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Selected Characteristics of Municipalities as Determinants of Enactment in Municipal Spatial Plans for Renewable Energy Sources—The Case of Poland

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Abstract: The article proposes methods by which an in-depth analysis of the factors determining the planning activity of municipalities for renewable energy sources can be carried out. The article aims to determine the relationship between the number of local spatial plans specifying designation for renewable energy sources and the municipality's area, population and planning situation. All local spatial plans in Poland (a total of 104,720 plans) were analysed, distinguishing in each municipality the number of plans with designation for renewable energy sources and micro-installations (a total of 11,338 plans). Then, using quantitative methods, this data was matched with data on the municipalities' population, area, and planning activity. At the same time, the article provides a literature review of the critical problems concerning the relationship between investments in renewable energy sources and local planning. The barriers encountered are transnational in nature. The discussion section indicates how the proposed research methods can address identified barriers. Further possible research directions are also identified. The study shows a correlation between the planning activity of municipalities in the field of renewable energy sources and both population and population density. The higher the population density (highly urbanised areas), the higher the planning activity as well, and with it, the associated planning activity for renewable energy sources. The results in this respect are spatially differentiated. The main contribution of the research is to identify the relationship between the spatial and demographic characteristics of the municipalities and the way spatial plans are approached. This research identifies how local spatial policies toward renewable energy sources can be assessed.

Keywords: renewable energy sources; spatial planning; spatial plans; municipalities

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1. Introduction

In many countries, the intensity of renewable energy investments depends on spatial planning arrangements [1]. These solutions should guarantee the reduction of spatial conflicts and the integration of development policies [2]. Considering the spatial aspect of the realisation of renewable energy sources is a significant challenge for most countries, regardless of their regime or formal and legal conditions (which, of course, must also be considered in detailed analyses). At the same time, it can be concluded that in most countries, there are significant barriers to effectively linking the spheres of energy transition and spatial planning [3]. These barriers are diverse and can be characterised by different points of view. They are rarely considered from the perspective of the characteristics of individual municipalities that determine spatial policy. Some studies [4] show some regularities in the strategic approach to renewable energy sources in spatial planning. These regularities concern the functional and spatial characteristics of the municipalities. On this basis, it can be concluded that another important research issue seems to be the verification of whether the characteristics of the municipalities concerning the population and the area of the municipalities exert an influence on the planning activity of the municipal authorities in the field of renewable energy sources. The role of renewable energy sources in the spatial acts of municipalities with an active spatial policy also needs to be verified.

A country where these issues can be analysed in more detail is Poland. In Poland, spatial plans at the local level are optional: municipalities are therefore not obliged to enact them, and numerous mistakes are made in the planning process, demonstrating the system's inefficiency [5,6]. Municipalities also have no obligation to adopt spatial plans for renewable energy sources. The decision to adopt such a plan depends on the subjective assessment of the municipal authorities. In such a state of affairs, it is possible to analyse the issues mentioned above in detail (in countries where spatial plans are obligatory, such analysis is possible but difficult). In particular, verifying the extent of municipalities' planning activity is possible.

There is no doubt that for the development of renewable energy sources, the role of the central government is very important. In the case of Poland, serious neglect over many years can be identified here [7–9]. Poland's settlement structure is specific from the perspective of the possibility of locating renewable energy sources. There is the possibility of very wide implementation of renewable energy micro-installations (which can be coordinated with scattered buildings). The second distinguishing characteristic of the Polish system (from a central perspective) is the reluctance at the central level to realise wind power, which has existed at least since 2016 [4]. In such conditions, much, therefore, depends on the local level, where (thanks to the initiative of local authorities) specific investment solutions can be supported. This possibility is not tantamount to assuming that local authorities fulfil this role. A key task—both from the perspective of the Polish system and the broader theoretical discussion—is to discuss this role and its associated barriers.

This article aims to determine the relationship between the number of local spatial plans designated for renewable energy sources and the municipality's area, population and planning situation. All local spatial plans in force in Poland were analysed (separately as of 2015 and separately as of 2020—a total of 104,720 plans). Each municipality determined the number of plans with renewable energy sources and micro-installations (a total of 11,338 such plans were extracted). The extracted data were statistically compared with other data concerning the municipalities. The literature review outlines the key challenges in synthesising renewable energy investment and spatial planning systems. Barriers to the use (and understanding) of spatial plans in different countries and the specificity of the Polish spatial planning system are also presented. The Methods section details the research assumptions and methods used. The results are also referred to in the literature in the Discussion and Conclusions.

This article offers a significant scientific contribution. It includes an econometric analysis of the relationship between the binding provisions of spatial plans for renewable energy sources and other characteristics of municipalities. As the analysis involves numerous observations typical for the issue at hand, research methods were sought from the data mining group of methods; in particular, regression trees and association rules were used. Building such models aims to obtain subsets (municipalities) that are as homogeneous as possible in terms of the dependent variable under study—spatial plans for renewable energy sources. It is a first step toward comparing municipalities and looking for reasons to explain their different renewable energy activities.

The research focused on the spatial plans included wind energy investments and micro-installations. It is these renewable energy investments that are directly included in Polish law. In particular, the laws specify how these investments are to be included in the spatial plans. Thus, for this type of investment, it is possible to carry out the broader analyses proposed below [10]. More specifically, it is possible to verify the inclusion of these types of renewable energy sources in all of the local spatial plans in force in Poland. This is not possible to the same extent as other renewable energy sources.

It should be emphasised that it covers the case of an entire country, and the methods used here could work well for analyses of other countries or large geographical areas.

2. Literature Review

2.1. Renewable Energy Sources in Spatial Planning Systems

The relationship between the implementation of renewable energy sources and spatial planning systems is noted in the literature. It is part of a broader reflection on the directions of the response to climate change [11–13]. It is perceived from diverse perspectives. One group of perceived issues includes the impact of the energy transition on urban space [14] and potential spatial conflicts occurring in rural areas [15]. One of the leading research issues is the possibility of spatial plans shaping investments in renewable energy sources. This possibility does not exist in every country. For example, in the European Union, it is only present in a quarter of the countries [1].

Two groups of related problems can be distinguished. The first group concerns systems where national regulations leave little room for spatial planning of renewable energy sources at the local (municipal) level. Examples are Germany and Austria [3,16]. In the case of these, but also in other countries, renewable energy sources are primarily planned at the central level. At the local level, only selected technical and economic issues remain to be defined [17]. A much greater risk of spatial conflicts then arises [10]. The second issue concerns how planning regulations for renewable energy sources are formulated. In particular, the dilemma concerns how spatial plans at the local level (which vary from country to country but generally have at least analogical functions) should shape investments in renewable energy sources [18].

Teschner and Alterman [19] concluded that opaque legal and planning frameworks contribute to additional barriers to implementing the indicated investments—the use of additional solutions must be considered. Klepinger [20] suggests that separating zones in the local spatial plans is optimal and relevant from the perspective of wind energy needs. In the author's opinion, this is a much better solution than a fragmentary determination of the possibility of locating wind power installations, e.g., for a specific category of land use. Other authors from other countries also express a similar view [16]. It is also indicated [21] that directionally more extensive renewable energy sources should be assigned to specific land categories.

The concept of integrated spatial and energy planning should be considered one of the key ones [18]. In this view, spatial and energy planning are key tools because of their potential impact on urban design, infrastructure, mobility, land use, private property rights, water supply, food security, environmental protection, public health, local development, resilience and sustainability. From this perspective, the task of spatial planning should not only be to raise awareness and system integration of different energy sources but also to select optimal sites for the location of renewable energy sources, also accounting for environmental and social considerations. Reference can also be made to recent recommendations at the European Union level [22], which postulate, inter alia, the identification of renewable energy zones in the Member States. These zones would provide opportunities for faster implementation of the indicated investments. These objectives can be linked to the aims and objectives of spatial plans.

Spatial plans at the local level are key spatial planning instruments in most countries [1,23]. Of course, they have different characteristics and scope in different countries. Spatial plans found in different countries often differ significantly. Consequently, different classifications are possible. One of the key divisions concerns the distinction between spatial plans that are binding legal acts (e.g., France, Poland) and spatial plans that are non-binding instructions (United Kingdom). This, moreover, is related to the specific direction of the classification of spatial planning systems [23–26]. In addition, it should be emphasised that in most systems at the local level, different types of spatial plans occur simultaneously [27]. The most common classification includes general spatial plans and detailed spatial plans. Bearing these differences in mind, it can be pointed out that, to a large extent, spatial plans separate the zones of individual areas (in other words, they define the use of the land, e.g., residential, commercial, etc.) and specify the permissible development parameters [28,29]. Of course, in practice, different spatial plans exceed this "common minimum". In addition to zoning and development parameters, they also regulate, for example, environmental and heritage protection principles and other guidelines. Therefore, a broader determination of the role of spatial plans (and the detailed differences in this respect from country to country) should be considered as a separate research task. However, this does not change the assessment that in most systems, spatial plans at the local level should co-create the framework for the implementation of renewable energy sources, especially larger investments in this field. The following elements need to be emphasised here:

- The implementation of integrated development planning is an opportunity to take into account different perspectives in spatial planning, including investment and implementation of renewable energy sources;
- The compatibility between strategic spatial planning and regulatory spatial planning is very important;
- The inclusion of investments in renewable energy sources in spatial plans should be oriented towards two main objectives:
  (a) Developing renewable energy sources on a national scale;
  (b) Reducing potential spatial conflicts and reconciling differing perspectives and points of view.

Against this background, the example of the spatial planning system in Poland is particularly interesting and important. This is so for several reasons:

- Poland has a severe shortage of renewable energy sources. At the same time, Polish settlements are dispersed, creating a unique basis for implementing micro-installations of renewable energy sources [7].
- In the Polish spatial planning system, spatial plans at the local level are optional. Their enactment is, therefore, at the discretion of the municipalities;
- There are serious weaknesses in strategic spatial planning [30,31].

At this point, it is necessary to briefly outline the basic features of the Polish spatial planning system. At the local level, there are two types of planning acts:

- Studies of spatial planning conditions and directions, i.e., strategic spatial planning acts. They must be enacted in every municipality. However, they do not contain legally binding guidelines addressed to investors and property owners. Instead, they are binding when drawing up local spatial plans [10,32];
- Local spatial plans—municipalities are not obliged to adopt them. However, if they adopt a spatial plan for a particular area, it will be a binding basis for realising the investment. At the local level, there is one type of spatial plan (unlike in other countries). If a spatial plan is not enacted in a particular area, some investments can be carried out based on a location decision.

2.2. Characteristics of the Polish Spatial Planning System

Furthermore, it should be pointed out that since 2016, larger wind power investments can only be realised in Poland based on spatial plans. That is, the lack of enactment of a spatial plan is tantamount to the inability to realise a larger wind energy investment in a municipality [33,34]. At the same time, the Polish spatial planning system has been criticised for years as incoherent and chaotic [35,36]. The solutions do not guarantee the protection of spatial order [37–39]. At the same time, there is no significant integration of development policies in Poland.

Therefore, the analysis of the Polish case makes it possible to answer the question of the reasons for the broader interest of local authorities in renewable energy sources.

A manifestation of such interests is the enactment of spatial plans enabling the implementation of the indicated investments. The literature cited above discusses the barriers associated with taking up the issue of renewable energy sources at the local level. Previous research (not covering all Polish spatial plans) shows that spatial plans covering renewable energy sources are most often adopted in suburban areas [4]. It is worth continuing this line of research. This is because an analysis of the Polish spatial planning system also makes it possible to determine whether the population, the area of municipalities and the involvement of municipal authorities in spatial policy influence the degree of interest in renewable energy sources in spatial planning.

3. Research Methods

Due to the nature of the variables and the number of observations, the study focused on methods belonging to the data mining group of methods; in particular, regression trees and association rules were used.

Most often, studies related to the analysis of local plans deal with assessing the quality of planning as a process, but also with small areas and a small number of plans, so there is no need for data mining methods [40]. In our case, plans for the whole country were analysed with a high level of detail, including at the level of individual districts, for quantitative variables, which justifies the use of more sophisticated methods for large sets. Hence, the tools used are not typical of the research conducted to date, which in the area of spatial planning has most often concerned its efficiency using GIS tools [40,41], the graph method [42], or looking for ways to reduce transaction costs using decision models [43,44]. Digital methods and techniques, as well as transient models and case studies [45], are also commonly used in the spatial planning research process. In this paper, we have reached for advanced data mining methods, showing that interesting results can be obtained with their help.

When looking for a relationship between the number of plans covering RES and the population (in effect, the intensity of the urbanisation process), regression classification trees can be used for the dependent variable on at least an interval scale. The aim of building such models is to obtain subsets that are as homogeneous as possible with regard to the values of the dependent variable. The subdivision of a set of observations is usually done according to the Gini rule, entropy measures or binary. The advantage of regression trees (e.g., CART) is that variables with non-linear relationships can be used [46], differential independent variables do not need to be standardised, and qualitative multicategorical variables do not need to be recoded into artificial variables [47]. In practice, ensembles of models (model families) combined into a single ensemble are now used, which reduces model instability (lower variance) and allows more complex relationships to be rearranged [48]. A set of models is built in many ways, by repeatedly modelling the same data set and merging it into a single pooled model (weights for individual models are adjusted, e.g., by averaging) or by taking the error in the test sample as a criterion. A division of the sample into a learning, test and validation sample is then required [49].

One of the bagging methods used in this paper is bootstrap aggregating [46], which involves combining multiple models built for different k bootstrap samples (an independent draw of k return samples of size n is made from a learning sample of size N). The prediction result is the effect of averaging the results from these models (e.g., Random Forest—a random forest based on the CART classification tree algorithm or boosted trees).

In models with amplification, misclassified objects are given higher weighting coefficients, and this correction is followed by re-drawing the learning sample and building models with increasingly higher prediction accuracy. The more models that are tested, the better the quality of the correct classification, but at the expense of a decrease in the test sample quality. When the error estimated from the test sample starts to stabilise, the process of building more trees stops. Assessing the quality of regression models involves using popular measures calculated on the residuals (mean square of the residuals, mean absolute deviation, relative deviation). The quality of the classification can be checked by plotting the mean square error for the learning and test sample, determining the optimal number of models. The suggested proportion of teaching, testing and validation sample most often means 70% and 15%, respectively.

When looking for relationships between the co-occurrence of values of different variables in a given case, one can use association rules (Associations), which are categorised as models without a teacher, i.e., model-free taxonomy. The model is of form A to B, where A, B are sets of variables, the combined occurrence of the two variables in the sample is denoted by the Support coefficient, i.e., the probability of the conjunction of the two events, and the Confidence coefficient is a conditional probability measure P(B/A). The analyst's task is to find association rules that meet the minimum value of Support and Confidence set by the researcher. The advantage of the method is that it analyses a large amount of data and does not require discretisation of the variables. The results of association rules are presented in tabular or graphical form.

As a result, the research procedure involved several steps, which are shown sequentially in the diagram below. The diagram indicates that the starting point for further methods was the determination of descriptive statistics of the analysed variables (Figure 1).

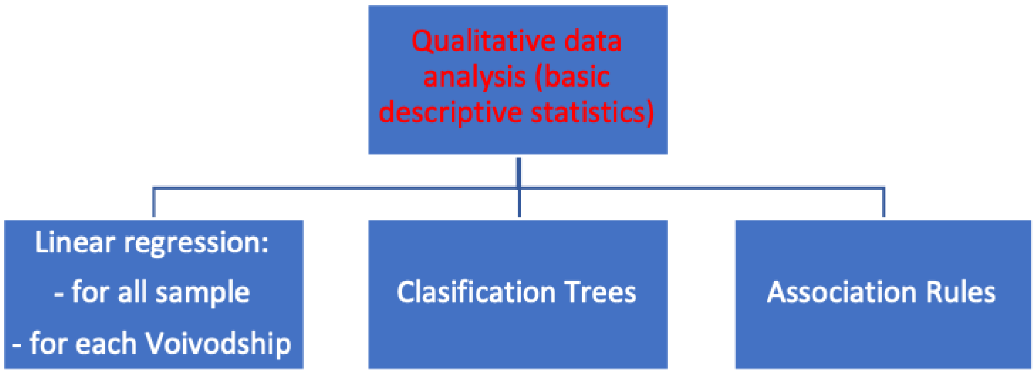

Figure 1. Methods used in the empirical study.

4. Date and Results

4.1. Data

In line with the stated aim of the study, 2477 municipalities were analysed and described with variables on real scales collected in 2015 and 2020, adopting the following designations (Table 1).

The population and administrative data came from public statistics (the Local Data Bank database of the Central Statistical Office), while the data on the planning situation of municipalities came from local spatial development plans. In relation to the aim of the study, the spatial plans in force in 2477 municipalities in Poland (i.e., all Polish municipalities) were analysed. Two periods of validity of the plans were distinguished: the end of 2015 and the end of 2020. The valid plans were determined based on provincial official gazettes and the Legalis legal programme. This, therefore, includes all spatial plans in force in Poland in both periods. From this group, information was extracted for each municipality concerning:

- The number of spatial plans for wind power investments as of 2015;
- The number of spatial plans for wind power investments from 2016 to 2020 (adopted by the indicated deadline);
- The number of spatial plans allocating the possibility of locating micro-installations of renewable energy sources as of 2015;
- The number of spatial plans allocating renewable energy micro-installations by 2020.

Table 1. Variables used in the study.

Variable Symbol	Variable Description	Comments
Municipality	Municipality	N = 2477
Voivodship	Voivodship	N = 16
NMP	Number of Spatial Plans	
NMA	Area of Municipal	
NSP_1	Number of Spatial Plans	until 2015
NSP_2	Number of Spatial Plans	from 2016
NSP	Number of Spatial Plans	
ASP_1	Area of Spatial Plans	until 2015
ASP_2	Area of Spatial Plans	from 2016
ASP	Area of Spatial Plans	
NSP_WT_1	Number of Wind Turbines Spatial Plans	until 2015
NSP_WT_2	Number of Wind Turbines Spatial Plans	from 2016
NSP_MIP_1	Number of Micro-Installation Provisions Spatial Plans	until 2015
NSP_MIP_2	Number of Micro-Installation Provisions Spatial Plans	from 2016
NSP_MIPM_1	Number of Housing Micro-Installation Provisions Spatial Plans	until 2015
NSP_MIPM_2	Number of Housing Micro-Installation Provisions Spatial Plans	from 2016
TOTAL_OZE_1	Number of OZE Spatial Plans	until 2015
TOTAL_OZE_2	Number of OZE Spatial Plans	until 2015
TOTAL_OZE	Number of OZE Spatial Plans	

4.2. Linear Regression Model

Preliminary quality analysis was carried out for the variables obtained, focusing on the completeness of the data and the interdependence of the variables. The number of local plans containing provisions on renewable energy sources (RES), in particular, wind turbines and micro-installations (TOTAL_OZE), was used as the dependent variable. Using Spearman's linear correlation for data on real scales, variables that are not dependent on the explanatory variable (TOTAL_OZE) were eliminated in the first step. In the second step, explanatory variables with a strong correlation were eliminated. In practice, a statistically significant correlation was found between the variables in the subdivision of the two sub-periods of the individual RES with the variables for the entire research period. As a result, four independent variables were adopted for further analysis: NMP, NMA, NSP, ASP and the dependent variable, TOTAL_OZE. The table below shows the basic descriptive statistics of the variables adopted for the analysis (Table 2).

Table 2. Descriptive statistics of the variables analysed.

	TOTAL_OZE	NMP	NMA	NSP	ASP
Average	4.58	15,448.13	12,624.35	42.28	7715.60
Median	1.00	7505.00	11,190.00	21.00	2776.00
Total	11,338	38,265,013	31,270,525	104,720	19,111,529
Minimum	0.000	1290.000	332.000	0.000	0.000
Maximum	129	1,794,166	63,370	1314	99,740
Lower quartile	0.000	4882.000	7679.000	6.000	454.000
Upper quartile	5.00	13,204.00	15,963.00	50.00	10,978.00
Standard deviation	9.70	51,145.37	7875.48	69.68	11,111.61
Coefficient of variation	211.85	331.08	62.38	164.82	144.02
Skewness	5.53	21.45	1.45	5.83	2.48
Kurtosis	45.73	640.57	3.47	64.73	9.05

A total of 104,720 local plans were analysed, covering an area of more than 19,000 hectares of land (i.e., 47,468 spatial plans from 2015 and 57,252 spatial plans from 2020). Of these, 11,338 plans included provisions on RES. The survey included municipalities where no such plans were enacted (25% of municipalities—lower quartile) and those where

129 plans, including RES were enacted, with 75% of the surveyed municipalities having a relatively low level of plans with RES (upper quartile, i.e., 75% of observations = 5).

The linear regression analysis evidences the statistical significance of the variables, the results of which are presented in the next table (Table 3).

Table 3. Estimation of linear regression model parameters for the entire study sample (N = 2477).

	b	Standard Error	t (2472)	p
Constant	1.822336	0.312207	5.83696	0.000000
NMP	0.000035	0.000004	9.83296	0.000000
NMA	−0.000097	0.000021	−4.61673	0.000004
NSP	0.061794	0.002613	23.64519	0.000000
ASP	0.000108	0.000015	7.26390	0.000000
$R^2 = 0.325$				

All estimated parameters at the explanatory variables are statistically significant ($p < 0.05$), although the coefficient $R^2 = 0.0325$ is at a rather low level, suggesting a non-linear nature of the relationship. However, the signs of the estimated parameters are logical and as expected. Only one estimated parameter with the NMA variable has a negative sign with a small value of this parameter, which can be interpreted as a small negative relationship between the area of the municipality (NMA) and the number of RES plans. TOTAL_OZE is most strongly influenced by the number of plans enacted in the municipality (NSP). For comparison, local linear models were estimated at the level of individual provinces, and the results for those in which the level of fit was high ($R^2 > 0.6$) are presented in the next table (Table 4).

Table 4. Estimation of linear regression model parameters for selected provinces (N = 16).

		b	Standard Error	t (164)	p	R^2
Constant	Mazowieckie	3.985538	1.000084	3.98520	0.000084	0.75
NMP		0.000005	0.000005	0.85754	0.391813	
NMA		−0.000056	0.000081	−0.68809	0.491915	
NSP		0.214879	0.009204	23.34599	0.000000	
ASP		0.000078	0.000041	1.89497	0.059030	
Constant	Opolskie	−1.93657	1.266709	−1.52882	0.131088	0.67
NMP		0.00020	0.000041	4.98500	0.000005	
NMA		0.00004	0.000093	0.39908	0.691121	
NSP		0.07943	0.022460	3.53662	0.000747	
ASP		0.00003	0.000045	0.68569	0.495308	
Constant	Wielkopolskie	2.259691	1.216309	1.85783	0.064524	0.62
NMP		−0.000050	0.000016	−3.00253	0.002986	
NMA		−0.000104	0.000085	−1.22854	0.220552	
NSP		0.078537	0.006851	11.46278	0.000000	
ASP		0.000012	0.000061	0.19214	0.847806	
Constant	Zachodniopomorskie	−0.627914	0.773372	−0.81192	0.418625	0.85
NMP		0.000192	0.000016	11.88476	0.000000	
NMA		−0.000013	0.000034	−0.37712	0.706827	
NSP		0.023581	0.010998	2.14416	0.034263	
ASP		−0.000005	0.000025	−0.18674	0.852211	

The parameter estimates for the NMP variable concerning the number of inhabitants in the municipality were statistically significant ($p < 0.05$) only in the three models for Opolskie and Zachodniopomorskie Voivodeship. At the same time, in each of the presented cases, the parameter estimates for the NSP variable concerning the number of existing local plans were significant. It should be noted, however, that the area of the Mazowieckie Voivodeship includes the capital city of Poland, Warsaw, with a significantly different population than the other cities. In summary, in 16 linear models for individual voivodeships, in 7 out of 16, the NMP variable had statistically significant ($p < 0.05$) estimates. This does not clearly indicate a strong relationship between the number of RES plans and the population of municipalities within individual provinces. However, from a global perspective (Table 3), the relationship is statistically significant.

For the variables prepared in this way, their preliminary analysis and the stated aim of the study, the research methods were adjusted, focusing on more advanced research methods.

4.3. Aggregate Models—Amplified Classification Trees

The algorithm allows for the use of large datasets, and identifies predictors with a strong influence on the class membership of the objects, which will allow us to assess whether the class membership in the analysed municipalities will depend on the population and the number of plans considering RES. In the first step, a regression task was selected with the dependent change TOTAL_OZE and the quantitative predictors NMP, NMA, NSP, ASP and Voievodenship. The standard parameters of the analysis were set by taking the number of trees to be 200, the learning rate to be 0.1 and the stopping parameters having a maximum number of levels set at 10, and a maximum number of nodes set at 7. The optimal number of trees is determined by plotting the mean square error for the learning and test trials, with the moment of test trial error stabilisation set at 35 trees in the study (Figure 2).

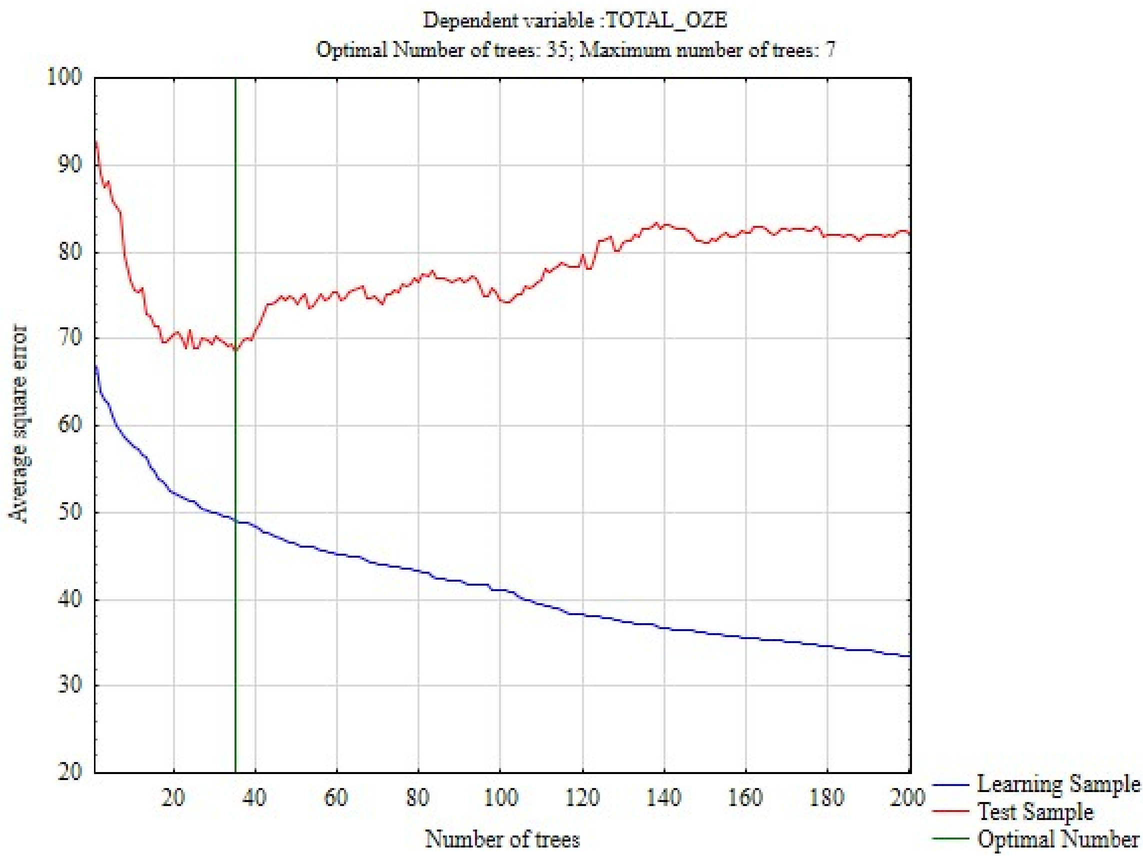

Figure 2. Determining the optimum number of trees.

After obtaining unidimensional breakdowns, the predictor variables can be ranked on a scale from 0 to 100 according to how important they are in influencing the dependent variable's values. In the analysed dataset, the following rankings were obtained: NSP (100), NMP (45), ASP (26), and NMA (25), which means that the most important variable that influences the number of plans with RES is the number of enacted local NSP plans, but the number of populations in municipalities, which is an interesting variable given the purpose of the study, turned out to be equally important.

Below is an example of a classification tree for the adopted parameters, i.e., the number of split nodes was 3, and the number of terminal nodes was 4, where M is the mean node, and Var is the variance (Figure 3). The variables above the horizontal green line denote the grouping variables (in the case analysed, successively, NSP, NSP, NMP); in the right corner, N is the number of objects classified into a given group, while ID is the leaf number (sum of red and blue frames), with the number of terminal nodes 4 being the final (blue) frame.

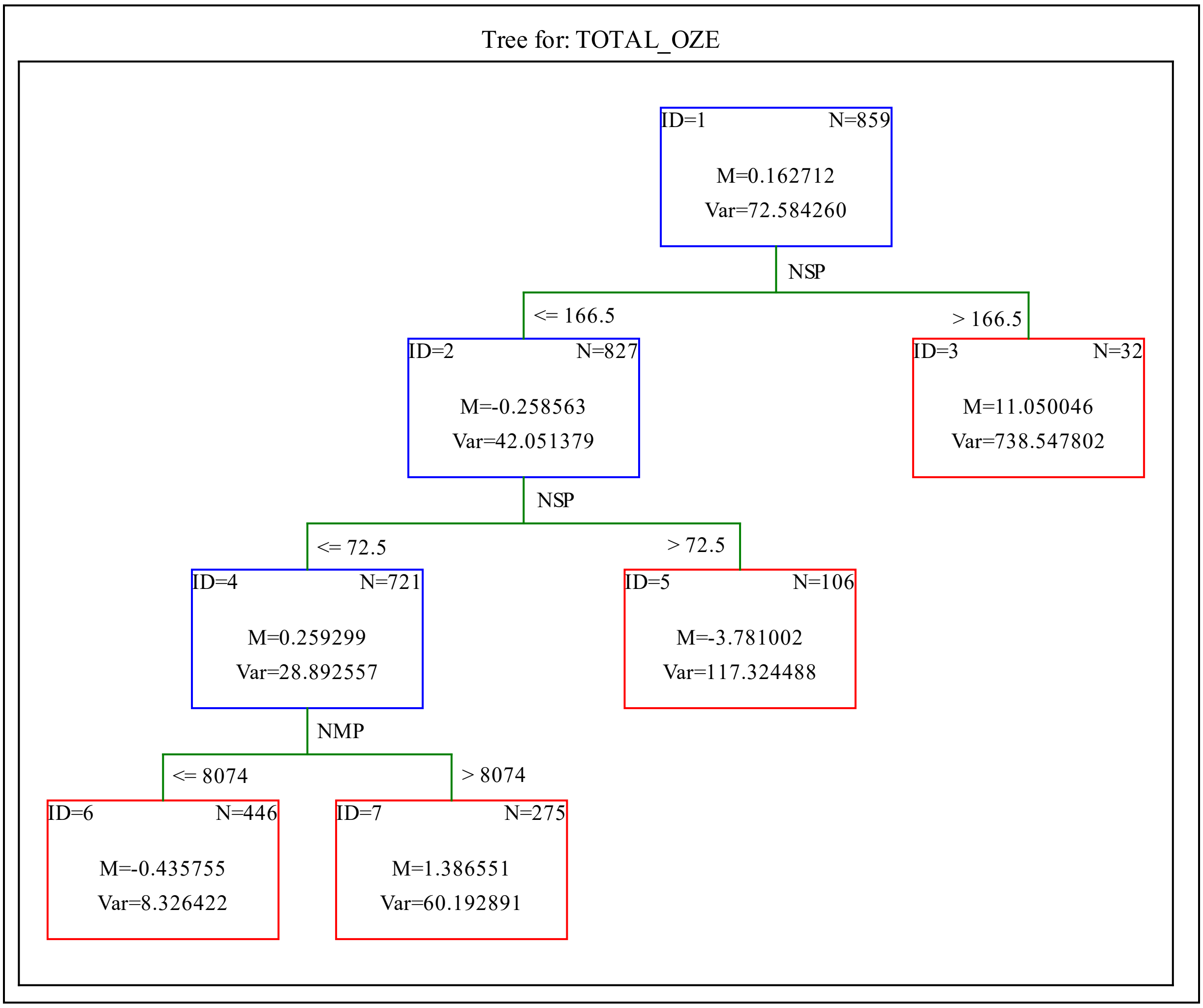

Figure 3. Example of classification result for a variable TOTAL_OZE.

In the example presented, it can be assessed that out of the 859 municipalities in the learning sample that have plans for RES (ID = 1), only 32 municipalities have rounded more than 166 enacted local plans (ID = 3). On the other hand, analysing the left side of the tree, it can be considered that out of the 859 municipalities that have plans for RES, exactly 827 municipalities have less or exactly 166.5 enacted local plans (ID = 2), and further among them 721 have less or exactly 72.5 enacted local plans (ID = 4). Among them, 446 municipalities are municipalities with less or exactly 8074 inhabitants (ID = 6), and 275 municipalities have more than 8074 inhabitants (ID = 7). Each path from the four final nodes can be followed in an analogous way. The mean of the residuals for the test sample is 0.000087, with a median of −0.6467, while the mean absolute deviation is 6.948. This result is influenced by several outlier observations in the set of residuals, as evidenced by the right-sided asymmetric distribution of the residuals. The quality of the model obtained is satisfactory.

4.4. Models without a Teacher—Association Rules

For the application of the method, the variables ASP, NSP and NMA were calculated per person (dividing by the number of inhabitants in the municipality, i.e., the NMP change), while the variable TOTAL_OZE was related to the number of adopted local plans in the municipality, i.e., the NSP variable. As a result, it was possible to assign a value of 1 to the variables TOTAL_OZE/NSP, ASP/NMP and NSP/NMP when they actually had a value of zero and 1 otherwise. For the variable indicating the population coefficient NMA/NMP taking values in the range (0; 24) with a right-handed extremely asymmetric distribution, an integer value was taken for values less than or equal to 6 and 7 for the others. As a result, each object is described by one of the values on the nominal scale between 0 and 7.

A support factor of 20% and a confidence factor of 10% were assumed for the data prepared in this way. The results of selected popular association rules, in which the predecessor is the TOTAL_OZE/NSP variable (1—when plans for RES were enacted, 0—no plans considering RES) and the successor is a variable indicating the municipality's population density, are presented in the table below (Table 5).

Table 5. Selected association rules for the predecessor TOTAL_OZE/NSP (N = 2477).

	Antecedent	Consequent	Support (%)	Confidence (%)	Increment
1	TOTAL_OZE/NSP = 1	ASP/NMP = 1, NMA/NMP = 0	23.86	40.87	1.31
2	TOTAL_OZE/NSP = 1	ASP/NMP = 1, NMA/NMP = 0, NSP/NMP = 1	23.86	40.87	1.31
3	TOTAL_OZE/NSP = 1	NMA/NMP = 0, NSP/NMP = 1	23.86	40.87	1.31
4	TOTAL_OZE/NSP = 1	NMA/NMP = 0	24.06	41.22	1.30
5	TOTAL_OZE/NSP = 0	ASP/NMP = 1	37.99	91.27	0.96
6	TOTAL_OZE/NSP = 0	ASP/NMP = 1, NSP/NMP = 1	37.99	91.27	0.96
7	TOTAL_OZE/NSP = 0	NSP/NMP = 1	37.99	91.27	0.96
8	TOTAL_OZE/NSP = 1	ASP/NMP = 1	56.60	96.96	1.03
9	TOTAL_OZE/NSP = 1	ASP/NMP = 1, NSP/NMP = 1	56.60	96.96	1.03
10	TOTAL_OZE/NSP = 1	NSP/NMP = 1	56.60	96.96	1.03

The support factor (confidence) indicates the probability of the combined predecessor and successor, i.e., no (TOTAL_OZE/NSP = 0) or no RES plans (TOTAL_OZE/NSP = 1) in relation to the variable NMA/NMP = 0 (area per capita less than 1.0 hectare/person). In most cases, the variable NSP/NMP = 1 (when the number of enacted plans per capita is different from zero) and ASP/NMP = 1 (area of enacted plans per capita is different from zero), or NMA/NMP = 0 (area per capita when the figure is between 0.0 and 1.0 hectare/person) also appear in the corollary, i.e., for municipalities with high population density.

Rule 1.3 and Rule 4 deserve attention. In the case of the first rule, TO-TAL_OZE/NSP = 1 and the corollary ASP/NMP = 1 and NMA/NMP = 0 can be interpreted as follows: with a probability of 23.86%, plans including RES have been adopted in the studied municipalities, and the area of these plans per capita is different from zero. They are municipalities with a population ratio not exceeding 1.0 hectares/person. This means that the share of such municipalities meeting the above condition is 23.86% of the total number of municipalities in Poland. On the other hand, the ratio of 40.87% represents the conditional probability, i.e., the condition ASP/NMP = 1 and NMA/NMP = 0 means that there were RES local plans in these municipalities. Given the purpose of the study, it is also interesting to note the fourth rule, which shows that 24.06% of the smallest municipalities with a population density of less than 1.0 hectares/person have a RES-related local plan. Therefore, almost one-quarter of municipalities with a high population density (degree of urbanisation) take RES into account in their planning.

5. Discussion

The estimation of the linear regression model for the dependent variable number of plans taking into account renewable energy sources indicates the statistical significance of the estimated coefficient for the explanatory variable number of population (NMP), which confirms the assumption made in the study objective. The signs of the estimated parameters are also as expected. However, the quality of the model is not satisfactory due to a low level of R^2 = 0.325, which suggests the appearance of random dependencies in the model. This does not detract from the diagnostic value of the model; at most, it may represent a predictive disadvantage of the model. In addition, the models estimated for individual provinces indicate a strong variation in the dependence of TOTAL_OZE and the population variable (NMP), suggesting a search for other local predictors of differential impact on TOTAL_OZE. The quality of the models was not improved by nominated variables, e.g., population density or the percentage of plans with renewable energy sources in the total of adopted local plans.

Due to the low R^2 and the large dataset and scale of measurement, additional tools were sought to show the relationship (relevance) of the population and, therefore, the municipality's urbanisation level with spatial planning directions, including RES. Two Data Mining tools were used, the reinforced classification tree method, which includes aggregated models, and the association method, which is popular in marketing research. The first tool was to show that in the regression trees, the significant explanatory variable TOTAL_OZE is population (the results of the validity of the explanatory variables confirmed this relationship). In turn, the analysis of association rules as a complement allows attention to be drawn to the numerous relationships between the level of spatial planning, taking into account renewable energy sources and urban planning parameters, including population density. The article provides examples of association rules suggesting a relationship between population density and the inclusion of renewable energy installations such as wind farms and micro-installations in the adopted local plans.

However, it can be assumed that the research carried out confirms the validity of the research direction undertaken. The article proposes research methods that can be applied in other countries simultaneously. It can (and should) be developed in relation to other variables. Nevertheless, already at this stage, the authors emphasise the particular importance of such research. As indicated above, the international discussion diagnoses various problems related to the relationship between the sphere of renewable energy sources and spatial planning [4,18,33]. The fact that these concerns exist is an argument for the search for particular regularities in this area. As indicated above, the case of Poland is particularly interesting here. Municipalities are not obliged to enact plans, so the fact that a plan may be enacted for renewable energy sources is a sign of broader activity and determination. In other countries, such determination can be combined with a qualitative assessment of the content of individual spatial plans. Assessing planning activity is, therefore, a more difficult task. In Poland, on the other hand, the mere fact that an area is designated for renewable energy purposes in a spatial plan remains a significant point of reference.

The study shows a correlation between the planning activity of municipalities in the field of renewable energy sources and both population and population density. It can be seen that the higher the population density (highly urbanised areas), the higher the planning activity as well, and with it, the associated planning activity for renewable energy sources. The results in this respect are spatially differentiated, but the conclusion indicated is nevertheless vital. Population numbers can be considered from the perspective of spatial conflicts. A high number of spatial conflicts can (and often does) block the adoption of a given plan. The inclusion of renewables in the plans of municipalities with larger populations leads to the conclusion that especially the more severe spatial conflicts in this area are not explicitly related to the municipality's population. It confirms the thesis that the condition affecting spatial conflicts is more the functional–spatial type of the municipality [15]. The broader inclusion of renewable energy sources in the planning-active municipalities can also be linked to legal problems and barriers, especially pitfalls in the construction of planning regulations [19]. Municipalities that are less active in planning (and therefore have less experience in formulating planning regulations) may fear such issues. As a consequence, when they are not obliged to do so, they do not enact spatial plans for renewable energy sources. Consequently, this exacerbates these municipalities' passivity in terms of spatial policy.

Reference should be made to proposals for zoning for renewable energy sources. Such proposals relate to spatial plans' content [20] and broader, supra-national solutions [22]. However, these two directions do not have to be mutually exclusive. On the contrary: renewable energy zones should not be introduced top–down, as this would pose an even more significant threat to the planning autonomy of municipalities [3]. Promoting renewable energy sources should be correlated with spatial planning instruments, including the content of local spatial plans. On the other hand, the drawing up of such spatial plans must be linked to in-depth analyses. Therefore, identifying trends in terms of the feasibility (but also the efficiency) of including renewable energy sources in spatial plans will be much needed.

The paper analyses all the spatial plans in force, singling out those that relate to renewable energy sources (specifically, those renewable energy sources whose inclusion in spatial plans is defined by Polish law). Such a large number of spatial plans is partly due to the specificity of the Polish spatial planning system. For this reason, it is difficult to directly compare the results obtained to those of other studies. Other studies on a similar issue are based on the legal framework's analysis or specific case studies [3,15,16]. This article complements the indicated approaches by providing concrete proposals for the integrated development planning advocated by other authors. Relating the content of plans to the characteristics of municipalities also allows for a more rational reduction of spatial conflicts [20].

Notwithstanding the above, it is also possible to relate the results of the research in question to the scientific discussion on the classification of spatial planning systems. This discussion attempts to determine the optimal comparison of the diverse national spatial planning systems, including local spatial planning instruments. The analyses conducted thus far show that it is absolutely not sufficient to compare legal solutions alone [1,50]. The postulated consideration of selected issues (including the realities of planning practices) in the comparison is sometimes complicated and necessitates an interdisciplinary approach. In this context, the research results presented in this article provide an additional perspective. Indeed, they show how the legal provisions, and the economic and social context can be related.

The regression analysis indicates a spatial variation of the planning phenomenon under study, including renewable energy sources; hence the direction of future research should also include spatial models. The number of explanatory variables may also be unsatisfactory. Therefore, it will be important in future research to consider local economic policy, climatic conditions and the material situation of the inhabitants of the municipalities under study (the latter, especially in the context of micro-installations of renewable energy sources). It also seems worth considering the inclusion of investments in renewable energy sources made in individual municipalities as variables (in the Polish case, the difference caused by the aforementioned interference of the Polish legislator in 2016 should be taken into account here). Similar studies should also be carried out in other countries because, as indicated, there are also serious barriers and problems in this respect there. However, in the case of countries where spatial plans are obligatory (i.e., in principle applicable to the entire area of municipalities), a similar analysis is possible with regard to the share of renewable energy plans in spatial planning and, thus, the activity of individual areas in sustainable development. Where plans are not obligatory, the results obtained for Poland provide necessary comparative material and point to directions for future research.

It must be stressed that the number of spatial plans enacted alone does not translate into the quality of coverage of renewables in spatial planning. It is also necessary to analyse their quality. This should be counted as a limitation of the study. Nevertheless, the results presented above are important for a number of reasons. One of them is the specificity of the Polish spatial planning system [51]. Spatial plans at the local level are not obligatory; their enactment depends on the individual decision of the municipal authorities. From this perspective, the very fact of enacting a plan for a particular development should be assessed as important and necessary. Indeed, a major challenge is the correct terminology of the content of plans [52]. However, in the Polish spatial planning system, verifying whether a plan has been enacted for a specific investment is far more important. Terminological errors contained therein may constitute a certain barrier but are definitely less important. The situation is different in the case of another act in Poland: studies of spatial development conditions and directions. In their case, the correct coverage of renewable energy sources is even more important.

Among the significant limitations of the study, the authors also see difficulties in evaluating the implementation of the planning provisions (there is a lack of such data that can be applied to the whole country, only case study verification is possible). A certain limitation is the reference of the research results to the cases of other countries (which have different systems). Nevertheless, some basic similarities of legal solutions authorise partial analogies.

The article's contribution to the theory and future research is to indicate a possible direction for verifying the content of spatial plans for renewable energy sources and to present the possibility of relating these data to selected socio-spatial characteristics of municipalities. Possible research methods to be used are identified. An important contribution is also the identification of possible ways to analyse the content of spatial plans. This is especially true for those national systems where spatial plans constitute legal acts binding for investors. The analysis of such laws beyond mere legal analysis is a major challenge. Nevertheless, it is necessary from the perspective of an overall diagnosis of planning conditions. The article shows how this legal dimension can be combined (using statistical methods) with other relevant thematic levels.

6. Conclusions

Studying how renewable energy sources are included in local spatial policies is an important and topical scientific issue. Local authorities play the most important role in spatial policy-making in most systems. At the same time, in a noticeable number of countries, an attempt is made to integrate spatial and renewable energy issues. The research results presented in this article provide possible directions for in-depth, interdisciplinary analyses. In the authors' view, deeper integration of diverse perspectives—both academically and practically—seems necessary. This applies especially to the content of spatial plans and their translation into the realm of implementation. In countries with more local spatial plans, an in-depth statistical analysis of them, including reference to other aspects, seems possible (and advisable). The results show that such a possibility exists and identify preliminary regularities. They also provide a basis for further analysis in other countries, on the one hand, but also deeper analysis in Poland. At the same time, it should be noted that in the face of increasingly serious climate challenges, such analyses seem not only advisable but necessary.

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