Determinants of Farmland Abandonment in Selected Metropolitan Areas of Poland: A Spatial Analysis on the Basis of Regression Trees and Interviews with Experts

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Abstract: Dynamic land use changes in metropolitan areas are global phenomena. The influence of urbanisation processes on farmland is twofold: urban encroachments predominantly take place at the expense of farmland, and also result in farmland abandonment processes, especially in Central Eastern and Southern Europe. This paper analyses determinants of farmland abandonment in 280 municipalities situated in six selected Polish metropolitan areas. The analysis, which covers secondary statistical data as well as primary data collected via a survey among experts, applies the regression tree method. Within the six selected metropolitan areas nearly 9% of the farmland is permanently excluded from agricultural production (actual abandonment), plus another 11.5% is currently not being used for production (semi-abandonment). For actual abandonment, physical and economic sizes of farms, part-time farming, and soil quality constitute the most relevant determinants. Socio-economic variables play a more important role in explaining semi-abandonment than actual abandonment. Temporary exclusion of farmland from agricultural production is connected with urbanisation processes. Higher shares of built-up and urbanised areas, higher population densities, and positive migration rates result in higher shares of semi-abandonment. Naturally, areas characterised by agrarian fragmentation, where due to low agricultural incomes farmers more often decided to abandon agricultural production, were, in particular, subject to this process.

Keywords: farmland abandonment; determinants; regression trees; metropolitan areas; Poland

1. Introduction

Dynamic land use changes in metropolitan areas are global phenomena [1–3]. The latter half of the twentieth century witnessed urban growth and sprawl on a scale never seen before due to people being attracted to peri-urban areas and beyond [4,5]. The spatial growth of cities and metropolitan areas most often takes place at the expense of agricultural areas being converted into non-agricultural uses [6–8]. In Europe, there has not only been an increase but also an extensive spread in urban development in...
forms that differ very considerably from those considered typical of suburban development [9]. Due to the increasing predominance of buildings and the new infrastructures associated with them, there has been overspill into areas which traditionally formed part of the rural landscape, making them more and more disparate, resulting in them losing their identity [1,5,10,11]. As a consequence, not only is agricultural land progressively diminishing, but we are also facing the prospect of large swathes of land that are abandoned or given over to miscellaneous use [4,5,12].

The problem of farmland abandonment and its determinants, especially in metropolitan areas, has not been sufficiently explored so far [13,14]. Studies still highlight the difficulties connected with defining this process [15], collecting data [16], as well as the complexity and multidimensional nature of driving forces for farmland abandonment (more detail in Section 2.2).

So far in studies covering Europe and other global Northern hemisphere regions, scholars usually focus on land abandonment in mountainous areas [17,18], land abandonment due to the Common Agricultural Policy (CAP) [19], and in countries formerly under Soviet influence [20,21]. International studies based primarily on secondary data (e.g., official statistics, data from the Farm Accountancy Data Network) reveal that farmland abandonment occurs in unfavourable agro-ecological conditions [15,22,23]. In addition, they show that an excessive scale of land abandonment is determined by an unfavourable farm structure (land fragmentation, small farms), as well as low farm stability and viability [17,20,22]. A significant role is also played by institutional factors [19]. International studies also analysed location [21,24–26] and socio-economic factors (including urbanisation factors) [2,22,27–29]. Most authors highlight that farmland abandonment is determined by urbanisation processes while the impact of location is variously interpreted and assessed [24,25].

The literature rarely analyses cities or metropolitan and peri-urban areas, where the dynamics and scale of urbanisation processes are usually very strong, but also varied across space [13,14]. Grădinaru et al. [13,30] and Gavrilidis et al. [31] note that the problem of farmland abandonment refers in particular to cities and metropolitan areas of Central and Eastern Europe, where the system transformation in the 1990s intensified this phenomenon. For example, in Poland, the share of abandoned farmland is above 15%, with some municipalities reaching even more than 30% [32]. The problem of excessive farmland abandonment is also visible in some Southern European countries, including the Barcelona metropolitan area [4,33], Catania metropolitan area in Italy [5], other metropolitan areas of Mediterranean countries [34], as well as in the metropolitan areas of Concepción (Chile) [12] and Canada [35].

Regional and local studies into farmland abandonment in peri-urban or metropolitan areas [4,12,13,30,33–36] were mostly based on analysis of satellite images (assessment of the scale and change of farmland abandonment) and official statistics data. To assess the drivers of farmland abandonment, the scholars mainly used regression analysis (different types) [13,32,36], as well other methods [4,13,34]. Those studies clearly emphasised factors of regional nature, i.e., localisation and socio-economic factors. The results of the studies confirmed the statistically significant impact of socio-economic and location factors in explaining farmland abandonment, however, scholars differed in their assessments [13,14,34]. There are also few studies of the process of farmland abandonment in metropolitan and peri-urban areas of Central and Eastern Europe countries [13,15,30–32] that indicate several specific factors connected with the imperfection of the agricultural land market (historical background), land tenure, speculations, etc.

Farmland abandonment is a significant land use process across Europe [15,22,25], and also a phenomenon that is likely to persist for several decades to come [18,37,38]. Scholars stress that urbanisation leads to an increased scale of farmland abandonment. Cities and metropolitan areas, especially in Central Eastern Europe, are subject to this process on an excessive scale [4,12,13,16]. Studies of farmland abandonment drivers in metropolitan and peri-urban areas are relatively rarely conducted, and their results vary depending on where they are carried out (Central Eastern Europe versus Southern Europe versus other countries) and on regional and local factors (e.g., speculations, problems with land tenure, etc.) This means it is of interest to analyse the determinants of the
abandonment of agricultural land in order to predict how the phenomenon will develop in the future and to identify possible ways of halting or redirecting the process and limiting its negative impacts [36].

The objective of this article is to assess the factors leading to spatial variations in the abandonment of farmland in selected metropolitan areas of Poland. For the purposes of the research presented, official statistical data has been used, along with the results of a survey conducted with local land use policy experts.

The paper analyses determinants of farmland abandonment in six selected Polish metropolitan areas. Farmland abandonment is not a new phenomenon, but scholars still indicate difficulties in defining and measuring it. Moreover, the literature offers a great many concepts and studies of farmland abandonment factors. Thus, in Section 2 we present selected definitions of farmland abandonment and discussed main drivers of farmland abandonment. The studies were based on results of Agricultural Census and surveys conducted among local experts, as described in Section 3. In Section 4.1, we use two regression tree models to assess main drivers of farmland abandonment for municipalities situated in metropolitan areas. In addition, in Section 4.2 we present results based on a survey conducted among local experts, who assessed farmland abandonment factors. In Section 5 we discuss the results, and in Section 6 we present key conclusions.

2. Definition and Drivers of Farmland Abandonment

2.1. Definition of Farmland Abandonment

Due to differences in definition, the absence of any coherent cross-EU data, and the difficulty of identifying abandoned areas of agricultural land using data gathered by means of remote sensing, it is challenging to carry out measurements and comparisons of farmland abandonment [39]. Definitions are challenging due to the fact that abandoned farmland may be in a state of transition, and that there may not be any set patterns in change of land use, which is often not linear [23]. The estimation of abandoned farmland or land in the process of abandonment is difficult because transitions of different land uses are not always unequivocal and precise [15]. Furthermore, farmland abandonment is defined in various ways, with the different definitions provided in the literature reflecting the complexity of this subject. The individual definitions depend on the type of approach (administrative, social, economic, etc.) and are adaptable to the context of the country [15,24,26,40,41]. Farmland abandonment is commonly defined (a) qualitatively by the condition of land, and (b) quantitatively by the number of years without agricultural use [41].

From an economic perspective, farmland abandonment “is the result of a landowner’s decision to reduce the intensity of use of land for agriculture (including grazing) for an undetermined period of time, based on either natural, socio-economic, or personal constraints” [23]. Similarly, Rudel [42] defines the abandonment of land as a change in its use to a lower economic state. He argues that just because farmland has been abandoned, that does not have to mean that it is no longer in use, and that it may in fact still be used for agricultural purposes or other forms of rural economic activity. A similar opinion is held by Pointereau et al. [15], who distinguish three categories of farmland abandonment: actual abandonment, semi-abandonment, and transitional abandonment. In the first case the vegetation may change depending on the natural geographic conditions through a series of ecosystems of tall grassland, bush, and forest. When use of farmland is only managed to a low degree, it is defined as “semi- or hidden abandonment”. The land is not abandoned in the formal sense and is managed to some degree, possibly just to ensure that it remains available to be used again in the future. Transitional abandonment is observed due to land reforms and restructuring of land, and is a phenomenon most often encountered in post-socialist countries.

In this paper, farmland abandonment is understood to be a process that involves reducing the intensity of farmland use. Two types of farmland abandonment are differentiated and measured: (1) actual abandonment; and (2) semi-abandonment. The method of measuring these categories is presented in detail in Section 3.3.1.
2.2. Drivers of Farmland Abandonment

There is a vast literature of empirical studies that have examined various drivers of farmland abandonment, and numerous scholars emphasise that factors of farm abandonment are multidimensional [16,22,25,43]. Usually these drivers are grouped into either natural constraints, socio-economic factors, demographic structure, and the institutional framework [22]. Some authors, such as Rey Benayas et al. [27], consider reasons related to unadapted agricultural systems to belong to a separate group of factors, while others, such as Terres et al. [22], emphasise the regional context of factors determining farmland abandonment. The specific nature of the process of farmland abandonment in areas with a high intensity of urbanisation means that location (proximity to the city) and socio-economic factors are taken to account to a greater degree in studies [34]. Thus, we propose to divide the driving forces up as follows: (1) socio-economic factors, (2) locations, (3) natural environmental features, (4) farm characteristics, and (5) institutional framework.

The first group of factors concerns socio-economic drivers. They include market incentives (more off-farm jobs), migration, urbanisation (more built-up areas), etc. [27] Increase in population density, migration, and an increased number of enterprises also result in farmland abandonment [13]. Nevertheless, the greater pressure of urbanisation related to a rise in population density, for example due to migration, may, however, have a completely different effect. Terres et al. [22], as well as Rey Benayas et al. [27], draw attention to the fact that one of the effects of an increase in demand for food and services provided by farms may be a decrease in farmland abandonment. Agriculture, as the weakest sector of the economy, loses in the competition for land, capital, and labour factors [2], often resulting in reduced intensity of production, including farmland abandonment, in areas subject to urbanisation. Risk of farmland abandonment may increase when agricultural income is substantially below that of the rest of the economy [22]. Usually, some of these drivers are mediators of large-scale or macro-driving forces of change, representing, ultimately, new economic opportunities [27].

The second group of determinants include location factors. The factor of location is strongly related to socio-economic factors, and this is why it is overlooked by certain scholars or treated as a category of socio-economic factors [24]. Several studies have analysed the relationship between farmland abandonment and proximity to settlements (travel time to the city centre) and roads [17,28]. The influence of these factors on the process of farmland abandonment are difficult to determine clearly. On the one hand, it is argued that peripheral land is more likely to suffer from abandonment [22,24], while on the other hand, it is pointed out that proximity to cities increases the likelihood of farmland abandonment due to better opportunities of finding off-farm jobs and options to sell farmland in the near future for urban uses, e.g., for housing [30,44,45]. The reason for farmland abandonment in the proximity of cities is related to increasing land-use change pressures in these areas, where there is a tendency to set aside land for speculative development purposes [43,45].

The next type of drivers refers to natural environmental features (also referred to as geo-bio-physical or ecological features). These features take factors such as altitude, slope, fertility, soil erosion, climate, and climate change into consideration. Several authors show that where the natural environment is less suitable, there is an increase in the risk of agricultural land being abandoned [17,20,22,29].

The fourth type of factor is farm characteristics. Farmland is typically abandoned when it is not able to create income [22]. Agricultural constraints due to low profitability and less favourable farm structures (predominance of small farms and fragmentation of land, lack of successors, etc.) lead to farmland abandonment [2,6,22].

The factors which are the hardest to assess, but which also play a significant role in the preservation of farmland in metropolitan areas, are those related to the institutional framework. Various forms of supporting agriculture as part of the Common Agricultural Policy were, and continue to be, particularly important in countries of Central and Eastern Europe. Diverse CAP measures have limited the degree of farmland abandonment by providing farms with additional income [16,25]. Various forms of supporting urban agriculture as part of food strategies and other plans for urban agriculture development may also be significant [46].
3. Study Area, Data Collection, and Methods

3.1. Study Area

Farmland abandonment is analysed in six monocentric metropolitan areas (MA) of Poland—the large metropolitan area of Warsaw, the mid-sized metropolitan areas of Krakow, Wroclaw, Poznan, and of the Tricity conurbation, and the small metropolitan area of Lublin. These areas were delimited on the basis of spatial development plans and strategies adopted by regional authorities [47]. In total, 280 municipalities have been selected for analysis, including 6 cities forming city centres (cores) of selected (monocentric) metropolitan areas and 274 municipalities from adjoining metropolitan areas (outer zone). Four municipalities in which the farmland share is below 2% are excluded. The analyses investigate the agricultural area (AA) cultivated by family farms in a particular municipality, while AAs with organisational legal status other than of private farms were deliberately left out.

The scope of the study covers 9.6% of the total area of Poland and includes 24% of the Polish population. The metropolitan areas have been selected in order to reflect the various environmental, social, and economic conditions in different parts of Poland [48]. The Warsaw, Krakow, Wroclaw, Poznan, and Tricity MA’s are some of Poland’s largest metropolitan areas, and the Lublin metropolitan area is slightly less populous than the Łodz MA (ranked 6th in terms of population) but was chosen deliberately to represent the slightly less-developed Eastern part of Poland in the studies [49]. The largest metropolitan area in Poland, the polycentric Upper Silesian Metropolitan Area was excluded from the studies. This metropolitan area is characterised by many specific development processes (among which the restructured mining sector is of considerable significance), and irregular positioning of the cities forming the core makes it impossible to take the factor of location into account [50].

3.2. Data Collection

Measuring and assessing the scale of farmland abandonment, as well as the drivers of this process, is a difficult task. One of the challenges is selection of appropriate source data. In order to achieve the aim of this study, both secondary and primary materials were used. Secondary materials included the scientific literature and data from the Statistics Poland, while primary material was a survey conducted among local experts. The individual data sources are described in Sections 3.2.1 and 3.2.2.

3.2.1. Secondary Data

Studies conducted by other authors (the scientific literature) were the first of the secondary materials used in this study. The overview of the literature was conducted in the first half of 2018. Literature research was performed to find useful keywords and to get an overview of the availability of farmland abandonment studies. The search was undertaken in the Web of Science, primarily using the keywords: (farm)land abandonment, and drivers and factors of farmland abandonment. The gathered material (based on abstract analysis) was subjected to selection—the latest analyses conducted in Europe and pertaining to peri-urban and metropolitan areas were given priority. The study also draws on some local and regional papers (e.g., Polish language publications) which describe specific conditions of farmland abandonment in Poland.

For measurement of the scale and drivers of farmland abandonment, the study used data from Statistics Poland, including data from the Agricultural Census 2010 and other information contained in the Local Data Bank (LDB). The Agricultural Census was conducted as a complete survey of agricultural farms, of physical persons with agricultural land, and legal persons and organisational units without legal personalities. Results of the Agricultural Census enabled collection of data on the scale of farmland abandonment and its drivers, in particular farm characteristics. Data concerning the other drivers of abandonment come from the Local Data Bank. LDB is Poland’s largest database of the economy, society, and the environment, and offers more than 40,000 statistical features, grouped thematically [51].
Secondary data were used to assess the scale of farmland abandonment (dependent variable) and identify its drivers (independent variable). The details of how dependent and independent variables were defined are presented in Section 3.3. The time period of the analyses is limited by availability of data. Dependent variables are for 2010, while the independent variables are for the years 1995–2010, whereby, depending on access to data, some variables cover shorter periods. Detailed information is provided in Tables.

3.2.2. Primary Data—Survey

The factors of farmland abandonment are very complex and often difficult to measure, therefore, apart from analysis of secondary data, a survey was conducted among experts. The respondents, who were familiar with the specific conditions and processes characterising the agriculture of metropolitan areas [46–48,50], indicated the main factors in land abandonment.

The survey has been conducted in 96 deliberately selected municipalities situated in Polish metropolitan areas. They represent municipalities located at varying distances from the metropolitan cores, and they are characterised by diverse environmental conditions of agricultural production (Figure 1). The principles underlying the selection of municipalities for expert surveys result from the assumptions of the research project entitled Urban Agriculture as a Challenge for Sustainable Development of Metropolitan Areas in Poland; that is, socio-economic, environmental, and planning-related aspects. In accordance with these assumptions in each of the metropolitan areas, at least two of the surveys come from MA cores, five from municipalities bordering the core, and ten from the other MA municipalities. The number of fully and correctly completed surveys is 113. When selecting municipalities surrounding the core, those with the relatively best and worst environmental conditions for agricultural production are included.

![Figure 1. Metropolitan areas falling within the scope of the study. Source: own work.](image)

The respondents are experts familiar with the local agricultural conditions, i.e., employees of offices of agricultural advisory centres. The survey questionnaire, together with the guiding letter, was sent to Directors of Regional Agricultural Advisory Centres in Poland. The directors were asked to pass the surveys on to employees with more than 20 years of professional experience in providing agricultural advisory services and with an excellent knowledge of the economic and environmental conditions determining agricultural development in the municipality being assessed (in Poland, the work of agricultural advisors is usually limited to the area of a given municipality). Above 90% of respondents have higher education, mainly agricultural or economic. The survey was carried out in the second half of 2017 and in the first half of 2018. The survey questionnaire consisted of
7 sections (49 mainly open questions) concerning issues of agricultural development in metropolitan areas. For the purposes of this study, the questions in the section entitled “The state and significance of agriculture in the development of metropolitan areas” (“Stan i znaczenie rolnictwa w rozwoju obszarów metropolitalnych”) were used. The question about abandonment factors was open-ended and due to the survey requirements it was answered by 55 out of 113 experts. The experts assessed the mechanisms and factors determining farmland abandonment over a timeline covering the past 20 years, as well as the percentage of actual abandoned farmland for 2017. All of the experts selected completed the surveys, providing comprehensive answers and explanations. After verification of the collected surveys, some information that was missing in a few cases was completed by making contact by e-mail or telephone.

During the surveys, a similar number of questionnaires was collected in each MA. As a consequence, very large metropolitan areas of Warsaw and Krakow, which are characterised by a large scale of farmland abandonment, can be considered as “under-represented”. In each metropolitan area, information was collected for a similar number of municipalities with the relatively best and worst agricultural conditions. This also reduced the representativeness of the sample.

3.3. Definition of Research Variables and Data Analysis

For the analysis of farmland abandonment drivers, the regression trees method was used. Regression trees modelling is a nonparametric approach which can explain the response of a dependent variable—farmland abandonment—among independent continuous or categorical variables. Subsequent sections present ways of defining dependent variables (farmland abandonment) and a set of independent variables which characterise potential drivers of farmland abandonment. In the last section we give an introduction to the regression trees method.

3.3.1. Dependent Variables

As the abandonment of agricultural land is often a gradual process involving a complex set of considerations, the research is based on three different approaches. Two forms of abandonment, considered to be dependent variables, are identified later in Section 4.1: namely, actual and semi-abandonment. Actual abandonment of farmland is defined as total cessation of cultivation of land in any form [15,42]. This corresponds with the term “other agricultural land” used in Polish official statistics, i.e., farmland not cultivated and not maintained in good agricultural conditions.

Farmland is considered to be semi-abandoned when it is not used for agricultural production, but where there are certain signs of it being cultivated or managed. Semi-abandonment refers to land that is maintained in a good agricultural condition, in compliance with the environmental protection requirements, but is currently not used for any kind of production [15]. This category contains in particular: (1) fallow land, including land as a result of compulsory set-aside schemes (as part of CAP payments); (2) land that was temporarily excluded on a voluntary basis from agricultural production; and (3) non-used permanent grassland (NuPG). The first two categories were calculated based on data from Statistics Poland (Agricultural Census), while the third (NuPG) one was estimated using the methodology proposed by Musiał et al. [52].

The share of permanent grassland (PG) in Polish metropolitan areas reaches approximately 16% of AA, while the quantity of grazing livestock is comparably small. In about 70% of the municipalities, each livestock unit (LSU) of grazing animals relates on average to more than 0.75 ha of PG, which according to Musiał et al. [52] means an extensive form of grassland management.

Musiał et al. [52] claim that in a situation where the farmer does not have grazing animals or where livestock density is very low, PG is not used productively (therefore, the share of NuPG is higher than the one declared by farmers as part of the Agricultural Census), because in Poland there are no alternative ways of using feed from meadows, and especially pastures. Thus, in this paper, the area of NuPG declared by farmers (Agricultural Census data) is adjusted for the areas that are potentially not used in livestock production.
Following the methodology proposed by Musial et al. [52], it is assumed that 1 LSU of grazing livestock (cattle, horses, sheep, and goats) needs a maximum of 0.75 ha of PG to be fed. If that surface area is greater, it means that PG is potentially not being used productively (semi-abandonment is occurring). Consequently, in the authors’ own work, in municipalities where:

- the area of NuPG declared by farmers (Agricultural Census data) is less than the potential NuPG (based on the nutritional needs of livestock), it is assumed that the area of NuPG corresponds to the potential NuPG;
- the area of NuPG declared by farmers is larger than the potential NuPG, the Agricultural Census data (declared by farmers) is used.

According to Musiał et al. [52], the potential surface of area of NuPG estimated in this way is even lower than the actual area that in fact exists, as currently livestock is not fed mainly with feed from meadows and pastures.

The dependent variables (actual- and semi-abandonment) have a normal distribution, meaning that an arithmetic average (AV) was employed for the purpose of the analyses (Table 1). Within Polish metropolitan areas, an average of 8.6% of AA is permanently excluded from agricultural production (actual abandonment), to which another 11.5% of AA can be added, which is not being used for production (semi-abandonment). In both cases, there are huge variations, both between the six MAs and also on an intra-metropolitan level (SD > 0.10). Within the two largest Polish metropolitan areas, i.e., Warsaw and Krakow, almost every fourth municipality has actual abandonment shares of more than 20%.

### Table 1. Set of dependent variables.

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Definition of Variable and Unit</th>
<th>Data Source</th>
<th>Range of Variation/Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual abandonment</td>
<td>Share of farmland not cultivated and not maintained in a good agricultural condition in the overall surface of AA in an individual municipality in 2010 (%)</td>
<td>Agricultural Census 2010</td>
<td>AV = 8.6%; SD = 0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min = 0.0%, Max = 54.2%</td>
</tr>
<tr>
<td>Semi-abandonment</td>
<td>Share of fallow land and permanent grassland not used for agricultural production, as held by farms, in the overall surface of AA in an individual municipality in 2010 (%)</td>
<td>Agricultural Census 2010</td>
<td>AV = 11.3%; SD = 0.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min = 0.0%, Max = 45.5%</td>
</tr>
</tbody>
</table>

Source: own work based on Statistics Poland Data.

The lowest shares of farmland abandonment occur in the Poznan metropolitan area, where the share of actual abandonment exceeds 3% of AA only in ten out of 45 municipalities. Furthermore, a relatively high share of actual abandonment is recorded in all MA cores in and directly around the cores, although this varies significantly from region to region.

#### 3.3.2. Independent Variables

Farmland abandonment results, among other things, from historical social and economic changes. The list of variables explaining the variation in the degree of farmland abandonment has been drawn up on the basis both of theoretical considerations and empirical research conducted by other scholars. Some independent variables have no normal distribution, hence median (ME) and minimum and maximum values are used for characterisation (Table 2). A range of variables that may impact farmland abandonment in Polish metropolitan areas were used in the study.
we wanted to investigate how bigger chances of finding alternative employment (low unemployment rate) and growing housing needs (higher population density and increase in net migration rate) affect farmland abandonment.

The first group is socio-economic drivers, including unemployment rate, built-up and urbanised areas, entrepreneurship, and commuting to work. By including these variables in the analyses, we wanted to investigate how bigger chances of finding alternative employment (low unemployment rate, high entrepreneurship, etc.) and growing housing needs (higher population density and increase in net migration rate) affect farmland abandonment.

Location factors constitute another very important group of farmland abandonment drivers. This is because proximity of an attractive labour market may result in a greater scale of land abandonment.

Table 2. Set of independent variables.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Name of Variable</th>
<th>Definition of Variable and Unit</th>
<th>Range of Variation/Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-economic</td>
<td>Population density</td>
<td>Population density of municipality—average for the period 1995–2010 (inhabitants/km²)</td>
<td>ME = 111.0</td>
</tr>
<tr>
<td></td>
<td>Net migration rate</td>
<td>Internal net migration per 1,000 inhabitants—average for 2003–2010 (person)</td>
<td>ME = 2.5</td>
</tr>
<tr>
<td></td>
<td>Commuting to work</td>
<td>Number of people coming in to work per 1 person going out to work for 2006 (person)</td>
<td>ME = 0.4; Max = 11.1</td>
</tr>
<tr>
<td></td>
<td>Unemployment rate</td>
<td>Share of registered unemployed people in the population of working age—average for 2003–2010 (%)</td>
<td>ME = 6.7; Max = 19.2</td>
</tr>
<tr>
<td></td>
<td>Entrepreneurship</td>
<td>Economic entities including natural persons—average for 2002–2010 (entities/10,000 population of working age)</td>
<td>ME = 1,319.4; Max = 5,474.4</td>
</tr>
<tr>
<td></td>
<td>Built-up and urbanised areas</td>
<td>Share of built-up areas in the total area of a municipality in 2010 (%)</td>
<td>ME = 5.5; Max = 86.5</td>
</tr>
<tr>
<td>Natural environmental features</td>
<td>Soil conditions</td>
<td>Soil conditions, agro climate, relief, and water conditions calculated on the basis of the Agricultural Production Space Valuation Ratio (point) **</td>
<td>ME = 51.4; Max = 84.6</td>
</tr>
<tr>
<td></td>
<td>Agro Climate</td>
<td>Agricultural Production Space Valuation Ratio (point) **</td>
<td>ME = 10.2; Max = 15.0</td>
</tr>
<tr>
<td></td>
<td>Relief</td>
<td>ME = 4.2; Max = 5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water conditions</td>
<td>ME = 3.2; Max = 4.8</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Travel time to the city centre</td>
<td>Travel time from centre of the municipality to the centre of the MA core (minutes) *</td>
<td>ME = 45.0; Max = 85.0</td>
</tr>
<tr>
<td>Farm characteristics</td>
<td>Small farms</td>
<td>Share of farms with a total area less than 5 ha in the overall number of farms—average for 1996, 2002, and 2010 (%)</td>
<td>ME = 62.4; Max = 98.8</td>
</tr>
<tr>
<td></td>
<td>Economically strong farms</td>
<td>Share of farms with an economic size in excess of € 15,000 of Standard Output for 2010 (%)</td>
<td>ME = 12.8; Max = 59.6</td>
</tr>
<tr>
<td></td>
<td>Successor</td>
<td>Share of farm owners with successors in 2010 (%)</td>
<td>ME = 8.8; Max = 46.8</td>
</tr>
<tr>
<td></td>
<td>Development prospects</td>
<td>Share of farms with good development prospects according to the farmer’s self-assessment in 1996 (%)</td>
<td>ME = 27.7; Max = 60.4</td>
</tr>
<tr>
<td></td>
<td>Part-time farming</td>
<td>Share of farm users making a living mainly from an off-farm job in 2002 (%)</td>
<td>ME = 79.9; Max = 99.9</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>Share of farmers with at least medium level education in 2002 (%)</td>
<td>ME = 12.0; Max = 43.8</td>
</tr>
<tr>
<td></td>
<td>Farmer age</td>
<td>Share of farmers under 44 years of age in 2010 (%)</td>
<td>ME = 35.0; Max = 58.6</td>
</tr>
<tr>
<td>Institutional framework</td>
<td>Spatial planning</td>
<td>Share of surface area of municipalities covered by spatial development plans for 2009–2010 (%)</td>
<td>ME = 32.1; Max = 100.0</td>
</tr>
<tr>
<td></td>
<td>Protected natural areas</td>
<td>Percentage of the overall surface area of a municipality that is land subject to various forms of environmental protection—average for 1996–2010 (%)</td>
<td>ME = 15.5; Max = 100.0</td>
</tr>
</tbody>
</table>

Note: * travel time according to Google Maps based on the shortest route by car; ** the Agricultural Production Space Valuation Ratio measures the quality of soil, climate, topography, and water conditions. The maximum possible value is 125 points. Based on this method of calculation, an average value of 66.6 points was obtained for Poland [53]. Source: own work based on Statistics Poland Data.
In order to assess the impact of location in the process of farmland abandonment, we test the time travel variable, which, on the one hand, shows the possibility of commuting to a city (the proximity to a city may accelerate the process of exiting agricultural activity), while on the other hand represents a potential risk of farmland speculation, which may lead to abandonment. We hypothesise that proximity to a city means a higher demand for land used for non-agricultural purposes (e.g., building land), therefore some farmers decide to abandon land because they expect an increase in prices and may be reluctant to sell their land [13,45].

The next analysed group of farmland abandonment factors relates to natural environmental features. The following variables are used in the analyses: soil conditions, agro climate, relief, and water conditions [53]. These variables vary considerably across municipalities and may impact the scale of land abandonment, which is confirmed by literature review.

Farm characteristics are also decisive in determining the scale of farmland abandonment. In this study we use the set of variables that characterise (dis)advantageous structures: small farms, part-time farmers, economically strong farms, as well as variables concerning the age of farmers, education, farm development prospects, and farm succession. According to the studies of other scholars (as described in Section 2.2) disadvantageous structures, as well as the lack of motivation for development (old age, poor development prospects, etc.), are likely to increase the risk of farmland abandonment.

Two variables are used to assess the impact of institutional framework on farmland abandonment: the proportion of the area of municipalities for which spatial development plans are established, and the share of land covered by various forms of environmental protection. These are included because suitable land use policies and protection of farmland are likely to contribute to reduced farmland abandonment [54]. In the metropolitan areas studied, the share of surface area covered by spatial development plans is lower than 30% in 50% of municipalities. The lack of such plans, especially in municipalities located close to cities, encourages speculation, as land for agricultural use may potentially be sold, for example, for the purposes of housing. The risk of farmland abandonment, thus, grows as a result [45].

The percentage of the overall surface area of a municipality that is land subject to various forms of environmental protection may have a double impact on farmland abandonment. On the one hand, farmers working in those areas often receive additional CAP payments [27], which should limit abandonment, while, on the other hand, various types of legal regulations restricting doses of mineral fertilisers, crop harvest dates, and livestock density may have a negative impact on profitability and increase farmland abandonment [55].

Some institutional factors were omitted in this paper, as they are the same for all the analysed units (municipalities), e.g., amount of payments under the CAP.

The article takes account of the most important independent variables from publically-available statistics for municipalities in Poland. The study did not seek to conduct an analysis of external factors leading to farmland abandonment, such as those related to broad-scale economics, policy, innovations, external migration, etc., firstly because our analysis is static in nature, and secondly because external factors have a similarly strong impact on all the analysed units (municipalities).

The method of regression tree analysis employed means that it is not necessary for independent variables to have normal distributions and that there is also no need to check whether there is any correlation between them [56]. There was found to be a relatively high degree of volatility in the individual variables.

3.3.3. Data Analysis—Regression Trees

Regression trees are an investigative method for analysing data. This article employs a method founded on the CART (Classification and Regression Trees) algorithm, one of the most innovative methods of creating regression trees. Regression trees offer several benefits over other models, including the much-favoured regression models. Some of the benefits of CART are: (1) the ability to process a
wide range of types of response, including numeric, categorical, and survival data, as well as ratings; (2) independent variables not being subject to variance due to monotonic transformations; (3) being robust and easy to build; (4) being easy to interpret; and (5) the ability to tolerate missing values in both responses and independent variables [57,58]. Furthermore, the step-by-step nature of the approach means the issue of collinear variables can be handled automatically, and because we do not need formal parametric tests of statistical significance, spatial autocorrelations cannot prevent correct use of CART [56].

The tool proposed by Breiman et al. [59] aims to search for a set of logical conditions that split the “if-then” relationship. Figure 2 presents an example of a regression tree explaining how CART algorithm works. When building a tree, a set of findings is split recursively into distinct sub-sets [60]. Using an algorithm to minimise variance, regression tree models split the data up over and over again to form increasingly homogeneous sub-groups, on the basis of criteria which split the independent variable. The aim of regression tree analysis is to arrive at a structure, for the independent variable, which results in the most homogeneous nodes. Data for dependent variables is divided up into a succession of child nodes derived from the primary nodes [61].

![Regression Tree Diagram](image)

**Figure 2.** An example of a regression tree showing factors impacting monthly spending on cinema. Source: own elaboration.

When selecting the optimum split, the software tries to keep the average “impurity” of the two child nodes to a minimum. For a node \( t \) of the tree, the “impurity” is defined as the sum of squared deviations \( i(t) = \sum(y - \bar{y}_t)^2 \), where \( \bar{y}_t \) is the sample mean of response variable \( Y \) in \( t \) and the sum is greater than the \( y \) values in \( t \). The split of \( t \) into child nodes \( tL \) and \( tR \) that maximises the reduction in node impurity \( i(t) - i(tL) - i(tR) \) is selected. The division of the tree into nodes continues until the \( y \) values are constant in a given node, or the node sample size falls below a pre-defined limit value. The tree is then pruned by means of cross-validation and the sub-tree with the lowest estimated mean squared error is selected [62]. To avoid unwanted complexity of models, the size of each node split into child nodes is limited to a minimum of ten instances. As a result, any branch of a node with less than ten instances is rejected.

One form of output from the CART procedure takes the importance of the predictors into consideration, ranking them in order of declining importance of the role they play in the building of trees. To obtain a score that reflects a predictor’s importance, CART calculates a measure of the improvement due to each variable were it to be used as a substitute for the primary split. The values of these improvements are added up for each node of the tree and scaled in relation to the variable which performs best. The variable with the highest cumulative total of improvements is given a score of 100, while all other variables receive lower scores ranging down from 100 to 0 [63].
When assessing the quality of a regression tree model, its authors recommend measurement of a model’s impurity reduction [62]. In our research impurity reduction is illustrated by variance, which at the first node in model I was 0.009491, and in model II was 0.016581. The used tree splits enabled variance reduction by around 65% in the case of model I and by 61% in the case of model II. This means that the models constructed are, respectively, 65% and 61% better at providing an explanation for the variation in the proportion of abandoned land as a percentage than the null model, i.e., a model without predictors. The theoretical concepts which underpin this method of data mining are described and discussed in further detail in the sources cited under references [62–64]. In our project, all calculations are performed with the use of STATISTICA 13 software (StatSoft, Tulsa, Oklahoma, USA).

4. Results

4.1. Factors Determining Differences in the Scale of Farmland Abandonment

The fundamental question posed in this paper concerns the factors that determine the scale of farmland abandonment. The constructed regression tree models show that the most important variable explaining the share of actual abandonment is the size of farms; in this case small farms below 5 ha of farmland (Figure 3).

Figure 3. Model I—regression tree diagram which shows predictors with an influence on determining the proportion of actual abandonment. Source: own elaboration.

Municipalities in which the share of small farms exceed 68.9%, the share of actual abandonment is 15% AA, whereas in the second group of municipalities (node ID = 2) it is only 4.6% recognisably lower. The scale of actual abandonment is determined by the quality of soil when the share of small farms is below two thirds. In municipalities where the soil quality reaches more than 44.5 points (maximum score is 95 points), less than three per cent of the agricultural area is abandoned, while in those with poorer soil quality the figure is almost three times higher (node ID = 6). In municipalities with a relatively small share of small farms and good soil conditions (node ID = 7), farmland abandonment is primarily determined by the share of economically strong farms and the quality of soil. Entities...
in which the share of economically strong farms exceed 30%, nearly no agricultural area (0.8%) is abandoned, whereas in the second group of municipalities (node ID = 8) the figure reaches nearly four per cent. However, if good soil conditions exist here, farmland abandonment is close to zero (0.2%).

While analysing the variation of farmland abandonment in municipalities dominated by small farms (node ID = 3), the factor that accounts for the largest variation in the phenomenon being studied is the share of built-up and urbanised areas. Urbanised regions (built-up and urbanised areas > 5.4%) are characterised by higher farmland abandonment shares compared to less urbanised and built-up municipalities (node ID = 4 versus node ID = 5).

In the presented model, “farm characteristics” variables dominate, which indicates that they play the most important role in explaining the topic of investigation and that it is those characteristics that guarantee the highest degree of “purity” of the model at each split in the tree (Figure 4). Nevertheless, it of course does not follow from this that the other variables are of no importance in describing the topic being investigated.

Apart from actual abandonment, especially in Polish metropolitan areas, semi-abandonment also occurs on a large scale. Semi-abandoned farmland is farmland that is out of production, but where the farmland is still being maintained in good agricultural condition. This complies with CAP direct payment regulations. The average share of semi-abandonment in MAs is 11.5% of AA (Figure 5).

One factor that can be singled out as playing one of the most important roles in determining the variation in semi-abandonment is the share of built-up and urbanised areas. In 45 municipalities where the share of such land exceeds 17.7%, i.e., in MA cores and mainly small towns, the average share of semi-abandoned farmland reaches one quarter (node ID = 3). In municipalities where the share of built-up and urbanised areas is higher than 17.7%, and over 89.7% of farmers earn their living mainly from off-farm jobs, abandonment is even higher and accounts for 30% (node ID = 5). In the other group of municipalities, namely ones with relatively high urbanisation and a slightly lower percentage of part-time farming, the share of farmland abandonment is somewhat lower, i.e., 18.6% AA.
When analysing differences of farmland abandonment in municipalities with a slightly lower percentage of built-up and urbanised areas it can be noted that population density is the factor that clearly determines semi-abandonment (node ID = 2). Municipalities with a population density > 115 inhabitants/km² have a farmland abandonment share of 13.6% AA, whereas in the remaining less densely populated municipalities the share of abandoned farmland is more than 50% lower. The significant importance of socio-economic factors in explaining semi-abandonment is evidenced in further splits of the regression tree. It turns out that in municipalities with comparable low shares of urbanised areas and high population densities (> 115 inhabitants/km²), abandonment rates are higher (15.4% on average) if there is a positive net migration (node ID = 63). If, additionally, there is a relatively low unemployment rate in such municipalities (below 8.1%), then as much as 17.2% AA is abandoned. In each of the described splits, a higher intensity of urbanisation processes, i.e., higher population density, higher net migration, and greater chances of finding an off-farm job (low unemployment rate), result in greater farmland abandonment. Agricultural activity, especially in the case of smaller farms, ceases to be a source of income, and as a result gradual extensification of production occurs.

Farmland semi-abandonment in municipalities with relatively low shares of built-up and urbanised areas and moderate population densities (< 115 people/km²) is widely determined by part-time farming. Municipalities in which the share of farmers who earn their living mainly from off-farm jobs is below 86.8%, 4.3% AA is abandoned, whereas in the group of 26 municipalities dominated by part-time farming the figure is as high as 16.5%. The abandonment shares are lowest in municipalities that—apart from relative low urbanisation pressures—are characterised by higher percentages of full-time farmers and lower percentages of small farms (node ID = 14).

When evaluating the importance of the individual variables in providing an explanation for the variation in semi-abandonment, it should be noted that the share of part-time farming is the most important (Figure 6). Although this variable does not appear first in tree splits, but on average in the whole tree sequence, it shows the highest capability of raising the “purity” of the model. The variable’s...
share of built-up and urbanised areas, small farms, and economically strong farms have slightly lower importance in explaining semi-abandonment.

![Figure 6. Importance of the predictors for the share of semi-abandonment. Source: own elaboration.](image)

In contrast to the previous model, variables illustrating socio-economic factors are more important. The part-time farming variable, although it was classified to the group “farm characteristics”, can be partially treated as an element of socio-economic situation, as it indirectly indicates chances of finding an off-farm job. Similarly, to the previous model, location and institutional drivers were of minor significance.

4.2. Factors of Actual Farmland Abandonment according to Experts

The information that is contained in this section shows the results from the survey among local experts. The experts indicated the main determinants of farmland abandonment.

The analysis allows the named determinants to be divided into specific and more universal ones. The specific factors include fragmentation of farms and their low economic power (low incomes of farms). These factors are mainly indicated by experts from Krakow MA (16 of 19 respondents), Warsaw MA (12 of 19 respondents), and Lublin MA (5 of 18 respondents), therefore the problem is analysed separately. Land fragmentation has its roots in history and only occurs in certain (in the South and East of the country) regions of Poland [65]. Within these regions of agrarian fragmentation the experts indicate that the key factor is fragmentation of farms and low profitability of agricultural production. They note that the owners of small farms, unable to obtain satisfactory income from agriculture, have for decades earned their income mainly from off-farm jobs, with decreasing profitability of small-scale agricultural production leading to its abandonment.

A relatively well-developed urban labour market manifests as a universal determinant of land abandonment (Figure 7). The experts stress that when a landowner takes up a more profitable off-farm job, they are gradually resigning from land cultivation. One of the experts notes that “as long as the ancestors are alive, the land is cultivated, but after their death it is sold piece by piece or abandoned.” This argument was mainly raised by the experts assessing the municipalities located in highly urbanised regions or municipalities with fragmented agrarian structures. Another very important factor is low production quality of land. The experts stress that land of poor soil quality or located on slopes, and land with difficult access (e.g., when farmland is divided by a highway) account for by far the largest share of abandoned land. Neither its owners nor potential lessees are interested in cultivating such land. According to the experts, speculations of landowners who expect an increase in the value of
the land also play a significant role. This refers in particular to land located close to built-up areas. Landowners, i.e., usually people who inherited the land, but also typical investors, are not interested in leasing the land for agricultural use, so the farmland is abandoned. However, some experts claim that landowners often overestimate the capacity of the construction land market and expect very high prices for land in locations where, for example, houses will not be built in near the future. They think that "land, even without proper infrastructure, is worth millions", and do not want to sell it to other farmers or lease it.

A reasonably important factor, though not mentioned so frequently, is lack of successors. In municipalities with an excessive scale of farm abandonment, several problems occur concurrently, including land fragmentation, poor natural-geographical conditions, and consequently, low profitability of production. As a result, it is hard to find individuals willing to take over the farm. This vicious circle leads to an even larger scale of farmland abandonment. The experts also indicate other factors, such as family disputes, and significant difficulties with running a farm in municipalities with considerable migration. Newly arrived inhabitants often consider agricultural activities and related inconveniences, such as odour, soiled roads, dust, or traffic blocked by agricultural machines, problematic. In the first phase, farmers often resign from livestock production, which is also translated into problems with farming pastures and meadows and leads to stepwise abandonments.

Concerning institutional frameworks, experts’ opinions are mixed, as some, mainly from the Poznan MA and Tricity MA with a relatively good agricultural structure, unanimously claim that direct payments lead to reduction of farmland abandonment. Experts from regions with agrarian fragmentation argue that direct payments and other measures as part of CAP reduce farmland abandonment, but it does not apply to very small farms. They explain that in the case of very high land fragmentation, some plots do not qualify for these payments.

5. Discussion

The scale of farmland abandonment varies significantly in Polish metropolitan areas and in some it is said to even pose a potential risk to sustainable development (loss of production function, recreation activities, agrobiodiversity loss, landscape degradation, fire frequency, etc.). Indeed, in the literature on the subject, it is emphasised that farmland abandonment limits the multiple benefits of urban agriculture [66–68]. The farmland abandonment is specific to certain countries and regions, and as such requires a separate reflection [15,16,23,26,40–43]. In Polish metropolitan areas, small farms are the main factor of actual abandonment. Also, experts who are situated in regions with agrarian fragmentation

![Figure 7. Ranking of farmland actual abandonment factors according to experts. Note: The answers were given by 55 experts, who indicated a maximum of 3 factors. Source: own elaboration.](image-url)
(mainly Krakow MA and Warsaw MA) explain actual abandonment with unfavourable farmland fragmentation. This paper’s main results are consistent with findings from other scholars, who link small-scale agriculture and fragmented land ownership with high abandonment rates [15,18,19,22,32]. Also, the experts score land fragmentation as the most important factor, which is additionally compounded by other factors, including an attractive labour market, speculation, and poor soil quality. Additionally, it is stated that farmland owners often do not want to sell their land, because the costs of selling small areas of agricultural land are often higher than actual or potential benefits. Satola et al. [45] explain this situation with the existence of a range of explicit and implicit costs and by rent seeking. Sale or lease of land, and thus resignation from the status of a farmer, means loss of tax and insurance advantages (which are very attractive in Poland), resignation from funds as part of the CAP, and loss of potential benefits connected with a future increase in land prices or converting land for building purposes (the so-called planning rent). Similar conclusions have been arrived at by other scholars, including Kilian and Salhofer [69] and Molnár and Vandenbroucke [70]. From the perspective of an individual farmer, it can be more profitable to own land and extensify production, which results in semi-abandonment or actual abandonment.

The findings also show that actual abandonment mainly depends on the size and economic strength of farms, as well as soil quality. These factors largely determine farm stability and viability [22]. This relationship is with other findings, e.g., Baumann et al. [20] show that high yield potentials reduce the probability of agricultural land being abandoned. Similar conclusions have been reached by Gellrich and Zimmermann [17] and Xie at al. [6]. Part-time farming, development prospects, and level of farmers’ education also play a relatively large role in explaining actual and semi-abandonment. For part-time farmers, the manifold job possibilities outside agriculture make them more inclined to leave farming [71–73] and abandon land. Farmers’ high education levels and positive self-assessments of development prospects have a positive influence on maintaining farmland in good agricultural condition, a conclusion that is also confirmed by other scholars [74,75].

Summing up the discussion on the factors of actual abandonment, the variables “farm characteristics” and “natural environmental features” are most important. Less important are socio-economic variables and location. This may be due to a relatively small influence of Polish cities on some municipalities—in particular those located further outwards in the MA periphery. In Poland suburbanisation processes started relatively late [76,77] and actual abandonment refers to land that has not been used for many years. This latter process may not have left its full mark yet, which can be confirmed by surveyed experts from municipalities located on the MA outskirts. Experts often indicate that cities influence agriculture and land markets only to a small extent. The experts there also indicate that the main factors determining farmland abandonment are natural environmental features and farm characteristics. This does not neglect the influence of socio-economic and location variables on actual abandonment. Proximity to urbanised areas, especially in countries with improper legal protection of farmland, such as Poland, facilitates speculation [47]. Land, used or not, is most often not sold or leased due to expected land price increases. This is in line with the conclusions drawn by Krzyk et al. [78] and Grădinaru et al. [13], who note that abandoned land is a forerunner of built-up areas. Krzyk et al. [78] stress that in Poland abandoned land is easier to convert for construction purposes. This phenomenon is mainly observed where urbanised areas are sprawling. A similar trend is also reported for Barcelona MA [4] and Bucharest [13].

Socio-economic and location factors are not the main factors of actual abandonment, but they are of utmost importance in explaining semi-abandonment. Thus, urbanisation generates semi-abandonment at the first stage and only over time is such land in danger of being fully abandoned. One of the factors identified as being of the most importance in determining semi-abandonment is the share of urbanised and built-up areas. Further variables of relevance are population density and migration rate. Nowadays living habits demand land, so that population growth, migration [79], economic and employment growth [80], together with high population densities [81] lead to urban encroachments.
Most often, this occurs at the cost of AA, which are abandoned in the first phase, and then converted to meet the needs of urban development [13,47].

These results have very important implications because, both in Poland [82] and in Europe [1], increasingly dynamic processes of suburbanisation (increase in population density, increase in number of jobs, etc.) are envisaged in suburban areas. According to forecasts by Piorr et al. [1], peri-urban areas may even double in size by 2030. The presented models have the potential to be developed into a model for the purpose of prognostics. The authors’ findings may prove to be useful in order to identify municipalities in MA affected by future farmland abandonment. Based on forecasts concerning economic growth, processes of migration, etc., it is possible to indicate areas that are most vulnerable to farmland abandonment. Knowledge of mechanisms and factors that play a part in determining farmland abandonment also makes it possible to plot further courses of action that can be taken to protect AAs in MAs. As in the case of actual abandonment, speculations of landowners and a growing pressure from newly settled inhabitants lead to reduced production intensities as a result of various kinds of inconveniences, such as unpleasant odours, pollution, roads soiled with agricultural equipment, etc. Similar conclusions are drawn by Lisansky and Clark [83], Zasada et al. [84], and Bernard et al. [85]. Further interrelated determinants of relevance in explaining actual and semi-abandonment are part-time farming, small farms, and economically strong farms. Small shares of large and economically strong farms go together with part-time farming. People that have an off-farm job often resign from agricultural activity—especially one that is conducted on a small scale.

Contrary to other studies [18,21,26,44], the predictor that reflects location in relation to the core (time travel) is only of minor importance. This is surprising, as the experts indicate the distance from urbanised areas is a factor of importance in determination of farmland abandonment. In the case of the city centres of MA and municipalities directly bordering them, three quarters of the experts state that proximity to urbanised areas has a negative influence on continuation of agricultural activity. However, the small significance of location factors may result from the scope of the research. Municipalities are units of comparably large areas (on average 106.4 km²) and processes of increased farmland abandonment may take place mainly at the peri-urban interfaces of cities. Moreover, it should be stressed that except for Warsaw MA, municipalities with a very small share of semi-abandonment are located close to the cores of metropolitan areas. The experts explain this fact by a long tradition of supplying cities with agricultural products, high specialisation, and good quality of soil. Indeed, this was the case for municipalities with very favourable environmental conditions, and in Poland many municipalities bordering the cores of MA have good production conditions [47].

Other scholars highlight that CAP payments can reduce farmland abandonment [24,25,86]. Also, in our survey, the experts confirm that these funds significantly reduce actual abandonment. Thanks to these financial incentives, some land that would have been permanently abandoned is being maintained in a good agricultural condition. Actual farmland abandonment decreased in Poland from 1.9 million hectares in 2002 to 0.7 million hectares in 2010, which Dzun [87] relates primarily to the introduction of CAP direct payments. This allows the analysed MA to increase their food security. However, such funds are only of little significance in regions with agrarian fragmentation, because plots that are too small, and in farmers’ opinion, if levels of public support are too low, discourage farmers from maintaining land in good agricultural condition.

6. Conclusions

Actual farmland abandonment of the chosen six Polish MAs, i.e., the share of farmland that is permanently excluded from agricultural production and is not maintained in a good agricultural condition, covers 8.6% AA. In addition, around 11.5% AA is temporarily excluded from agricultural production (semi-abandonment) in the six analysed MAs.

Considered determinants of farmland abandonment can be grouped into natural environmental features, socio-economic conditions, location factors, institutional framework, and farm characteristics.
In the case of actual abandonment, most relevant are farm characteristics, in particular the physical and economic size of farms and part time farming. The quality of soil is also important. Thus, the large share of actual abandonment is mainly due to the weaknesses of agriculture and difficulties with generating satisfactory incomes. Additionally, farmland abandonment is increased by a relatively high attractiveness of the local labour market, which leads to part-time farming, with farmers deciding to abandon agricultural production over time. Socio-economic variables play a more important role in explaining semi-abandonment than actual abandonment. Farmland’s temporary exclusion from agricultural production is connected with urbanisation processes. Higher shares of built-up and urbanised areas, higher population densities, and positive migration rates result in higher shares of semi-abandonment. Naturally, areas characterised by agrarian fragmentation, where due to low agricultural incomes farmers more often decided to abandon agricultural production, were in particular subject to this process.

Regarding farmland abandonment, the research demonstrates that present CAP instruments are effective only in some MA municipalities. They cannot prevent land abandonment in municipalities struggling with farm fragmentation. This indicates the need to research legal and economic instruments and their effectiveness for municipalities characterised by agrarian fragmentation and remaining municipalities. It seems that currently there is an urgent need in Poland to formulate new legal instruments and solutions that will limit free disposal of agricultural land, correcting market mechanisms (a landowner’s desire for maximisation of benefits) and contributing to sustainable development of such areas.

**Author Contributions:** W.S. and T.W. developed the original idea for the paper. M.S., P.S., and O.P. were responsible for data collection, including conducting surveys. B.P. contributed to the design of the research, provided guidance, and proofread the manuscript. The final manuscript has been read and approved by all authors.

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