On farm non-agricultural activities: Recent evolution and dynamics in Portugal

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DOI: 10.30682/nm2404d
JEL codes: Q15, Q24

Abstract

An increasing share of farmer's revenues derives from on-farm non-agricultural activities (OFNAA), which constitute a complement to the farmer's income and can function as a factor for the development of farms, enhancing the endogenous resources of the territories and contributing to the multifunctionality of rural areas. Therefore, it is relevant to understand the importance of these non-agricultural activities in the territory, their diversification, spatial trends at local level and the relation with farm's orientation. This paper intends to analyse the OFNAA, using as object of study the Portuguese municipalities. To analyse the diversification of the OFNAA, a diversification index based on entropy is proposed. The relationships between OFNAA diversification and the farms' technical-economic orientation (TEO) are also analysed using correlation matrixes, while the spatial patterns are studied, using the global Moran I and local Moran-LISA. The results provide important insights of the OFNAA dynamics and diversification. Therefore, this study provides an important tool for policy management and implementation.

Keywords: *On-Farm Non-Agricultural Activities (OFNAA), Diversification Index (DI), Normalised entropy, Global Moran I, Local Moran's I - LISA.*

1. Introduction

Agriculture is typically an activity subject to risk and uncertainty. According to Bairwa *et al.* (2013) "Risk can be defined as imperfect knowledge where the probabilities of the possible outcomes are known, and uncertainty exists when these probabilities are not known". Farmers carry out their activity in a highly uncertain environment. Moschini and Hennessy (2001) state that this uncertainty can have several sources, such as production uncertainty; technological uncertainty, and political uncertainty. In the Mediterranean area, Céu and Gaspar (2024) studied the financial distress of farms cultivating vines and olives and highlighted that the effects of climate change and free trade, imply interventions to enhance the economical context of rural areas and reduce risk. To control risk and reduce uncertainty regarding

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different factors, farmers can implement different strategies (Boncinelli *et al*., 2017), one of which involves the development of other non-agricultural activities, such as tourism, food production, or renewable energies, among others.

Several investigations carried out at the international level indicate that an increasing part of farm income comes from on-farm non-agricultural activities (OFNAA) (Boncinelli *et al*., 2017), with many empirical studies supporting the contribution of diversification to increase household income and reduce uncertainty (Reardon *et al*., 1992; Mishra and Sandretto, 2001; de Janvry *et al*., 2005; Owusu *et al*., 2011). Besides stimulating family income, OFNAA can provide a substantial contribution to rural development, namely by reducing the level of poverty, especially in developing countries (Lanjouw and Lanjouw, 2001; Lanjouw and Shariff, 2004) and are gaining importance in rural economies. According to Boncinelli *et al.* (2017), based in Eurostat's Farm Structure Survey (2008), 12% of European farms had OFNAA. For the USA, Vogel (2012), cited by Boncinelli *et al.* (2017), provides an estimation that 40% of the total agricultural production originates from OFNAA.

In the last 40 years, the European Union has promoted agricultural diversification through direct support programs at both national and supranational levels (Chaplin *et al*., 2004). On the other hand, as Elisiário (2018) points out, there is a growing demand for "rural" and society expects diverse functions from the rural world, having sparked interest in studying the means of achieving progress in rural areas and how this impacts the farmer's activity. In Portugal, OFNAAs constitute a complement to the farmer's income and can contribute also to the development of agricultural holdings, through the enhancement of traditional activities, using existing endogenous resources, both on the farm itself and in the surrounding territories. The sustainable development of Portuguese agriculture must be related to an equitable development of profitable non-agricultural activities, which can support the development of agricultural holdings and the rural communities where they are located. Moreover, there are also new dynamics on farms, through new activities arising from market demand and new food diets, which give rise to new needs to be met, particularly in the energy and tourism areas, where the demand for clean energy and amenities make the study of OFNAA interesting.

The collection of OFNAA data has been carried out since 1999 in agricultural census, whose definition says that they are on-farm profitable activities, which use the farm's resources, and which can be carried out by family labour and/or hired labour. Studying it over time shows trends that can later be considered by agricultural policy to develop additional income for farmers, creating conditions for improving rural development and the well-being of agricultural entrepreneurs.

However, few studies analyse these activities in Portugal. Elisiário (2018) stands out in a study at regional level, from 1999 to 2016, relating the OFNAA trends to various factors related to "geographical distribution and the physical, economic and labour dimensions" of agricultural holdings. To date, there appears to be no research that analyses the degree of diversification of different Portuguese municipalities in non-agricultural activities and that relates these activities to the dominant farms' technical economic orientation (TEO). However, the Agricultural Census of 1999, 2009, and more recently of 2019, provide information regarding OFNAA with a spatial disaggregation at the municipality and parish level.

In this context, it was considered pertinent to study the dynamics of OFNAA's evolution in small territorial units, namely municipalities, identifying the differences in terms of diversification. A more diversified OFNAA will imply more resilience.

To measure diversification, entropy provides an interesting tool. The entropy concept, from physics, was introduced by Shannon (1948) in information theory and used by Jaynes (1957) in statistics. Several authors have used the normalised entropy measure (Golan, 1994 cited by Golan *et al*., 1996; Xavier *et al*., 2018), to measure uncertainty. The relation with the TEO, may be analysed with statistical methods such as correlations and the differences in diversification among them may be analysed employing a One-Way ANOVA. Finally, spatial statistics such as Global Moran I (Moran, 1948) and Local Indicator of Spatial Association (LISA) (local Moran's I) (Anselin, 1995) can identify spatial autocorrelation.

This article intends to analyse the OFNAA, disaggregated at the level of municipality, having as object of study the territory of mainland Portugal. More specifically, the objectives are the following: analyse the OFNAA and their dominant categories; create a novel index to study OFNAA diversification; analyse the relation among OFNAA diversification and TEO, and finally to analyse spatial trends, namely the existence of autocorrelation.

In addition to the introduction, the article is organized into 5 more sections, literature review, methodology, empirical implementation, results and discussion, and final conclusions.

2. Literature review

A farm strategy of diversification into non-farm activities can be a form of self-insurance, helping farmers to increase and stabilize their incomes. (Alasia *et al.*, 2009; Seng, 2015). In Portugal, only a few recent studies address the issue of OFNAAs. Elisiário (2018) study stands out studying the evolution of OFNAAs by agrarian region from the year 1999 to 2016. The author states that the trends that led to the intensification and specialisation of agricultural production are felt in OFNAAs. In Portugal, diversification based on non-farm activities has declined over the past two decades, coinciding with a trend toward farm specialization. Specialized farms typically focus on one or a few activities, while non-specialized or mixed farms not only diversify their agricultural production but also appear more likely to engage in a wider range of OFNAAs.

The theoretical basis of the farm diversification process has its origins in the farm household model (Mishra *et al.*, 2001; Boncinelli *et al.*, 2017). Grilli *et al.* (2024) review the determinants of agricultural diversification, and highlight that the number of factors that may influence diversification is large and many models don't integrate all the important factors, possibly due to lack of some important data. Nevertheless, the literature has emphasized the structural factors that shape farm diversification, such as the characteristics of farms, farmers, and households (Meraner *et al.*, 2015). McNamara and Weiss (2005) found that young persons will diversify their activities since they have less aversion to risk and old farmers will tend to diversify due to the reduced workload. Lipshits and Barel-Shaked (2021) analyse the importance of policy reforms in the farmers' diversification decision concluding that "younger, educated, and wealthier farmers who are more peripheral, prone towards diversifying income".

McNamara and Weiss (2005) highlighted that on-farm diversification and off-farm labour allocation are related to farm characteristics and that farm size is one important factor to consider with larger farms tending to be more diversified. Chmieliński *et al.* (2023) on the other hand studied the diversification strategies of family farms in Poland. The authors concluded that small farms will tend to diversify, while large farms won't.

Other studies highlight the importance of geographical location.

Meraner *et al.* (2015) analyse the determinants of farm diversification in the Netherlands. The authors found that specialization can impact diversification decisions, since mixed farming systems tend to be diversified. On the other hand, farm size will contribute to diversification, but the authors also highlight that geographical conditions and farm location (namely socio-demographic, economic, and geographical factors) are related to farm diversification.

Boncinelli *et al.* (2017) studied the determinants of farm diversification, using as case study Tuscany, a region in the centre of Italy, concluding that diversification is important in reducing risk and that there is a tendency for farms situated in marginal regions to be more dependent on agriculture as their main source of income.

Pfeifer *et al.* (2009) analyse the importance of location, for agricultural diversification in the Gelderse Vallei area, Netherlands, concluding that landscape conditions may influence farm's diversification.

Zasada (2011) highlights that farmers that develop their activity in peri-urban areas have increased the importance of different activities to answer to the necessities of the urban society. Zasada and Piorr (2015) studied the local conditions for development policy in Brandenburg, Germany. Žibert *et al.* (2021) examined the key factors and causal relationships involved in the diversification of non-agricultural activities in Slovenia. Their findings suggest that the development of farm tourism activities is influenced by the level of tourism in a particular local. These studies showed that market access affects diversification, with farmers closer to touristic or urban areas easily accessing the market and tending to diversify to satisfy touristic and urban needs (Zasada, 2011; Zasada and Piorr, 2015; Žibert *et al*., 2021).

On the other hand, Bartolini *et al*. (2014) highlights that farmers located in more distant and remote areas will tend to diversify, while being close to "urban areas reduces the probability of diversifying".

Numerous studies calculate technical efficiency and productivity for farms separately according to their specialisation (e.g. Ameur *et al*., 2024; Sintori, 2023; Kashiwagi and Kamiyama, 2023). The Commission Regulation (EC) No. 1242/2008, of 8 December, introduced a new methodology for classifying agricultural holdings in terms of Economic Dimension (DE) and Technical-Economic Orientation (TEO), revoking the Commission Decision 85/377/EEC. The DE of a farm is now based on the Standard Output of its activities (and not, as before, in the Standard Gross Margin), and the TEO is calculated considering the relative contribution of each activity standard output to its total standard output (GPP, 2011).

There is evidence that agricultural productivity also plays a role in OFNAAS availability. Takeshima *et al*. (2018) studied a sample of farms in Nigeria, concluding that an higher agricultural productivity led to the investment of capital and labour in non-agricultural activities, namely linked to agri-environmental concerns. Additionally, higher agricultural productivity can increase the returns on capital and labour invested in non-agricultural activities, potentially boosting the contribution of these activities to economic growth. Seng (2015) studied the consequences of non-agricultural activities on farm household food consumption, concluding that by developing non-agricultural activities farmers had gains in food consumption thus perceiving the benefits of these activities. Concerning farm households, in the rural Himalayas, Scharf and Rahut (2014) investigated the distributional and welfare impacts of engagement in nonfarm work, concluding that by engaging in nonfarm activities, rural farm households make positive gains in per capita food consumption, thus confirming the hypothesis that engagement in nonfarm activities exerts positive effects on household food consumption. Tesfaye and Nayak (2022) analysed the impact of non-agricultural activities on food security of family farms in Ethiopia. The authors concluded that the significant determinants of non-farm income-generating activities are the age of the household head, family size, landholdings, access to extension services, total household income, and membership in agricultural organizations. Khan *et al*. (2024) examines the adoption of renewable energy as a supplemental income source for Pakistani farmers, specifically focusing on solar energy production. The findings indicate a positive correlation between solar energy generation and increased farmer income.

In Europe, several studies were carried out. Chaplin *et al*. (2004) analysed the diversification of family and corporate farms in Central Europe (Czech Republic, Hungary and Poland) and concluded that the diversification is relatively limited and that enterprise diversification by farmers is unlikely to generate a sufficient number of new jobs to address the prevailing high rural unemployment rate. Trnková (2021) studied the socioeconomic relevance of diversification to farm non-agricultural activities in 2018 for 135 European regions in 28 EU countries. The authors concluded that these activities are more important in Central and Northern Europe than in South and South-Eastern Europe. Salvioni *et al*. (2021) discuss the influence of on-farm non-agricultural activities diversification on the financial performance of family farms. The authors use as case study Italy, concluding that diversification strategies have a positive impact on the financial performance of family farms. Tafidou *et al*. (2023) try to determine if diversification of farms by integrating tourism infrastructure has positive effects on farms' income. The authors use a bootstrap regression analysis, implementing the approach in a case study in Greece, and concluding that tourism increases farms' performance. Rosa and Francescone (2023) analyse the situation of multifunctional farming activities in Italy, which concluded had benefits for farm income. Ohorodnyk and Finger (2024) analyse the agri-tourism in Ukraine, which can play an important role in farm income diversification, and has the potential to generate positive effects in Ukraine not only on the agricultural sector but also on the country's sustainable development. Grillini *et al*. (2023) analyse the impact of agri-turism on traditional agricultural activities. The authors used as a case study the Tyrol-South Tyrol-Trentino Euroregion. The authors conclude that it contributes positively to economic sustainability outcomes, such as increased income, while adversely affecting production (in quantity and value). Agir *et al*. (2023) studied the Turkish farmers' perspectives on the opportunities and challenges of Agrivoltaics, concluding that it constitutes an income opportunity.

Finally, other authors tried to help farmers implementing these activities. Baghernejad *et al*. (2024) use a combined SWOT-AHP-TOWS model to help farmers choosing strategies regarding non-agricultural activities in the Guilan province, Iran.

One important aspect related to diversification of farms' activities, is the diversification of agricultural practices. Zabala *et al*. (2023) carry out a study in which they review crop diversification practices in Europe, concluding that it presents an added value to farms "representing an adaptive management strategy for ecological transition, without compromising economic sustainability". Alcon *et al*. (2024) analyse the costs and benefits of diversified farming systems in Europe and highlight that in the long-term crop diversification has benefits.

These results suggest that the relation among diversification of OFNAAS and farms' technical economic orientation (TEO) is interesting and needed. Particularly in Portugal, and after an analysis by experts, it would be relevant to study the relation among diversification of OFNAAS and the following technical economical orientations: Farms specialized in vegetable productions (FEVP); Farms specialized in livestock breeding (FSLV) and Mixed orientation farms (MOF).

For building the nonfarm activities, a diversification index will be interesting, as it allows easy comparisons among territorial units. Regarding composite indexes, several references were considered in the theoretical background, such as OECD (2008) and Bathei and Štreimikienė (2023). OECD (2008) present a handbook that details methods for creating composite indicators, which include additive aggregation methods, geometric aggregation, and non-compensatory multi-criteria approach (MCA). Bathei and Štreimikienė (2023) provide a careful review of agricultural sustainability indicators identifying 101 indicators from previous studies. Within the scope of entropy that provided a solution to the problem, Golan *et al*. (1996) proposed a generalised maximum entropy methodology for data estimation, including error terms; Xavier *et al*. (2018) used this methodology in goal programming to analyse the sustainability of agricultural farms. Chen and Zhang (2023) use an entropy indicator to study the level of green agricultural development in Mianyang, China.

Portugal is very diverse in what concerns the TEO (Figure 1). This is linked with both the biophysical characteristics of the territory and the land ownership (property dimension and socioeconomic characteristics of the owner).

The Portuguese Agricultural sector and TEO are also related to agricultural policies, namely Common Agricultural Policy (CAP). For a summary of the Common Agricultural Policy History, see for instance European Council of the European Union (2024) or Giuliani and Baron (2023).

Several important marks of this policy are presented as follows. The first one, was the 1992 reform (REG. CEE 1765/92 and 1766/92) which intended to deal with several problems such as agricultural surplus production. This reform favoured the reduction of support to prices and the granting of direct subsidies to farmers to compensate for the drop in prices, tentatively aligned with world prices. These had new obligations relating to environmental protection, as well as incentives to improve the quality of the food produced. The set aside was introduced, which implicated that farmers with an area equivalent to a production of 92 tonnes of cereals per year would be forced to reduce 15% of their arable land in order to benefit from CAP support.

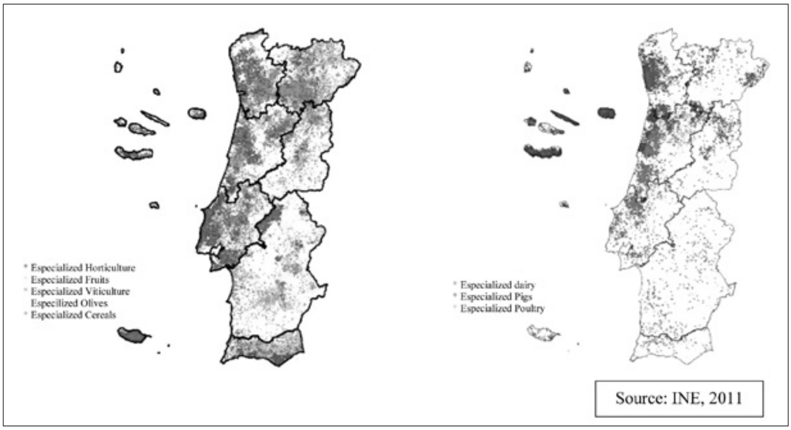


Figure 1 - Technical Economic Orientation of Portuguese farms.

The reform of 1999, considered future expansion of the European Union, was within the scope of "Agenda 2000". This reform had several objectives, among others: improving the competitiveness of community agriculture; defining a rural development policy (2nd pillar of CAP); contributing to animal welfare and plant health; guaranteeing an equitable standard of living for the agricultural population and valuing the multifunctional role of agriculture.

The CAP reform of 2003 was another major step that involved replacing support linked to income with a single farm payment (SFP), disconnected from production and conditioned by standards of food safety, animal and plant health, and animal welfare. Modulation allowed the reduction of direct payments to larger farms as a way of financing rural development.

In 2013, the reform attempted to respond to new challenges to ensure food supply and respond to challenges such as animal welfare, sustainable use of resources, and food security. This reform included the greening of payments, limitations to the support for big farms, and provided additional support for smaller ones (European Council of the European Union, 2024).

Finally, in 2021, the reform "aims to introduce a new strategic approach, giving member states the autonomy to put together strategic plans based on their needs and in line with EU-wide goals" (European Council of the European Union, 2024).

Bearing this in mind, another important issue is the spatial statistics and the relations among the territorial units. The existing of clustering of the specialisation or diversification of OFNAAS implies several different territorial strategies and can be related with the technical orientation of Portuguese farms as well as other biophysical and socioeconomic characteristics. This may be a clustering of high or low values, and its statistical significance has to be tested. For the analysis of spatial autocorrelation, a widely used measure is the global Moran index (I) (Moran, 1948), which evaluates the relationship of spatial interdependence between all polygons in the study area and expresses it through a single value for the study area (Moran, 1950, cited by O'Sullivan and Unwin, 2010; Luzardo *et al*., 2017; Alidadi *et al*., 2023). The global Moran's I analyse spatial autocorrelation for an entire area providing a single value and the local indicators of spatial association (LISA) measure spatial autocorrelation at each location (Anselin, 1995; Fu *et al*., 2014). Several studies have implemented this methodology (Global and Local Moran), from which we present the following examples: Luzardo *et al*. (2017) carried out an analysis of geospatial data associated with area features, in which the variable chosen for the study was the Municipal Human Development Index (HDI-M); Davarpanah *et al*. (2017) presented a study within the scope of geology; Almeida *et al*. (2009) analysed the dengue epidemic concerning the socioeconomic context according to geographic areas; Alidadi *et al*. (2023) studied the spatial distribution of COVID-19 cases in Tokyo; Tang and Werner (2023) analysed the global mining activity.

3. Methodological approach

The methodological approach used in this work follows different steps, as can be seen in Figure 2. The first step concerns the bibliographic review and analysis of available information. The agricultural census of 1999, 2009 and 2019 are the primary source of information. In the second step, the situation in Portugal and Mainland Portugal regarding OFNAAs and their trends throughout the period under study was analysed. The diversification index (DI) was calculated by municipality, in Mainland Portugal, for the years 1999, 2009 and 2019, as well as interannual dynamics considering this index. In a third step the spatial autocorrelation of the index was evaluated using the Global Moran index and the Local Moran I-LISA. A statistical analysis was carried out in which a relationship was established between the farms' orientation and the diversification index and a one-way ANOVA was used to verify if the differences among the different types of farms' orientation are significant.

3.1. *The Diversification Index*

The maximum entropy principle, formulated by Jaynes in 1957, provides a systematic approach to inferring probability distributions from partial knowledge (Golan *et al*., 1996). To measure the discrepancy between two probability distributions, Good (1963) proposed the concept of minimum cross-entropy. Golan *et al*. (1996) developed the Generalised Cross-Entropy (GCE) and the Generalized Maximum Entropy (GME), which considers the unknown distribution and the measurement of errors.

In agricultural censuses there is information, at municipality level, on the number of farms for each OFNAA, however, each farm can have more than one OFNAA. Therefore, the sum of the number of farms in all OFNAA categories will not coincide with the total number of farms. To overcome this problem, the concept of entropy was used, which evaluates the shape of the distribution independently of its numerical quantities. The concept of entropy has been used to construct sustainability indices by several authors, such as Chen and Zhang (2023). While its roots lie in physics, the entropy concept was adapted to the field of information science by Shannon (1948), who used an axiomatic method to define a single function that measures the uncertainty of a set of events.

Thus, the entropy of the probability distribu-

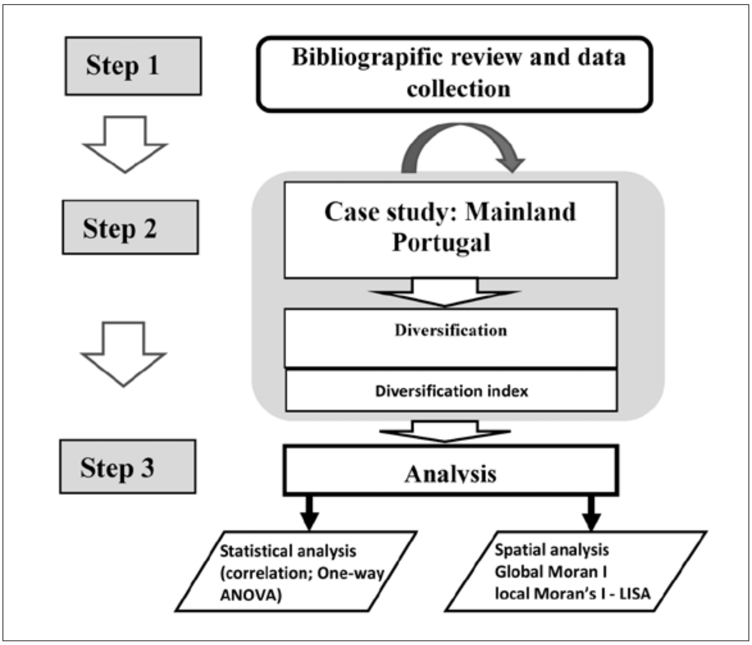


Figure 2 - Methodological approach.

tion, p = (p1, p2, …, pk), reaches a maximum when the probabilities are uniform. To measure the information content of a system and the contribution of each data to reduce uncertainty, several authors have used the normalized entropy measure (Golan, 1994 cited by Golan *et al*., 1996; Xavier *et al*., 2018). In this study, this concept is used to create the proposed diversification index (DI). Following the concept of normalized entropy, the weight of each category in relation to their total sum (and not the actual number of farms) is considered. Therefore, the DI calculation is as follows:

$$DI_i = \frac{-\sum_{i=1}^{I} p_{ik} ln(p_{ik})}{\ln(K)} \quad (1)$$

where DI_i is the diversification index of each unit i considered, p_{ik} corresponds to the weight of each OFNAA category, k, in the total K, in territorial unit i. A *DI* equal to 1 will imply a uniform distribution of OFNAAs in territorial unit i, that is, maximum diversification. A value of 0 will imply the concentration of OFNAA in a single category, that is, a strong specialization of the territorial unit.

3.2. *Statistical analysis*

Regarding the relationship between DI_i and TEO, correlation matrices were constructed and p values were calculated (Marôco, 2014; Field, 2024). A correlation matrix allows analysing individually the bivariate relations among several variables in the dataset. In this case, the dataset will contain, for all the municipalities, the diversification index and the percentage of each TEO. The results of the matrix contain a correlation coefficient, which in this case is the Pearson correlation coefficient (see Field, 2024 for more information). The correlation does not imply causation, so it is only intended to assess the existing relationship.

For assessing the statistical differences of the diversification among the types of TEO considered, a One-Way ANOVA (Analysis of Variance) was implemented (Marôco, 2014; Field, 2024). A One-Way ANOVA allows comparing the means of multiple groups (categorical variables) and defines if their difference is statistically meaningful. In this case, the mean difference of the *DI* for the groups of municipalities associated with a TEO. The first step of this analysis allows identifying if the mean of two groups is different. To identify the groups, post-hoc tests have to be implemented.

For statistical spatial analysis of the results the Global Moran I and the Local Moran I – Lisa were considered.

Autocorrelation relates to the level of similarity between the values of a variable with spatial references (Davarpanah *et al*., 2017), being based on Tobler's first law of geography (Tobler, 1979): "the pairs of adjacent values or spatial characteristics nearby are probably more similar than the values of more distant territorial units". Autocorrelation may be measured with the global Moran I index (Moran, 1948), which analyses the relationship of spatial interdependence between all polygons in the study area and expresses it through a single value for the entire area (Moran, 1950, cited by O'Sullivan and Unwin, 2010; Luzardo *et al*., 2017; Alidadi *et al*., 2023) and allows identifying the existence of spatial clusters (Davarpanah *et al*., 2018). It tests if the linked areas show more similarity than expected in a random pattern. It ranges from -1 to +1, being positive for direct correlation, and negative when inverse (Almeida *et al*., 2009).

The global Moran's I is then calculated using the following equation (Davarpanah *et al*., 2018; Alidadi *et al*., 2023):

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}) \sum_{i=1}^{n} (x_i - \bar{x})^2} \quad (2)$$

where n is the total number of municipalities, x_i and x_j are the values of the municipalities i and j, $\bar{x}$ is the average of x_i across the study area, and w_{ij} is the spatial weights matrix that represents proximity (distance) or contiguity relations between a municipality i and its surrounding municipalities j (Davarpanah *et al*., 2018).

After calculating the Moran index, it is important to test its statistical validity using "inferential statistics" to assess if the values represent a statistically significant spatial autocorrelation and are not the result of chance. The null hypothesis (H0) to be tested is "there is no spatial autocorrelation", and relates to a complete spatial randomness (CSR) of the spatial variable values in geographic space (Davarpanah *et al*., 2018). To accept or reject the null hypothesis (H0), the z score provides a measure for the standard deviation and the p-value indicates the probability of the spatial pattern being created by a random process (the null hypothesis) (Mitchell, 2005; Fox *et al*., 2012; Davarpanah *et al*., 2018).

The local indicator of spatial association (LISA) – local Moran I – measures the level of spatial autocorrelation at each municipality (Anselin, 1995; Feng *et al*., 2014) and (Levine, 2004; Fu *et al*., 2014; Alidadi *et al*., 2023) and can be expressed as:

$$I_i = \frac{z_i - \bar{z}}{\sigma^2} \sum_{j=1, j\neq i}^{n} \left[W_{ij}(z_i - \bar{z})\right] \qquad (3)$$

where $\bar{z}$ is the mean value of z with the municipality number of n; z_i is the value of the variable at municipality i; zj is the value at other municipalities; σ^2 is the variance of z; and W_{ij} is a distance weighting between z_i and z_j. The weight W_{ij} can also be determined using a distance band. It should be noted that the results of the index are affected by the definition of weight, data transformation, and extreme values (Fu *et al*., 2014).

The local version of the statistics aims to show where spatial patterns are located within the area under study. Thus, spatial units are defined in one of the following four classes (Tartaruga, 2020): high-high: positive autocorrelation, values of the unit variable and neighbours, on average, are high (the set of contiguous areas of this type is called hot spot); low-low: positive autocorrelation, values of the unit variable and neighbours, on average, are low (the set of these areas is known as cold spots); high-low: negative autocorrelation, unit variable value is high, however, those of its neighbours are, on average, low; low-high: negative autocorrelation, unit variable value is low, however, those of its neighbours are, on average, high.

4. Empirical implementation

The study area is Mainland Portugal. The study at the national level characterises the sector, at the level of municipalities in Mainland Portugal, analysing the importance of farms with OFNAAs and their diversification, through ID. The autonomous regions of the Azores and Madeira, although not considered in the spatial analysis, are considered when framing the data.

Figure 3 shows the territory of Mainland Portugal and its municipalities. Mainland Portugal is currently made up of 278 municipalities and has a territory of 88,889 km^2.

The approach was applied to data referring to the last 3 agricultural census: 1999, 2009 and 2019. There are some methodological differences related to changes between 1999 and 2009, through Regulation (EC) No. 1166/ 2008 of the European Parliament and the Council of 19 November 2008, regarding surveys on the structure of agricultural holdings and Agricultural Census. Thus, in 1999, the non-agricultural profitable activity item "Forest production" appears with a

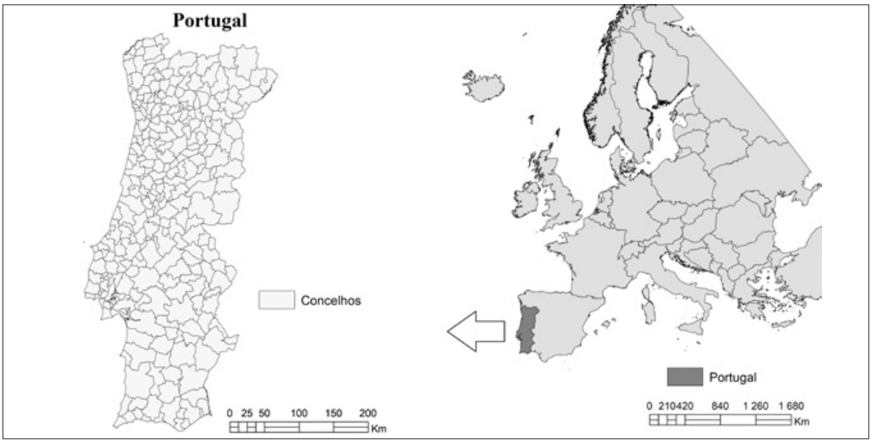


Figure 3 - Geographical location of Portugal Mainland.

value of 0 in all units. There was still no evidence of the notoriety of this variable as its collection was only considered important later, because of afforestation of agricultural land policy. In this situation, the OFNAAs present this year were not collected. Also, the same farm may have more than one OFNAA. Therefore, the sum of partial data will not coincide with the total data regarding the number of farms with OFNAAs.

When calculating the DI, the following OFNAAs were considered, as set out in the Agricultural Census: Rural tourism and directly related activities, Crafts and processing of non-food agricultural products, Processing of agricultural food products, Forestry production, Provision of services, Wood processing, Aquaculture, Production of renewable energy, Other profitable activities.

The proposed diversification index was applied to all municipalities in mainland Portugal. The IDs were classified by classes: 0-0.25; 0.25-0.50; 0.50-0.70; 0.70-0.80 and >0.80, with different amplitudes, resulting from the analysis of histograms of data distribution, to better capture spatial diversity.

To evaluate the relationship between the proportion of farms with OFNAAs and ID with TEO, the following TEO were considered: Farms specialised in vegetable productions (FEPV), Farms specialised in livestock breeding (FSLV) and Mixed orientation farms (MOF). These are general divisions that reflect the main orientations of the territory.

The kurtosis and asymmetry of the data were analysed. It was found that the data on the proportion of farms with OFNAAs had values that showed the existence of non-normal distribution in all years considered.

One requirement of parametric tests is normality. In cases where the distribution is non-normal, data may be transformed, to ensure that the distribution is as close as possible to normality (see Field, 2024 for details).

Therefore, we decided to transform the data for all variables using a base 10 logarithm. Feng *et al*. (2014) state that some of the problems and advantages of using this approach include correcting asymmetric data to achieve normality and such transformation should be used with caution. In cases where the distribution contained 0 values, a parameter common to all municipalities in the variable was placed, taking into account the guidelines of Feng *et al*. (2014). Feng *et al*. (2014) also stated that, as the logarithmic transformation can only be used for positive results, the common practice of adding a small positive constant to all observations before applying this transformation can have a relevant effect on the statistical significance of the hypothesis test.

When applying the global Moran index (I) and the Local Moran I-LISA, an Edges and Corner (Queen Contiguity) spatial continuity matrix was considered and the cells were normalised using the ARCGIS 10.4 software.

Finally, regarding technical implementation, Excel and SPSS were used to perform statistical calculations. The cartography construction was carried out using ARCGIS 10.4.

5. Results and discussion

The results are presented in accordance with the methodological approach previously analysed.

In Table 1, it can be seen that, in Portugal and on the Mainland, the total number of agricultural holdings and the number of holdings with OFNAAs decreased between 1999 and 2019. The proportion of holdings with OFNAAs also shows a decrease in its weight from 1999 to 2009, maintaining its relevance from 2009 to 2019. The generalized decrease in the number of agricultural farms was accompanied by increases in the farms' average area, due to the existence of more competitive and more specialised agriculture.

Table 2 presents the relevance of each of the OFNAA categories in Portugal and on the mainland. It appears that in the two territorial units considered, in 1999, "processing of agricultural food products" dominated, followed by "provision of services" and "other profitable activities". In 2009, the most important OFNAAs concerned "forestry production", followed by "service provision activities", "other profitable activities" and "processing of agricultural food products". Finally, in 2019, OFNAAs relating to "forest production" and "service provision" continued to dominate, with OFNAA, "Rural tourism and directly

Table 1 - Evolution of the OFNAAs in Portugal and Mainland Portugal.

Indicator	*1999*		*2009*		*2019*	
	Portugal	*Mainland*	*Portugal*	*Mainland*	*Portugal*	*Mainland*
Total number of farms (nº)	415969	382163	305266	278114	290229	266039
Number of farms with OFNAAs (nº)	33885	32721	15284	15045	14739	14463
Farms with OFNAAs (%)	8.0	9.0	5.0	5.0	5.0	5.0

Source: INE, National Agricultural Census 1999, 2009 e 2019.

Table 2 - Dynamics of the OFNAAs by category, Portugal and Mainland Portugal.

Activities	*1999*		*2009*		*2019*		*Dynamic % (1999-2009*		*Dynamic % (2009-2019*	
	Portugal	*Mainland*	*Portugal*	*Mainland*	*Portugal*	*Mainland*	*Portugal*	*Mainland*	*Portugal*	*Mainland*
Total	33885	32721	15284	15045	14739	14463	-54.9	-54.0	-3.6	-3.9
Rural tourism and directly related activities	444	418	606	573	1406	1320	36.5	37.1	132.0	130.4
Crafts and processing of non-food agricultural products	369	299	78	71	49	42	-78.9	-7.3	-37.2	-40.8
Processing of agricultural food products	29992	29009	1148	1114	1231	1172	-96.2	-96.2	7.2	5,2
Forestry production	0	0	10842	10836	9816	9809			-9.5	-9.5
Provision of services	2185	2109	1740	1616	1682	1604	-20.4	-23.4	-3.3	-0.7
Wood processing	684	674	118	111	227	216	-82.7	-83.5	92.4	94.6
Aquaculture	32	32	16	16	8	8	-50.0	-50.0	-50.0	-50.0
Production of renewable energy	24	24	101	99	485	482	320.8	312.5	380.2	386.9
Other profitable activities	923	907	1305	1270	1264	1211	41.4	40.0	-3.1	-4.6

Source: INE, National Agricultural Census 1999, 2009 e 2019.

related activities", gaining a prominent position and becoming the third most important.

Regarding the dynamics between 1999, 2009 and 2019 (Table 2), it is worth highlighting the strong growth of "Production of renewable energy", "Rural tourism and directly related activities" and "Wood Processing". It should also be noted that "Processing of agricultural food products" in the last decade showed a slight positive trend. The remainder revealed decreases, in absolute numbers. The high increases seen show the support of both the population in general and the response of farmers in the provision of services, particularly cleaner energy and, on the other hand, the new vision and adherence to the scenic and bucolic environment of the rural landscape. The fluctuations in wood processing are probably related to new environmental and energy concerns and the adaptation of the market to offer suitable products. Regarding the processing of food products, production has been adjusted to new hygiene, health and environmental rules in the manufacture of food products, which were implemented and closely monitored with the closure of many production units.

The spatial dynamics, in each year, of the proportion of farms with OFNAAs per municipality are presented, for 1999, 2009 and 2019. Figure 4 shows the spatial distribution of the proportion of farms with OFNAAs in the municipalities of the Mainland.

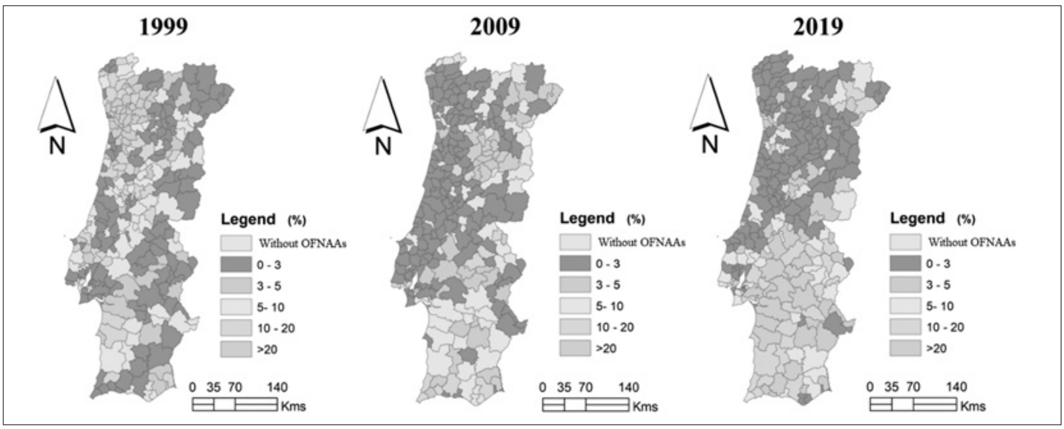
In 1999, the highest values were found in the northwest of Portugal in an area predominantly of smallholdings, where there appears to be a spatial clustering of data, and in the municipalities of the central littoral, where the size of the ownership is also very low (territories with high population density). The lowest values (below 3%) are recorded in large areas throughout the interior. To the south of the Tagus River, this class is predominant in the inland and almost throughout the south littoral. These are areas of low population density and tend to have a lower proportion of farms with OFNAAs. In the area of Lisbon and the Setúbal Peninsula, the reduced number of OFNAAs' proportions is linked to the competition with the industry in that territory.

In 2009, it was observed that the lowest proportions of farms with OFNAAs were found north of the Tagus, in the centre, and north of Portugal. It is also in this area that most municipalities without OFNAAs are located. The majority of municipalities with a proportion of 20% or more of farms with OFNAAs are also located in the previously mentioned area, corresponding to the international Douro territorial zone and the Serra da Estrela region. To the south of the Tagus, values greater than 3% are recorded, which may indicate changes in some policy measures such as decoupling.

Finally, in 2019, it was observed that the highest values for the proportion of farms with OFNAAs were recorded in the south of the Tagus (Alentejo and Algarve), as opposed to the centre and north where the lowest values were recorded. It is also concluded that there was a reduction in the number of farms without OFNAAs. The distribution of the results indicates the possibility of their spatial autocorrelation, and this distribution may be related to the edaphoclimatic and social conditions of the territory, with the OTE of farms and the adoption of policy measures.

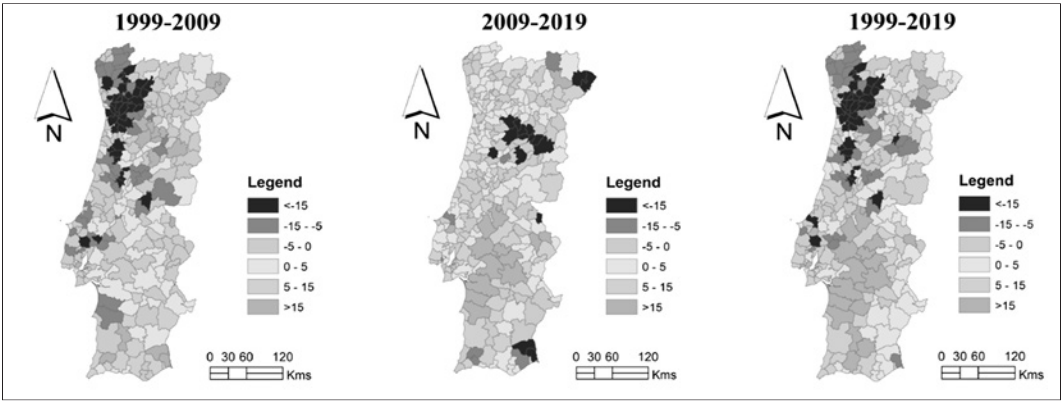
The temporal variation in the proportions of farm values with OFNAAs is shown in Figure 5 for the periods: 1999-2009; 2009-2019 and 1999-2019. Between 1999 and 2009, there was a clear decrease in the proportion of farms with OFNAAs in the municipalities of northwest Portugal, where in 1999, the highest values in the aforementioned series were recorded. It should also be noted that there is a group of nearby municipalities in the south of the Mainland where the proportion of farms with these activities grown. In the period 2009-2019, it appears that

Figure 4 - Spatial distribution of the proportion of farms with OFNAAs.



Source: INE, National Agricultural Census 1999, 2009 e 2019.

Figure 5 - Spatial distribution of the temporal variation of the proportion of farms with OFNAAs.



Source: INE, National Agricultural Census 1999, 2009 e 2019.

positive dynamics tend to be registered in the majority of Portuguese territory, with emphasis on the south of the Tagus River. It is also observed that municipalities in the central inland, which had prominent positive dynamics in the previous period, showed a strongly negative trend, namely in Serra da Estrela and adjacent municipalities, as well as in northeast. Finally, regarding the global evolution from 1999-2019, it is observed that there is a negative evolution, especially in the northwest of Portugal, the north and central coast, while in the south of the Tagus there are positive dynamics, as well as in the centre and interior north.

The diversification index (DI) for the Mainland and Portugal is presented in Figure 6. The analysis shows that the structure in 1999 was highly specialized, and in 2009 and 2019, there was an increase in the diversification of OFNAAs on Portuguese farms. This strong specialization may be related to Common Agricultural Policy (CAP) measures that maintained aid linked to production. In the middle of the decade there were profound changes in the CAP with the single payment regime completely decoupled, leaving the farmers more freedom to choose the possibility of freeing up land and labour for other uses.

Figure 7 presents the spatial dynamics of the proposed activity diversification index.

In 1999, the analysis of the DI shows that the northern municipalities had a specialized structure (vineyards and wine areas and intensive dairy farming). It can also be seen that the areas south of the Tagus River present higher values, which indicate greater diversification of OFNAAs. There is a tendency for several municipalities in the north to have greater specialization in OFNAAs, in contrast to several municipalities in the south of the Tejo River, with the southern regions concentrating diversity (0.25-0.50).

In 2009, several spatial patterns changed. Although the municipalities with the greatest diversification of OFNAAs on farms are located in the south of Portugal, it is observed that the municipalities in the north of Portugal have increased their degree of diversification. The lowest values of the diversification index (DI) are mainly located in the centre.

Figure 6 - Temporal evolution of the diversification index (DI) for Portugal and the Mainland.

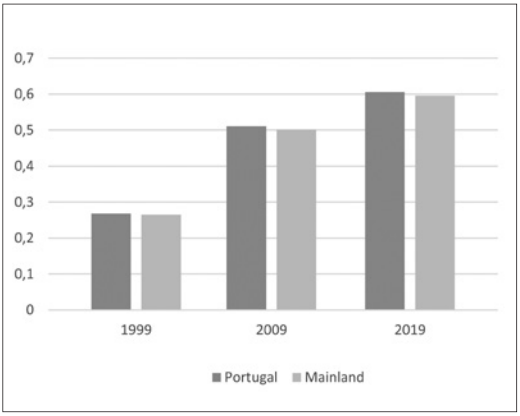
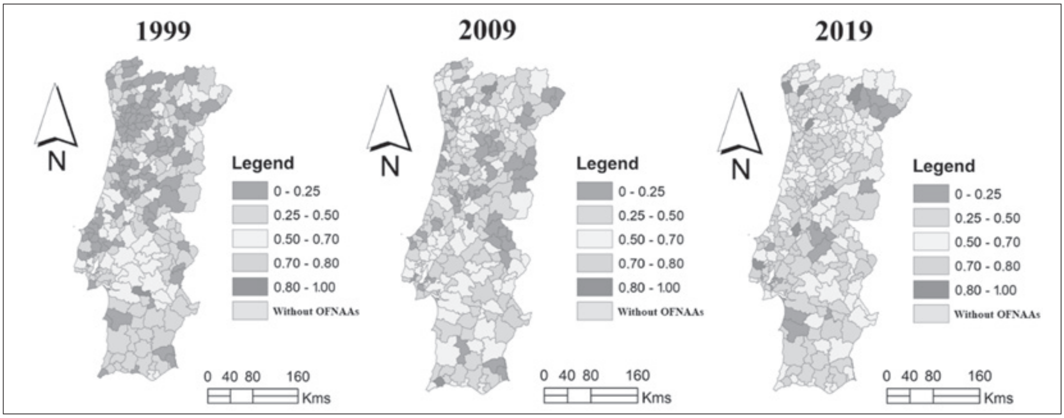


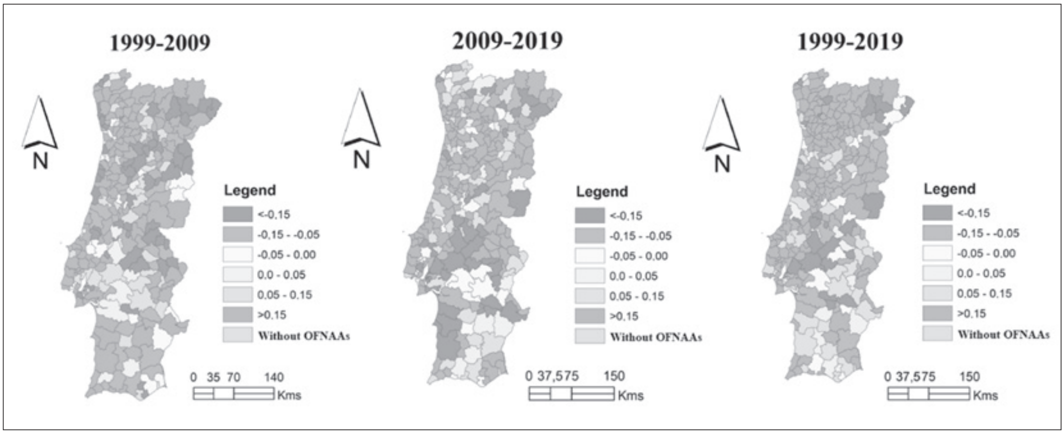
Figure 7 - Spatial distribution of the diversification index (DI).



In 2019, there was an increase in DI in the centre and north of Portugal, with many municipalities with a more diversified structure now located in these areas, that is, with 0.7 or more ID. The south of the Tagus River no longer has a prominent position in ID values and now have a structure that tends to show specialisation in some OFNAAs. Compared to the proportion of farms with OFNAAs, it can be observed that in some more diversified areas they end up being those in which the weight of farms with profitable non-agricultural activities is smaller. This is visible, for example, in 2019, where it was found that the municipalities with the highest proportions of OFNAAs are in the southwest littoral, but that they tend to have lower diversification rates.

Figure 8 shows the dynamics between the 3 time periods under analysis: 1999-2009 and 2009-2019 and 1999-2019 (global dynamics). When analysing these situations, it can be seen that, in the period 1999-2009, positive dynamics were observed throughout Mainland Portugal, with emphasis on the regions south of the Tagus River and northern Portugal (especially the northwest). The municipalities with negative dynamics are mainly located in the northern and central interior, also on the central coast. In the period 2009-2019, positive dynamics were noted, which tended to be located in the centre and north as well as in the interior of some southern regions. Regarding global dynamics 1999-2019, it can be concluded that positive dynamics were recorded throughout the country.

Figure 8 - Spatial distribution of the temporal variation of the diversification index (DI).



5.1. *Statistical analysis of the results*

Before proceeding with data analysis, a study was carried out on the skewness and kurtosis of the diversification index (DI).

Skewness assesses the extent to which a distribution of a variable is symmetrical. A skewness value between −1 and +1 is considered excellent, for assessing normality but a value between −2 and +2 is considered acceptable (Hair *et al*., 2022). Kurtosis analyses the flatness of the distribution: a positive value indicates a distribution more peaked than normal, while a negative kurtosis indicates a flatter shape. If the kurtosis is between -2 and +2 the values are accepted as indicators of normality. When both skewness and kurtosis are close to zero the distribution is considered as normal (Hair *et al*., 2022).

Kline (1998), cited by Marôco (2014), states that parametric test models are robust to asymmetry values below 3 and absolute kurtosis values of 8-10. Thus, according to Marôco (2014), the t test is considered to be robust to violations of normality assumptions when the asymmetry and kurtosis values are not very high.

These measures were calculated for the various logarithmized indicators (using the base 10 logarithm mentioned above) in the years 1999, 2009 and 2019. The results indicate the normality of most variables, with values of kurtosis of asymmetry between -2 and 2, many of which are between -1- and 1. Mixed orientation farms (MOF) present kurtosis values higher than the limit of 2 in all years and asymmetry values higher than the limit of 2 in 1999 and in 2009. Farms oriented to vegetable production (FEPV), also present a kurtosis slightly higher than 2 in 1999. Regarding the normality testing, the Kolmogorov-Smirnov, cannot lead us to accept the null hypothesis of normality. However, and considering Marôco (2014) and Kline (1998) (cited by Marôco (2014)), the application of parametric tests is possible in most of the situations presented.

Thus, correlation matrices were constructed, and the respective p-value calculated, for the 278 municipalities in Mainland Portugal for 1999, 2009, 2019.

The 1999 correlation matrix (Table 3) reveals that between the mentioned TEO and the DI, the correlation coefficients are weak. There is a positive correlation between DI of 0.095 with FEPV and 0.072 with FSLV and a slightly negative correlation with EXM of -0.216 ($p<0.01$). EXM and FSLV have a positive correlation of 0.693 ($p<0.01$).

In 2009 (Table 4), it can be concluded that the relationships between the diversification index and TEO are quite weak. There are also notable negative correlations between FEPV and FSLV (-0.609 and $p<0.01$) and EXM (-0.721 and $p<0.01$). Between EXM and FSLV there continues to be a positive correlation (0.385 and $p<0.01$).

In 2019 (Table 5), there was again a weak correlation between TEO and DI, as well as some tendency towards a correlation among TEO.

Table 3 - Correlation matrix for the year 1999.

	FEPV	*FSLV*	*EXM*	*DI*
FEPV	1			
FSLV	0.034	1		
EXM	0.144*	0.693**	1	
DI	0.095	0.072	-0.216**	1

**Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).*

Table 4 - Correlation matrix for the year 2009.

	FEPV	*FSLV*	*EXM*	*DI*
FEPV	1			
FSLV	-0.609**	1		
EXM	-0.721**	0.385**	1	
DI	-0.068	0.085	0.039	1

**Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).*

Table 5 - Correlation matrix for the year 2019.

	FEPV	*FSLV*	*EXM*	*DI*
FEPV	1			
FSLV	-0.670**	1		
EXM	-0.742**	0.493**	1	
DI	0.100	0.036	-0.122*	1

**Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).*

There is an inverse correlation of -0,122 ($p=0.05$) between EXM and DI. In TEO, a strong inverse correlation ($p<0.01$) between FEPV and FSLV and EXM and a positive correlation between EXM and FSLV($p<0.01$) can also be observed.

To assess the differences in the diversification index among the several farms' orientations, a One-Way ANOVA was conducted on the years of 1999, 2009 and 2019. The one-way ANOVA compares the means of the diversification index (DI) between the groups (in this case the farms' orientation, which is a categorical variable) allowing to identify if they are statistically significantly different.

Firstly, the data was tested regarding normality and homoscedasticity, which are requirements for this test. For normality, the Kolmogorov-Smirnov was used. Results show that for the 1999 data, we must reject the null hypothesis of normality for all farms' orientation. The skewness and kurtosis show some violation of the values mentioned before (Hair *et al*., 2022), however as mentioned by Marôco (2014), the parametric tests are robust to higher limits of asymmetry and kurtosis. Regarding 2009, for the Kolmogorov-Smirnov test, we accept the null hypothesis of normality for FSLV and MOF and reject it for FEPV. Nevertheless, in FEPV the kurtosis and skewness values are acceptable and are always below 2. Regarding 2019, the Kolmogorov-Smirnov test showed that only for FEPV we must reject the null hypothesis of normality, nevertheless, the skewness and kurtosis are below 2.

Table 6 - Levene statistics of variance homogeneity.

Year	*Levene statistic*	*df1*	*df2*	*Sig.*
1999	0.784	2	264	0.458
2009	1.298	2	275	0.275
2019	2.075	2	270	0.128

The Levene test for the homogeneity of samples is presented next (Table 6). We accept the null hypothesis of Homoscedasticity for all years of the series.

After verifying the ANOVA requirements, the first step is to test the effects of the several technical-economical farms' orientation in the diversification index (DI), therefore we're able to test if the mean of the diversification index is different in at least two groups or not. The results of the one-way ANOVA for 1999 (Table 7) and 2009 (Table 8) show that there is no effect of the several technical-economical farms' orientation in the diversification index (DI). For nominal (categorical) variables, the ANOVA analysis showed that there were no statistically significant relationships between those and the dependent variable and the mean differences of the DI among technical-economical orientations are not significant.

For the year of 2019 (Table 9), the effect of the several technical-economical orientations in the diversification indexes is significant ($p=0.01$), being the differences between the means statistically significant. These results don't allow identifying the groups in which there are the differ-

Table 7 - One-way ANOVA results for 1999.

DI99	*Sum of squares*	*df*	*Mean square*	*Z*	*Sig.*
Between groups	6.46	2	3.23	2.815	0.062
Within groups	302.941	264	1.148		
Total	309.401	266			

Table 8 - One-way ANOVA results for 2009.

DI09	*Sum of squares*	*df*	*Mean square*	*Z*	*Sig.*
Between groups	0.011	2	0.005	1.2	0.303
Within groups	1.212	275	0.004		
Total	1.223	277			

Table 9 - One-way ANOVA results for 2019.

DI19	*Sum of squares*	*df*	*Mean square*	*Z*	*Sig.*
Between groups	0.032	2	0.016	4.672	0.010
Within groups	0.927	270	0.003		
Total	0.960	272			

Table 10 - One-Way ANOVA post-hoc test results.

Dependent variable			*Average difference (I-J)**	*Std. Error*	*Sig.*	*Confidence interval 95%*	
						Lower limit	*Upper limit*
DMS	1	2	-0.0134	0.0148	0.364	-0.0425	0.0156
		3	0.0029*	0.0103	0.005	0.0087	0.0492
	2	1	0.0134	0.0148	0.364	-0.0156	0.0425
		3	0.0424*	0.0171	0.014	0.0087	0.0760
	3	1	-0.0289*	0.0103	0.005	-0.0492	-0.0087
		2	-0.0424*	0.0171	0.014	-0.0760	-0.0087
Bonferroni	1	2	-0.0134	0.0148	1.000	-0.0490	0.0221
		3	0.0289*	0.0103	0.016	0.0041	0.0538
	2	1	0.3421	0.0148	1.000	-0.0221	0.0490
		3	0.0424*	0.0171	0.042	0.0012	0.0836
	3	1	-0.0289*	0.0103	0.016	-0.0538	-0.0041
		2	-0.0424*	0.0171	0.042	-0.0836	-0.0012

** The mean difference is statistically significant at level 0.05. 1-FEPV; 2-FSLV; 3-MOF.*

ences. So, post-hoc tests have to be carried out. Given the different existing tests, two of them were selected: the DMS and the Bonferroni.

The DMS and the Bonferroni tests were used to identify the differences among groups for the year 2019 (Table 10). The DMS shows that the difference among FEPV and MOF is statistically significant (p=0.05) and the difference between FSLV and MOF (p=0.014) are statistically significant. The Bonferroni shows that the difference among FEPV and MOF (p=0.016) and with FSLV and MOF (p=0.042) are statistically significant.

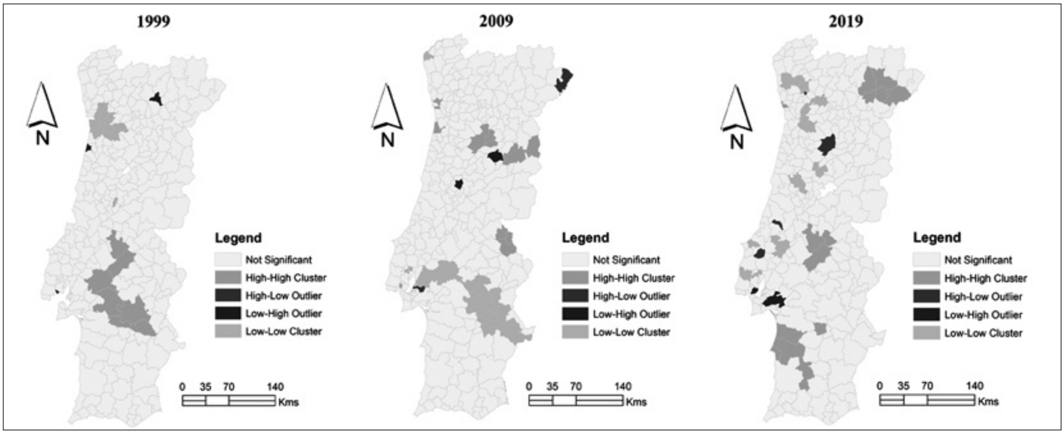
5.1.1. *Spatial statistics*

To evaluate spatial autocorrelation, the global Moran index was calculated, together with a significance test. Spatial autocorrelation analysis was applied to the diversification index (DI) in each of the years mentioned. The global Moran Index (I) for the diversification index of OF-NAAs is found in Table 11. As mentioned, the global Moran Index I test whether connected areas have greater similarity regarding the indicator studied than expected in a random pattern. The degree of existing autocorrelation can be quantified, ranging from -1 to +1, being positive for direct correlation, negative when inverse. When carrying out the test on Moran's I index, positive values were obtained for the indicator. The Z-score values that determine p-value allow rejecting the null hypothesis at 1% of absence of

Table 11 - Global Moran I for the DI in 1999, 2009 e 2019.

	1999	*2009*	*2019*
Moran Index	0.19789	0.19996	0.15480
Expected Index	-0.00357	-0.00357	-0.00357
Variance	0.00143	0.00143	0.00143
z-score	5.32962	5.38537	4.19422
p-value	0.00000	0.00000	0.00003

Figure 9 - Local Moran I results for the DI.



spatial autocorrelation (i.e., in which this clustering pattern would result from chance). It is therefore important to carry out a more careful spatial analysis looking for spatial factors that can explain these situations of spatial clustering.

Figure 9 presents the Local Moran results. In 1999 a high-high spatial cluster is observed in the central southern area, while a low-low cluster is present at the northwest area of Mainland Portugal. In 2009 we observe a low-low cluster in the central southern area, while a high-high cluster is present at centre of Portugal. Finally, in 2019, a cluster is present at the southern littoral and in the north of Portugal.

5.2. *Discussion*

Non-agricultural profitable activities are a source of additional income for the farmer and their analysis constitutes a relevant aspect when thinking about policies for rural areas and their multifunctionality.

The first aspect to discuss will be the relationship between the proportion of farms with OFNAAs and the diversification index (DI). Regarding the relationship between the diversification index (DI) and the TEO, the research shows that the relationship does not seem to be significant with the general groups of TEO. However, it is important to analyse this relationship within the subgroups of each of the TEO, which was not done. On the other hand, it should be noted that this relationship was limited since these TEO values refer to the total number of farms existing in each municipality and farms with OFNAAs often represent a small percentage of existing farms.

Another aspect to discuss will be the analysis of the identified spatial dynamics conditioning factors. It has been proven that there is a spatial autocorrelation between the results of the proportion of farms with OFNAAs and the DI, however, nothing has been advanced as to why these patterns occur in each year and what factors lead to common geographic groupings, in which there are geographic relationships guided by a clear positive autocorrelation of the results. This may be related to natural conditions or even socioeconomic factors and requires careful spatial analysis, never forgetting Tobler's law "All things are related to everything else, but close things are more related than distant things". A brief discussion is provided on the explaining factors for the diversification index (see Figures 7 and 9).

In 1999, there is a lower DI in northwest Portugal, as well a statistically significant spatial cluster of Low-Low values, which is explained by the fact that there is a specialized farm structure on vineyards and quality wine production, namely of Protected Designation of Origin (PDO) but also in Dairy farming for milk production. In south Portugal, in the northern part of Alentejo Region, there is a High-High Cluster with good values of the Diversification Index (DI). This is related to the fact that, in this year, farmers continued their land uses and activities and there wasn't a specialization of the agricultural activity. Farmers were oriented mostly to cereals, tomatoes and industrial crops, which are seasonal and had more free time to carry out other activities in their farms. There were still coupled subsidies, which had a role on farmers options.

In 2009 there are changes linked to decoupling of payments, introduced some years before the single farm payment (SFP). The farmer is free to choose the production and activities that are more favourable. In the South, a low-low cluster was identified in part of the Alentejo, which is mostly related to intensive irrigated crops, in the Alqueva Dam area, that imply specialization and are time intensive. In the north of Portugal there is specialization, but there are improvements in diversification. The liberalization of the Dairy milk production quotas also contributed to the diversification of OFNAA in this area. These and other conditions, together with the biophysical and natural context, created conditions to develop activities such as tourism.

In 2019, the diversification tendency continues in most of the Portuguese territory which is explained by decoupling and the agricultural policy context.

There is also a conceptual aspect that must be underlined when analysing these dynamics, as some statistical concepts changed between 1999 and 2009 and mark some differences in the matrices that were used to calculate the diversification index, and therefore, in its dynamics. These conceptual changes must be taken into account at the level of general dynamics' analysis, but also at the level of spatial patterns that were established in 1999, as opposed to other years.

6. Concluding remarks

This study presented an analysis of non-agricultural activities in mainland Portugal and made it possible to present a preliminary analysis of the situation of these activities at municipality level, including data from the 2019 agricultural census, which until now has not been analysed in previous studies. The structure of activities and the trend of farms at national level were studied. A recent growth trend was noted in the following OFNAAs: Production of renewable energy, Rural tourism and directly related activities and Wood Production. To analyse the diversification of activities, a diversification index was created based on the concept of entropy. This showed that Portugal registered an increasing diversification of OFNAAs on agricultural holdings, which is an important aspect to consider when we think about the multifunctionality of Portuguese agriculture.

A territorial analysis was carried out in the municipalities of Portugal, studying the dynamics of the proportion of farms with OFNAAs and their diversification over time. Regarding the proportion of OFNAAs in total farms, it appears that positive dynamics tend to be registered in the majority of Portuguese territory in the most recent period of 2009-2019, with emphasis on the south of the Tagus River. It is also observed that municipalities in the inland centre of Portugal that had prominent positive dynamics in the previous period showed a strongly negative trend. Regarding the diversification index, it is concluded that between 2009-2019 positive dynamics tend to be located in the centre and north.

An attempt was made to establish a relationship between DI and the proportion of farms with OFNAAs with TEO, using correlation matrices. Clustering and spatial grouping were also analysed using the global Moran I index, for the DI and proportion of farms with OFNAAs, where the existence of spatial clustering was concluded, and a hypothesis test was developed that proved that such positive spatial autocorrelation does not result from chance.

Therefore, based on the results obtained in this study, the following lines of investigation are now established:

- The first line of investigation will be the study of these activities including detailed data that allows their characterisation. The present data is aggregated, meaning it is not possible to have detailed information to characterise farms in terms of their TEO, main uses and crops, agricultural population and other relevant indicators.
- The second line of investigation concerns the analysis of spatial patterns and conditioning factors. The global Moran index indicates the existence of spatial autocorrelation. Such groupings of data dictate often common behaviours that must be better understood.

- A third line of research concerns the creation of a typology of farms taking into account their orientation towards the different OFNAAS, as well as analysing the relationship between the OFNAAs existing on the farms.

Funding

This research was funded by National Funds through Fundação para a Ciência e Tecnologia under the project grants number UIDB/05183/2020 and UID/04007/2020.

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