	R = 0.99629431 R^2 = 0.99260235 Corrected. R^2 = 0.99013646 F(6,18) = 402.53 p < 0.00000 std. error: 0.01503					
Intersept			0.139	0.008	16.887	0.0000
D1	0.289	0.034	0.0004	0.00005	8.373	0.0000
D2	0.245	0.026	0.0003	0.00003	9.589	0.0000
D3	−0.176	0.022	−0.0017	0.0002	−8.128	0.0000
D4	0.298	0.027	0.0003	0.00002	10.866	0.0000
D7a	0.265	0.032	0.00004	0.000005	8.217	0.0000
D7b	0.168	0.024	0.0161	0.0023	7.124	0.0000
2013	R = 0.99288540 R^2 = 0.98582142 Corrected. R^2 = 0.98109523 F(6,18) = 208.59 p < 0.00000 std. error: 0.01811					
Intersept			0.126425	0.00896	14.11051	0.000000
D1	0.2561	0.049056	0.000305	0.000059	5.22055	0.000058
D2	0.28482	0.039563	0.00022	0.000031	7.1992	0.000001
D3	−0.184943	0.028719	−0.001711	0.000266	−6.43984	0.000005
D4	0.292759	0.041806	0.000184	0.000026	7.00279	0.000002
D7a	0.227376	0.030905	0.011945	0.001624	7.35716	0.000001
D7b	0.224572	0.046893	0.000029	0.000006	4.789	0.000147
2016	R = 0.98691592 R^2 = 0.97400304 Corrected. R^2 = 0.96533739 F(6,18) = 112.40 p < 0.00000 std. error: 0.02043					
Intersept			0.108666	0.009221	11.78459	0.000000
D1	0.281342	0.066686	0.000276	0.000065	4.21893	0.000516
D2	0.319762	0.042822	0.000282	0.000038	7.46728	0.000001
D3	0.288382	0.039478	0.009957	0.001363	7.30489	0.000001
D4	0.349819	0.05475	0.000176	0.000027	6.38936	0.000005
D7a	−0.214998	0.038488	−0.001699	0.000304	−5.58606	0.000027
D7b	0.208994	0.062852	0.000023	0.000007	3.32519	0.003766
2019	R = 0.99398472 R^2 = 0.98800563 Corrected. R^2 = 0.98400751 F(6,18) = 247.12 p < 0.00000 std. error: 0.01613					
Intersept			0.119548	0.009112	13.12017	0.000000
D1	0.240778	0.045427	0.000271	0.000051	5.30037	0.000049
D2	0.279099	0.04781	0.000197	0.000034	5.83769	0.000016
D3	−0.176622	0.026478	−0.001409	0.000211	−6.6704	0.000003
D4	0.218311	0.027317	0.011527	0.001442	7.99184	0.000000
D7a	0.292289	0.039854	0.000173	0.000024	7.33394	0.000001
D7b	0.222805	0.047874	0.000028	0.000006	4.65399	0.000197

* nonstandardized coefficients.

References

1. Ramankutty, N.; Foley, J.A. Estimating Historical Changes in Global Land Cover: Croplands from 1700 to 1992. *Glob. Biogeochem. Cycles* **1999**, *13*, 997–1027. [CrossRef]
2. Berardi, G.; Green, R.; Hammond, B. Stability, Sustainability, and Catastrophe: Applying Resilience Thinking to U. S. Agriculture. *Hum. Ecol. Rev.* **2011**, *18*, 115–125.
3. Leal Filho, W.; Mandel, M.; Al-Amin, A.Q.; Feher, A.; Chiappetta Jabbour, C.J. An Assessment of the Causes and Consequences of Agricultural Land Abandonment in Europe. *Int. J. Sustain. Dev. World Ecol.* **2017**, *24*, 554–560. [CrossRef]
4. Estel, S.; Kuemmerle, T.; Alcántara, C.; Levers, C.; Prishchepov, A.; Hostert, P. Mapping Farmland Abandonment and Recultivation across Europe Using MODIS NDVI Time Series. *Remote Sens. Environ.* **2015**, *163*, 312–325. [CrossRef]
5. Rey Benayas, J.M.; Martins, A.; Nicolau, J.M.; Schulz, J.J. Abandonment of Agricultural Land: An Overview of Drivers and Consequences. *CABI Rev.* **2007**, *2*, 14. [CrossRef]
6. Keenleyside, C.; Tucker, G. *Farmland Abandonment in the EU: An Assessment of Trends and Prospects*; Report Prepared for WWF; Institute for European Environmental Policy: London, UK, 2010; p. 97.
7. Lasanta, T.; Arnáez, J.; Pascual, N.; Ruiz-Flaño, P.; Errea, M.P.; Lana-Renault, N. Space–Time Process and Drivers of Land Abandonment in Europe. *CATENA* **2017**, *149*, 810–823. [CrossRef]

8. Anguiano, E.; Bamps, C.; Terres, J.; Pointereau, P.; Coulon, F.; Girard, P.; Lambotte, M.; Stuczynski, T.; Sanchez Ortega, V.; Del Rio, A. *Analysis of Farmland Abandonment and the Extent and Location of Agricultural Areas That Are Actually Abandoned or Are in Risk to Be Abandoned*; Institute for Environment and Sustainability: Luxembourg, 2008.
9. Terres, J.-M.; Scacchiafichi, L.N.; Wania, A.; Ambar, M.; Anguiano, E.; Buckwell, A.; Coppola, A.; Gocht, A.; Källström, H.N.; Pointereau, P.; et al. Farmland Abandonment in Europe: Identification of Drivers and Indicators, and Development of a Composite Indicator of Risk. *Land Use Policy* **2015**, *49*, 20–34. [CrossRef]
10. Levers, C.; Schneider, M.; Prishchepov, A.V.; Estel, S.; Kuemmerle, T. Spatial Variation in Determinants of Agricultural Land Abandonment in Europe. *Sci. Total Environ.* **2018**, *644*, 95–111. [CrossRef]
11. Perpiña Castillo, C.; Coll Aliaga, E.; Lavalle, C.; Martínez Llario, J.C. An Assessment and Spatial Modelling of Agricultural Land Abandonment in Spain (2015–2030). *Sustainability* **2020**, *12*, 560. [CrossRef]
12. Zhang, Y.; Li, X.; Song, W. Determinants of Cropland Abandonment at the Parcel, Household and Village Levels in Mountain Areas of China: A Multi-Level Analysis. *Land Use Policy* **2014**, *41*, 186–192. [CrossRef]
13. Sroka, W.; Pölling, B.; Wojewodzic, T.; Strus, M.; Stolarczyk, P.; Podlinska, O. Determinants of Farmland Abandonment in Selected Metropolitan Areas of Poland: A Spatial Analysis on the Basis of Regression Trees and Interviews with Experts. *Sustainability* **2019**, *11*, 3071. [CrossRef]
14. Vinogradovs, I.; Nikodemus, O.; Elferts, D.; Brūmelis, G. Assessment of Site-Specific Drivers of Farmland Abandonment in Mosaic-Type Landscapes: A Case Study in Vidzeme, Latvia. *Agric. Ecosyst. Environ.* **2018**, *253*, 113–121. [CrossRef]
15. Quintas-Soriano, C.; Buerkert, A.; Plieninger, T. Effects of Land Abandonment on Nature Contributions to People and Good Quality of Life Components in the Mediterranean Region: A Review. *Land Use Policy* **2022**, *116*, 106053. [CrossRef]
16. Alcantara, C.; Kuemmerle, T.; Prishchepov, A.V.; Radeloff, V.C. Mapping Abandoned Agriculture with Multi-Temporal MODIS Satellite Data. *Remote Sens. Environ.* **2012**, *124*, 334–347. [CrossRef]
17. Zhou, Z.; Duan, J.; Li, W.; Geng, S. Can Rural Road Construction Promote the Sustainable Development of Regional Agriculture in China? *Sustainability* **2021**, *13*, 10882. [CrossRef]
18. Han, Z.; Song, W. Abandoned Cropland: Patterns and Determinants within the Guangxi Karst Mountainous Area, China. *Appl. Geogr.* **2020**, *122*, 102245. [CrossRef]
19. van der Zanden, E.H.; Verburg, P.H.; Schulp, C.J.E.; Verkerk, P.J. Trade-Offs of European Agricultural Abandonment. *Land Use Policy* **2017**, *62*, 290–301. [CrossRef]
20. Paudel, B.; Wu, X.; Zhang, Y.; Rai, R.; Liu, L.; Zhang, B.; Khanal, N.R.; Koirala, H.L.; Nepal, P. Farmland Abandonment and Its Determinants in the Different Ecological Villages of the Koshi River Basin, Central Himalayas: Synergy of High-Resolution Remote Sensing and Social Surveys. *Environ. Res.* **2020**, *188*, 109711. [CrossRef]
21. FAOSTAT Land Use. Available online: https://www.fao.org/faostat/en/#data/RL (accessed on 2 September 2022).
22. Corbelle-Rico, E.; Crecente-Maseda, R. Evaluating IRENA Indicator "Risk of Farmland Abandonment" on a Low Spatial Scale Level: The Case of Galicia (Spain). *Land Use Policy* **2014**, *38*, 9–15. [CrossRef]
23. Li, S.; Li, X. Global Understanding of Farmland Abandonment: A Review and Prospects. *J. Geogr. Sci.* **2017**, *27*, 1123–1150. [CrossRef]
24. Prishchepov, A.V.; Radeloff, V.C.; Baumann, M.; Kuemmerle, T.; Müller, D. Effects of Institutional Changes on Land Use: Agricultural Land Abandonment during the Transition from State-Command to Market-Driven Economies in Post-Soviet Eastern Europe. *Environ. Res. Lett.* **2012**, *7*, 024021. [CrossRef]
25. FAO. *The Role of Agriculture and Rural Development in Revitalizing Abandoned/Depopulated Areas*; FAO; The European Commission on Agriculture: Riga, Latvia, 2006; p. 15.
26. Cramer, V.A.; Hobbs, R.J.; Standish, R.J. What's New about Old Fields? Land Abandonment and Ecosystem Assembly. *Trends Ecol. Evol.* **2008**, *23*, 104–112. [CrossRef] [PubMed]
27. Nisini, L.; Anguiano, E.; Terres, J.-M. *Assessing the Risk of Farmland Abandonment in the EU*; JRC Scientific and Policy Reports; European Commission. Joint Research Centre. Institute for Environment and Sustainability: Luxembourg, 2013; p. 134.
28. Hou, D.; Meng, F.; Prishchepov, A.V. How Is Urbanization Shaping Agricultural Land-Use? Unraveling the Nexus between Farmland Abandonment and Urbanization in China. *Landsc. Urban Plan.* **2021**, *214*, 104170. [CrossRef]
29. Achieng, T.; Maciejewski, K.; Dyer, M.; Biggs, R. Using a Social-Ecological Regime Shift Approach to Understand the Transition from Livestock to Game Farming in the Eastern Cape, South Africa. *Land* **2020**, *9*, 97. [CrossRef]
30. Aide, T.M.; Grau, H.R. Globalization, Migration, and Latin American Ecosystems. *Science* **2004**, *305*, 1915–1916. [CrossRef] [PubMed]
31. Kuemmerle, T.; Hostert, P.; Radeloff, V.C.; Van Der Linden, S.; Perzanowski, K.; Kruhlov, I. Cross-Border Comparison of Post-Socialist Farmland Abandonment in the Carpathians. *Ecosystems* **2008**, *11*, 614–628. [CrossRef]
32. Munroe, D.K.; van Berkel, D.B.; Verburg, P.H.; Olson, J.L. Alternative Trajectories of Land Abandonment: Causes, Consequences and Research Challenges. *Curr. Opin. Environ. Sustain.* **2013**, *5*, 471–476. [CrossRef]
33. Milenov, P.; Vassilev, V.; Vassileva, A.; Radkov, R.; Samoungi, V.; Dimitrov, Z.; Vichev, N. Monitoring of the Risk of Farmland Abandonment as an Efficient Tool to Assess the Environmental and Socio-Economic Impact of the Common Agriculture Policy. *Int. J. Appl. Earth Obs. Geoinf.* **2014**, *32*, 218–227. [CrossRef]
34. Renwick, A.; Jansson, T.; Verburg, P.H.; Revoredo-Giha, C.; Britz, W.; Gocht, A.; McCracken, D. Policy Reform and Agricultural Land Abandonment in the EU. *Land Use Policy* **2013**, *30*, 446–457. [CrossRef]

35. van Leeuwen, C.C.E.; Cammeraat, E.L.H.; de Vente, J.; Boix-Fayos, C. The Evolution of Soil Conservation Policies Targeting Land Abandonment and Soil Erosion in Spain: A Review. *Land Use Policy* **2019**, *83*, 174–186. [CrossRef]
36. Pawlewicz, A.; Pawlewicz, K. Regional Differences in Agricultural Production Potential in the European Union Member States. In *Proceedings of the Rural Development and Entrepreneurship Production and Co-Operation in Agriculture*; Auzina, A., Ed.; Latvia Univ Agriculture: Jelgava, Latvia, 2018; Volume 47, pp. 483–489.
37. Bürgi, M.; Hersperger, A.M.; Schneeberger, N. Driving Forces of Landscape Change—Current and New Directions. *Landsc. Ecol.* **2004**, *19*, 857–868. [CrossRef]
38. Pawlewicz, A.; Cieslak, I.; Pawlewicz, K.; Szuniewicz, K. Natura 2000 Sites and Socio-Economic Development of Rural Communes in Eastern Poland. In *Proceedings of the Economic Science for Rural Development: Integrated and Sustainable Regional Development*; Kusis, J., Ed.; Latvia Univ Life Sciences & Technologies: Jelgava, Latvia, 2015; pp. 14–23.
39. Elbakidze, M.; Angelstam, P. Implementing Sustainable Forest Management in Ukraine's Carpathian Mountains: The Role of Traditional Village Systems. *For. Ecol. Manag.* **2007**, *249*, 28–38. [CrossRef]
40. Grădinaru, S.R.; Iojă, C.I.; Onose, D.A.; Gavrilidis, A.A.; Pătru-Stupariu, I.; Kienast, F.; Hersperger, A.M. Land Abandonment as a Precursor of Built-up Development at the Sprawling Periphery of Former Socialist Cities. *Ecol. Indic.* **2015**, *57*, 305–313. [CrossRef]
41. Perpiña Castillo, C.; Jacobs-Crisioni, C.; Diogo, V.; Lavalle, C. Modelling Agricultural Land Abandonment in a Fine Spatial Resolution Multi-Level Land-Use Model: An Application for the EU. *Environ. Model. Softw.* **2021**, *136*, 104946. [CrossRef] [PubMed]
42. Hart, K.; Allen, K.; Lindner, M.; Keenleyside, C.; Burgess, P.J.; Eggers, J.; Buckwell, A. *Land as an Environmental Resource*; Report Prepared for DG Environment, Contract No ENV.B.1/ETU/2011/0029; Institute for European Environmental Policy: London, UK, 2013.
43. Höchtl, F.; Lehringer, S.; Konold, W. "Wilderness": What It Means When It Becomes a Reality—A Case Study from the Southwestern Alps. *Landsc. Urban Plan.* **2005**, *70*, 85–95. [CrossRef]
44. Moreira, F.; Russo, D. Modelling the Impact of Agricultural Abandonment and Wildfires on Vertebrate Diversity in Mediterranean Europe. *Landsc. Ecol.* **2007**, *22*, 1461–1476. [CrossRef]
45. Dubinin, M.; Potapov, P.; Lushchekina, A.; Radeloff, V.C. Reconstructing Long Time Series of Burned Areas in Arid Grasslands of Southern Russia by Satellite Remote Sensing. *Remote Sens. Environ.* **2010**, *114*, 1638–1648. [CrossRef]
46. Schierhorn, F.; Kastner, T.; Kuemmerle, T.; Meyfroidt, P.; Kurganova, I.; Prishchepov, A.V.; Erb, K.-H.; Houghton, R.A.; Müller, D. Large Greenhouse Gas Savings Due to Changes in the Post-Soviet Food Systems. *Environ. Res. Lett.* **2019**, *14*, 065009. [CrossRef]
47. Gellrich, M.; Baur, P.; Koch, B.; Zimmermann, N.E. Agricultural Land Abandonment and Natural Forest Re-Growth in the Swiss Mountains: A Spatially Explicit Economic Analysis. *Agric. Ecosyst. Environ.* **2007**, *118*, 93–108. [CrossRef]
48. Baldock, D.; Selby, A.; Holland; van Landbouw, M.; Visserij, N. *Farming at the Margins: Abandonment or Redeployment of Agricultural Land in Europe*; Institute for European Environmental Policy: Brussels, Belgium, 1996.
49. Mather, A. The Transition from Deforestation to Reforestation in Europe. In *Agricultural Technologies and Tropical Deforestation*; CAB International: Wallingford, UK, 2001; pp. 35–52.
50. Kolecka, N.; Kozak, J.; Kaim, D.; Dobosz, M.; Ostafin, K.; Ostapowicz, K.; Wężyk, P.; Price, B. Understanding Farmland Abandonment in the Polish Carpathians. *Appl. Geogr.* **2017**, *88*, 62–72. [CrossRef]
51. Perpiña Castillo, C.; Kavalov, B.; Diogo, V.; Jacobs-Crisioni, C.; e Silva, F.B.; Lavalle, C. Agricultural Land Abandonment in the EU within 2015–2030. *JRC Res. Rep.* 2018. Available online: https://joint-research-centre.ec.europa.eu/system/files/2018-12/jrc113718.pdf (accessed on 1 January 2023).
52. EUROSTAT Agri-Environmental Indicator—Risk of Land Abandonment. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agri-environmental_indicator_-_risk_of_land_abandonment (accessed on 5 December 2022).
53. Kuropka, I. Prognozowanie na podstawie modelu ekonometrycznego. In *Prognozowanie Gospodarcze. Metody i Zastosowanie*; Cieślik, M., Ed.; PWN: Warszawa, Poland, 2001; pp. 104–139. ISBN 83-01-13347-3.
54. Milenkovic, N.; Vukmirovic, J.; Bulajic, M.; Radojicic, Z. A Multivariate Approach in Measuring Socio-Economic Development of MENA Countries. *Econ. Model.* **2014**, *38*, 604–608. [CrossRef]
55. del Holgado Molina, M.M.; Salinas Fernandez, J.A.; Rodriguez Martin, J.A. A Synthetic Indicator to Measure the Economic and Social Cohesion of the Regions of Spain and Portugal. *Rev. De Econ. Mund.* **2015**, *39*, 223–239.
56. Pérez, A.G.; Hernández-López, M.; Echeverria, F.R. *Sustainable Development Synthetic Indicators Based on Distance for Venezuela*; Bulucea, A., Ed.; WSEAS Press: Rome, Italy, 2015; Volume 42, pp. 194–200.
57. Ding, L.; Shao, Z.; Zhang, H.; Xu, C.; Wu, D. A Comprehensive Evaluation of Urban Sustainable Development in China Based on the TOPSIS-Entropy Method. *Sustainability* **2016**, *8*, 746. [CrossRef]
58. Fura, B.; Wang, Q. The Level of Socioeconomic Development of EU Countries and the State of ISO 14001 Certification. *Qual. Quant.* **2017**, *51*, 103–119. [CrossRef] [PubMed]
59. Hellwig, Z.H. Zastosowanie Metody Taksonomicznej Do Typologicznego Podziału Krajów Ze Względu Na Poziom Ich Rozwoju Oraz Zasoby i Strukturę Wykwalifikowanych Kadr. *Przegląd Stat.* **1968**, *4*, 307–327.
60. Wysocki, F. *Metody Taksonomiczne w Rozpoznawaniu Typów Ekonomicznych Rolnictwa i Obszarów Wiejskich*; Uniwersytet Przyrodniczy w Poznaniu: Poznań, Poland, 2010; ISBN 978-83-7160-583-3.
61. Pawlewicz, K. Differences in Development Levels of Urban Gminas in the Warminsko-Mazurskie Voivodship in View of the Main Components of Sustainable Development. *Bull. Geogr. -Socio-Econ. Ser.* **2015**, *29*, 93–102. [CrossRef]

62. Liu, X.; Zeng, F. Poverty Reduction in China: Does the Agricultural Products Circulation Infrastructure Matter in Rural and Urban Areas? *Agriculture* **2022**, *12*, 1208. [CrossRef]
63. Van Cauwenbergh, N.; Biala, K.; Bielders, C.; Brouckaert, V.; Franchois, L.; Cidad, V.G.; Hermy, M.; Mathijs, E.; Muys, B.; Reijnders, J.; et al. SAFE—A Hierarchical Framework for Assessing the Sustainability of Agricultural Systems. *Agric. Ecosyst. Environ.* **2007**, *120*, 229–242. [CrossRef]
64. Parysek, J.J.; Wojtasiewicz, L. *Metody Analizy Regionalnej i Metody Planowania Regionalnego*; Studia/Polska Akademia Nauk. Komitet Przestrzennego Zagospodarowania Kraju, t. 69; Państwowe Wydawnictwo Naukowe: Warszawa, Poland, 1979; ISBN 83-01-01219-6.
65. Kobe, I.H.; Olamide, O.E.; Bamidele, F.S.; Benedict, A.T.; Yemisi, B.K.; Kamal, D.A. Economic Assessment of Agricultural Land Market in Rural Nigeria: Pattern and Drivers. *J. Land Rural. Stud.* **2018**, *6*, 50–66. [CrossRef]
66. Ciaian, P.; Swinnen, J.F.M. Credit Market Imperfections and the Distribution of Policy Rents. *Am. J. Agric. Econ.* **2009**, *91*, 1124–1139. [CrossRef]
67. Pawlewicz, A.; Gotkiewicz, W.; Brodzińska, K.; Pawlewicz, K.; Mickiewicz, B.; Kluczek, P. Organic Farming as an Alternative Maintenance Strategy in the Opinion of Farmers from Natura 2000 Areas. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3793. [CrossRef] [PubMed]
68. Rickebusch, S.; Gellrich, M.; Lischke, H.; Guisan, A.; Zimmermann, N.E. Combining Probabilistic Land-Use Change and Tree Population Dynamics Modelling to Simulate Responses in Mountain Forests. *Ecol. Model.* **2007**, *209*, 157–168. [CrossRef]
69. Kalinowska, B.; Bórawski, P.; Bełdycka-Bórawska, A.; Klepacki, B.; Perkowska, A.; Rokicki, T. Sustainable Development of Agriculture in Member States of the European Union. *Sustainability* **2022**, *14*, 4184. [CrossRef]
70. Ziliaskopoulos, K.; Papalamprou, K. A Bilevel Linear Programming Model for Developing a Subsidy Policy to Minimize the Environmental Impact of the Agricultural Sector. *Sustainability* **2022**, *14*, 7651. [CrossRef]
71. MacDonald, D.; Crabtree, J.R.; Wiesinger, G.; Dax, T.; Stamou, N.; Fleury, P.; Gutierrez Lazpita, J.; Gibon, A. Agricultural Abandonment in Mountain Areas of Europe: Environmental Consequences and Policy Response. *J. Environ. Manag.* **2000**, *59*, 47–69. [CrossRef]
72. FADN. The Farm Accountancy Data Network (FADN)—The Standard Results Database. Available online: https://agridata.ec.europa.eu/extensions/FarmEconomyFocus/FarmEconomyFocus.html (accessed on 27 July 2022).
73. EUROSTAT Main GDP Aggregates per Capita. Available online: https://ec.europa.eu/eurostat/databrowser/view/NAMA_10_PC/default/table?lang=en (accessed on 5 December 2022).
74. EUROSTAT Employment by Sex, Age and Detailed Economic Activity (from 2008 Onwards, NACE Rev. 2 Two Digit Level)—1 000. Available online: https://ec.europa.eu/eurostat/databrowser/bookmark/582115c1-41fc-4c56-992c-ad2a9459ec53?lang=en (accessed on 5 December 2022).
75. EUROSTAT Population Density by NUTS 3 Region. Available online: https://ec.europa.eu/eurostat/databrowser/view/DEMO_R_D3DENS/default/table?lang=en (accessed on 5 December 2022).
76. EUROSTAT Road, Rail and Navigable Inland Waterways Networks by NUTS 2 Regions. Available online: https://ec.europa.eu/eurostat/databrowser/view/TRAN_R_NET/default/table?lang=en (accessed on 5 December 2022).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.