TYPOLOGY OF FARMS IN AREAS WITH NATURAL CONSTRAINTS – DIVERSITY OF LIVELIHOOD STRATEGIES AND THEIR DETERMINANTS

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Abstract. The characterization of a farming system and farm typology represents essential steps for formulating effective agricultural policy support. This is especially important in areas with natural constraints which are characterized by a high diversity of the farming system, and which face a number of challenges such as low land productivity, poor climate conditions, high altitude and steep slopes. The aim of the paper is to develop a farm typology in areas with natural constraints in Serbia which explains diversity among farming systems and contributes to formulation of effective policy. The sample included 371 farms in the mountain settlements of Southern and Eastern Serbia. Development of farm typology was based on multivariate analyses – the principal component analysis and two-step cluster analysis. Two-step cluster method which combines categorical and continuous variables was applied to overcome problems related to impossibility of quantifying all relevant farm features. According to the author's knowledge, this is the first attempt to apply a two-step cluster analysis in the classification of farm types. Multivariate analysis has identified three predominant farm types: farms with intensive mixed livestock production dependent on income from agriculture; farms with mixed livestock production and income from salaries and pensions; and farms with mixed livestock and crop production and diversified income.
Keywords: *mountain areas, farm classification, multivariate analysis, two-step clustering, policy formulation, family farms, rural development*

Introduction

Areas with natural constraints (ANC) suffer from different biophysical and socio-economic constraints such as poor quality of soil, lower yield, geographic isolation, difficult access to markets, lack of infrastructure and public services. All these factors lead to the depopulation of rural areas, threaten the continuation of agricultural land use, and have a negative impact on the ecosystems in rural areas (Dax, 2005; IEEP, 2006). This applies especially to mountainous areas were farming conditions are difficult, and which majority of them belong to high-nature value area (Ortyl and Kasprzyk, 2022). Since the mid-1970s, the European Economic Community (EEC) has provided special policy support for farmers in ANCs, aimed at solving socio-economic problems of rural areas. In the early 2000s the emphasis has been placed on environmental problems in order to address demands for sustainable agriculture and multifunctionality of rural areas (European Commission, 2005). Particular emphasis was also put on the preservation of historical rural landscapes that are formed due to traditional, low intensity land-use patterns, and that are predominantly located in upland and remote areas (Sklenicka et al., 2017).

However, the diversity of biophysical and socio-economic constraints in ANCs causes great difficulties to the European Union (EU) policy makers and scientific community when designing adequate development policies. Namely, ANCs are

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characterized by a huge diversity of farm types which operate in complex agro-ecosystems and face distinctive development problems (Ruben and Pender, 2004). In order to promote the multifunctionality of ANCs, there is a need for policies which will be created on the basis of the prior identification and characterization of the existing farming systems (Berger et al., 2006; van der Ploeg et al., 2009; Madry et al., 2013).

In Serbia, the current agricultural policy is not responsive to the diversity of farm types and practices, including specific constrains faced by farmers in ANCs, which causes difficulties in achieving the sustainable income of farmers, as well as preserving natural resources. The agricultural and rural policy measures are aimed more at the economic than at social and environmental objectives leading to wide diversity of farm types and farming systems in ANCs facing constrains in achieving sustainable livelihoods (Bogdanov, 2014; Papić, 2022).

The aim of the research is to develop the farm typology in ANCs in Serbia that could be used for developing mathematical models to test the impact of different policy scenarios. According to Köbrich et al. (2003), mathematical programming models are established means of generating recommended solutions, but to be effective they have to be developed for a representative situation. Therefore, the identification and characterization of farm types in Serbian ANCs is of great importance for designing an effective policy solution adjusted to the characteristics and circumstances of the prevailing groups of farms. This question is important for Serbia since, according to the official definition of ANCs (Criteria used for the ANC delimitation in Serbia include all settlements above 500 m a.m.s.l, villages within nature parks, and villages in the territory of municipalities with fewer than 100 employees/1,000 inhabitants (The Government of the Republic of Serbia, 2016). Since 2019, the third criterion has been changed and now covers the territory of devastated municipalities (The Government of the Republic of Serbia, 2018)), 40% of the territory, 30% of the total population, 29% of farms, and 24% of the utilized agricultural area (UAA) is located in these areas (Statistical Office of the Republic of Serbia, 2012). Also, Serbia is in the process of the EU integration, so it is expected to improve its policy towards ANC areas. In addition, lack of empirical research on these issues in Serbia hinders the creation and implementation of effective policy instruments. Therefore, the research results would provide guidelines for an evidence-based policy that is tailored to regional diversity and structural characteristics of farms.

The rest of the paper is structured as follows. The next section presents the literature review on the establishment of farm typologies in rural areas. The third section describes research methodology (research area, sampling method, multivariate techniques). The fourth section shows the application of principal component analyses and cluster analyses in establishment of farm typology in ANC. In this section used data set and the empirical results are elaborated. The final section of the paper contains conclusion and policy implications.

Literature review

No farm-household has the same resources or problems, and every farmer faces distinctive decision-making problems depending on the resources available to them and their lifestyle (Köbrich et al., 2003). In order to understand the complex diversity of farming systems and to evaluate realistically the constraints and opportunities that farmers face, classification schemes have been widely used in agricultural studies (Emtage, 2004). Farm classification schemes have been developed and evolved over

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time from those based on structural characteristics of farms to those that deal with the multifunctionality of agriculture (van der Ploeg et al., 2009). The strength of any farm classification depends on its ability to capture the differences of farming systems in a way that the distinguished farm groups show maximum similarities within the group, as well as significant differences between the groups (Köbrich et al., 2003; Iraizoz et al., 2007). For farms clustered into roughly homogeneous groups, it is possible to explain the factors that influence the success or failure of new policy interventions and to make more or less the same policy recommendation (Köbrich et al., 2003, Goswami et al., 2014).

Farm typology development is usually based on one approach or a combination of qualitative or quantitative approaches' (Iraizoz et al., 2007; Pienaar, 2013). The qualitative approach is based on the knowledge and judgment of experts related to defining the characteristics for segmentation (Iraizoz et al., 2007). Due to the unavailability of statistical data, this approach relies heavily on researchers 'estimates, which is the main deficiency of qualitative techniques (Pienaar, 2013). The quantitative approach highlights the advantages of quantitative typification techniques, and it is recommended when there is sufficient empirical information on farm characteristics (Köbrich et al., 2003; Robles et al., 2005). The quantitative approach for developing the typology of farms is conducted in six steps processes, which include: a) establishment of the theoretical framework; b) selection of variables; c) data collection; e) factor analysis; f) cluster analysis; and g) validation (Escobar and Berdegué, 1990), obtained from Köbrich et al. (2003).

The theoretical framework defines the purpose of typology development, while the selected variables define differences between farms. The literature review shows that the purposes of determining farm typology are different (*Table 1*). For example, farm typologies were used to study the effects of the Common Agricultural Policy – CAP (Serrano Martínez et al., 2006; Cots-Folch et al., 2009); to describe the heterogeneity of rural areas (Madry et al., 2013; Pienaar and Traub, 2015); to define appropriate development strategies for rural regions or sectors (Robles et al., 2005; Rivas et al., 2015; Kaouche-Adjlane et al., 2015; Alemu et al., 2016); to find factors that explain application of new technologies in rural areas (Bidogeza et al., 2009; Goswami et al., 2014); and to establish typical farms for developing mathematical models (Yilma, 2005; Shrestha et al., 2007; Rozakis et al., 2012; Janeska-Stamenovska, 2015). Also, Madry et al. (2013) described the use of farming system typology methodologies in the studies of the pasture-based farming system which prevails in ANCs. Since there is no universal rule for determining the variables, previous studies show that their selection depends mostly on: a) the experience of the researcher and the knowledge of the research area; b) the purpose of the research; and c) available quantitative information (Köbrich et al., 2003). Researchers use different combinations of variables (social, economic, organizational, production, structural and ecological variables) considering their relevance to the research problem (*Table 1*). Authors highlight that for less developed farming systems it is important to include qualitative variables such as farmers' activity, farmers' attitudes, as well as the household income (Madry et al., 2013; Pienaar and Traub, 2015).

Data can be collected from primary or secondary data sources, depending on the research question. Researchers have used administrative databases (The farm accountancy data network – FADN or The farm structure survey – FSS) or conducted their own surveys.

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Table 1. *Literature review on the use of multivariate techniques for the farm typology development*

Purpose of farm typology development	Authors and year	Methods and sample size	Main classification variables
Characterization of cattle farms after changes in CAP	Serrano Martínez et al. (2006)	PCA and CA (111)	35 variables related to production, income, and costs
Characterization of farms after the implementation of CAP related to rural landscape	Cots-Folch et. al (2009)	CA (50)	9 variables on land use (traditional; mechanized system, etc.)
Characterization of sheep farms for creation of development strategies	Rivas et al. (2015)	PCA andCA (157)	27 variables related to land use; livestock production; labour force
Characterization of goat farms for creation of development strategies	Castel et al. (2003)	MCAand CA (89)	73 variables related to the whole agricultural system
Characterization of dairy farms for creation of development strategies	Robles et al. (2005)	CA (40)	Socio-economic variables
Characterization of cattle farms for the management strategy improvement	Alemu et al. (2016)	PCA and CA (1005)	41 variables related to livestock production, land use, income, risk attitudes
Characterization of dairy farms for the sector potential improvement	Kaouche-Adjlane et al. (2015)	PCA and CA (16)	10 variables related to technical and economic characteristics of farms
Characterization of farms in heterogeneous rural areas for creation of development strategies	Madry et al. (2010)	PCA and CA (123)	32 variables related to production, socio-economic characteristics, infrastructure
Characterization of small farms in heterogeneous rural areas	Pienar and Traub (2015)	PCA and CA (634)	25 variables related to income, costs, production orientation, socio-economic status
Characterization of farms for the implementation of new technologies in rural areas	Bidogeza et al. (2009)	PCA and CA (96)	100 variables related to socio-economic characteristics, available resources and technologies
	Goswami et al. (2014)	PCA and CA (144)	23 variables related to income, land use and household characteristics
Grouping sheep farms for formulation of mathematical models	Rozakis et al. (2012)	PCA and CA (150)	31 variables related to farm size, production orientation and intensity, characteristics of farm holders
Grouping vegetable farms for formulation of mathematical models	Janeska-Stamenovska (2015)	CA (224)	Variables related to the economic and production characteristics of farms
Grouping farms for formulation of mathematical models	Yilma (2005)	PCA and CA (200)	10 variables related to technology, infrastructure and farm resources
Grouping farms for formulation of mathematical models	Shrestha et al. (2007)	CA (200)	Variables related to farm size, income, number of animals, milk yield, labour force and productivity

Note: PCA - Principal component analysis; CA – Cluster analysis; MCA – Multiple correspondence analysis. Source: Systematization of the authors based on literature reviews and Madry et al. (2013)

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The use of surveys for data collection is characteristic of researches aimed at establishing farm typologies for the purpose of modelling at the farm level, which usually requires detailed data about the farm management (Madry et al., 2013). After data collection, the next two steps include the application of techniques for data reduction and data grouping in order to develop specific groups of farms. The most commonly used methods of multivariate analysis are the principal component analysis and hierarchical cluster analysis (*Table 1*). In the recent studies two-step cluster analysis is often used following the principal component analysis, because it offers the possibility to use mixed data (both continuous and categorical variables) (Trpkova and Tevdovski, 2009; Schiopu, 2010). Namely, in the socio-economic research, there is a need for use of categorical variables for description of different feature of observation unit, since there is a risk that continuous data are not sufficiently precise or reliable. On the other side classical clustering algorithms cannot work efficiently with such data (Bacher et al., 2004). Also, two-step clustering method provide automatic selection of number of clusters, and therefore it is very efficient in classification of large data sets (Trpkova and Tevdovski, 2009).

The final step of the quantitative approach is the validation of the typology results to ensure their correspondence to reality. There is no definite method recommended to test differences between groups, so it remains the choice of researchers (Pienaar, 2013).

The use of multivariate techniques in the classification of rural regions/municipalities is not unknown in Serbia. For instance, Bogdanov et al. (2008) classified rural regions using principal component analysis and cluster analysis and found that the mountainous region in Serbia was characterized by high poverty rates, unemployment, unfavorable demographic structure, underdeveloped infrastructure, and processing capacities. Maletić and Bucalo-Jelić (2016) used cluster analysis to define six groups of municipalities in Serbia in terms of their development. However, multivariate techniques have not yet been applied for the farm typology development in Serbia. Therefore, the contribution of this paper to the literature is twofold: a) by classifying farm holdings in ANCs into a homogenous group that can be used to evaluate the impact of different policy solutions; b) by application of two-step cluster analysis in farm typology development. This paper will examine the idea that two-step cluster analysis is appropriate for classification of farm types.

Material and methods

The research approach consists of 6 parts, as shown in *Fig. 1*. The approach began with the description of objectives of research, and then it is followed by reviews of the literature on use quantitative methodologies for farm typology development. Next step represents empirical research (creation of questionnaire, sampling, data collection and validation). In the fourth step, multivariate techniques are applied in order to develop farm typology. At the end of research, results were analyzed and discussed, and conclusion is drawn.

Area of study

The research was carried out in the mountainous ANC areas of Southern and Eastern Serbia (NUTS II) that represent a sufficiently homogeneous territory in terms of natural resources endowments, farming practices and environmental characteristics and

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challenges. The spatial coverage included the mountain settlements of the municipalities that belong to the Bor, Zaječar and Pirot districts (NUTS III) (*Fig. 2*).

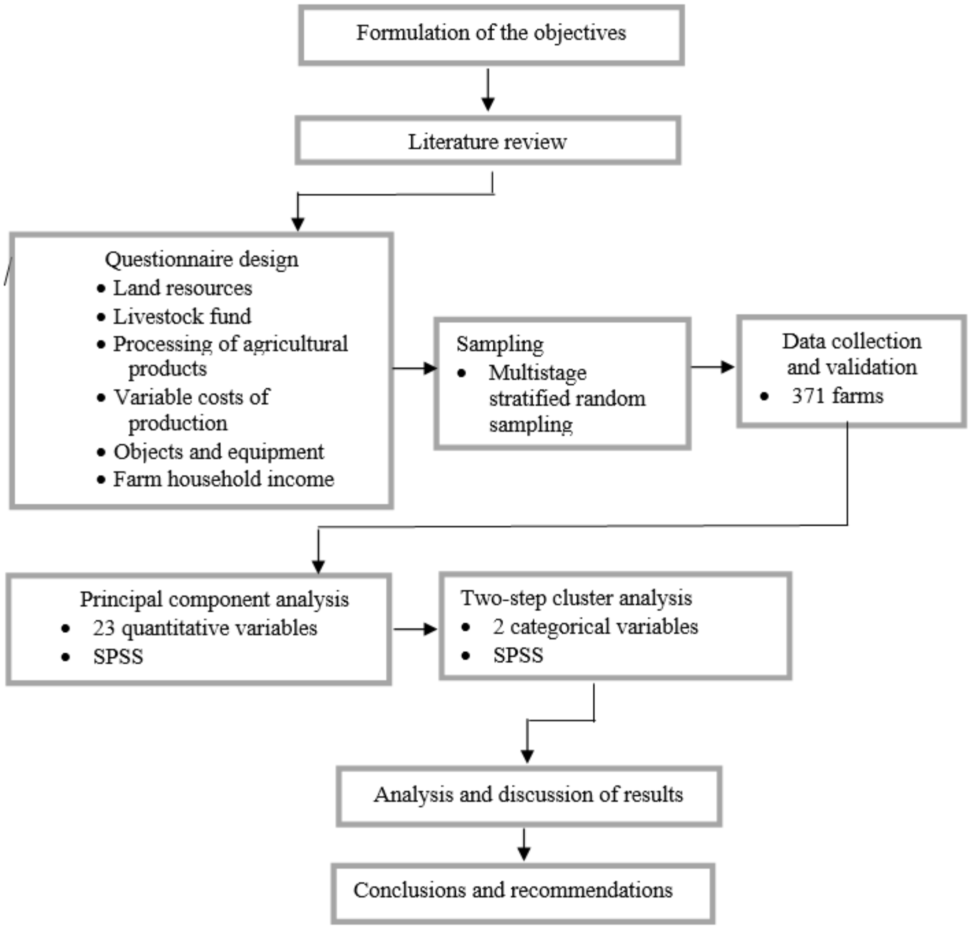

Figure 1. *Research Approach*

Such an approach was chosen due to the following principles: 1) delimitation of ANCs in Serbia is aligned with the EU definition only in terms of one criterion which refers to mountainous areas (The Government of the Republic of Serbia, 2018); 2) mountainous ANC areas occupy the largest part of ANC territory – exactly 89% of the settlements, 74% of the farms and 73% of the UAA of the total ANC territory (Statistical Office of the Republic of Serbia, 2012).

Sampling and data

Data collection was organized using a stratified multistage random sampling. Stratified random sampling involves the division of a population into homogeneous subpopulations, while multi-stage sampling divides large populations into stages to make the sampling process more practical (Lohr, 2010). The sampling process started with the determination of the population size. The research area included 15,422 farms, with the prevailing three types of farms: 1) mixed farms for crop and livestock production (28.34%); 2) mixed farms for livestock production (21.64%); and 3) specialized farms for grazing livestock (21.33%) (Statistical Office of the Republic of

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Serbia, 2012a). In order to obtain the precisely defined population from which the sample will be selected, the population size included three dominant farm types (N=10.997). They were selected to be the stratification variable and to divide the population into strata (the first stage of stratification). The first stratum represents specialized farms for grazing livestock (N1=3.289) which participate in the population with 29.91%. The second stratum represents mixed farms for livestock production (N2=3.337) which participate in the population with 21.64%, while the third stratum represents mixed farms for crop and livestock production (N3=4.371) which participate in the population with 39.75%.

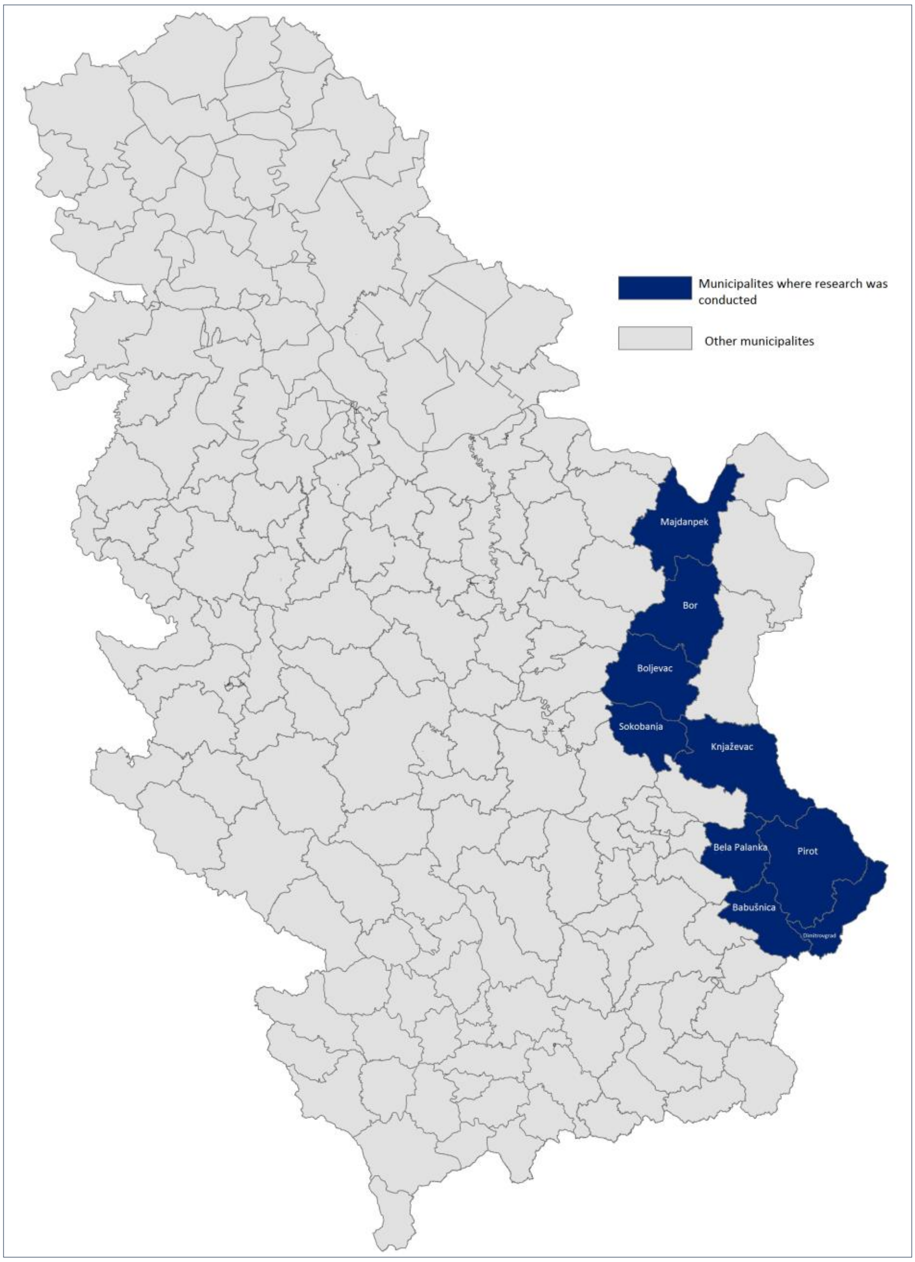

Figure 2. *Municipalities in Serbia – Research area shown in blue colour Source: Graphics background: Republic Geodetic Authority, done in Statistical Office of the Republic of Serbia; Papić (2021)*

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The suitable sample size was calculated according to the expression which includes the correction for finite population:

$$n = \frac{N}{1+\frac{c^2(N-1)}{Z^2\,p(1-p)}} = 371 \quad \text{(Eq.1)}$$

where,
N - population size
c - error margin of 5%, i.e. 0.05
Z – value for 95% confidence level is 1.96
p - probability that a certain answer will be obtained (50%).

In the second stage of stratification, the strata were distributed within the districts (the first level) and then within the municipalities (the second level). The distribution of the farms in the stratum by districts was proportional to the representation of the selected farm types in all three districts together. The distribution of the farms by municipalities was proportional to the representation of the selected farm types in the relevant district. The sample sizes for the selected strata were n1=111; n2=113; n3=147.

The mountain settlements where the survey was conducted were chosen randomly. However, the requirement was that there were economically and demographically viable farms in the settlement. The sample selection criteria were: 1) rural households had at least three members and 2) one member of the household was younger than 50 years of age. Similar selection criteria were used in previous rural research in Serbia (Bogdanov, 2007; Kotevska, 2015). Face-to-face surveys were conducted in the period July-August 2018. The questionnaire was mostly made up of a series of open-ended questions with the purpose of obtaining the most important data such as land use, livestock fund, processing of agricultural products, labour force, income sources, attitudes on agricultural policy and future plans, etc. The summary results from questionnaire are presented in the *Table 2*. Socio-economic characteristics of farms were analyzed using descriptive statistics method (percentage response distributions; measures of central tendency and dispersion measures), while attitudes on agricultural policy and future plans were measured through a 5-point Likert scale (1 – strong disagreement and 5 – strong agreement).

Research results show that majority of farm holders are men. Very few of surveyed farm holder has a university degree (3.8%). The average farm size in the sample is 12.7 ha, however standard deviation value indicates high variability (*Table 2*). The areas under permanent grassland are present in all farms in the sample, and almost all farms have areas under arable land (97.6%), with average size about 6.0 ha. The prevailing categories of livestock in research area are cattle (87.8%) and sheep (64.9%) (Papić and Bogdanov, 2021).

For about 60% of household's income from agriculture represent an important factor of social security and food security. It is usually income from the sale of animal products (mostly milk and cattle). Salaries are the most important income for around 20% of households. These mainly refers to households with small farm size and pressing need for additional income or to households for which wage income is relatively low.

Farmers from surveyed areas face various challenges when applying for agricultural and rural development support. Barriers are mostly related to the costs and preparation of documents, as well as by the possibilities for getting the necessary information.

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However, farmers are more familiar with direct payment support schemes, than with rules regulating access to rural development support. Farmers plan to continue activities in the agricultural sector, and to invest on the farm business in the next 3–5 years. Planned investments, however, are mainly low-risk, such as purchase of equipment (Papić and Bogdanov, 2021).

Table 2. *Characteristics of farms surveyed*

Indicators	
Farm holder profile	
Age (AV±SD; Me)	54.0±12.3;53.0
Primary education; Secondary school; College and University (%)	25.1;71.1;3.8
Men holder; Women holder (%)	74.1;25.9
Farm characteristics	
Utilized agricultural area (ha) (AV±SD; Me)	12.7±9.9;10
Arable land (ha) (AV±SD; Me)	6.4 ±5.2;5.0
Permanent grassland (ha) (AV±SD; Me)	6.1 ±8.2;4.0
Land under permanent crops (ha) (AV±SD; Me)	0.8 ±0.9;0.4
Total Livestock Unit * (LSU) (AV±SD; Me)	8.8±9.8;6.4
Cattle (LSU) (AV±SD; Me)	6.3 ±5.7;4.7
Sheep (LSU) (AV±SD; Me)	3.2 ±4.4;1.3
Pigs (LSU) (AV±SD; Me)	1.4 ±2.0;1.1
Goats (LSU (AV±SD; Me)	1.2 ±1.7;0.5
Main household income (%)	
Agriculture	66.1
Salaries	24.8
Pensions and social benefits	9.1
Main farm income (%)	
Sale of animal products	80.3
Sale of plant products	9.1
Sale of animal and plant processed products	4.7
Others	5.8
Attitudes on agricultural policy and future plans	
My knowledge and experience is enough to independently prepare the application for direct payments support (AV±SD; Me)	3.4 ±1.4; 4.0
My knowledge and experience is enough to independently prepare the application for rural development support (AV±SD; Me)	2.8 ±1.4; 3.0
Intention to keep agricultural production next 3-5 years (AV±SD; Me)	4.5± 0.9; 5.0
Plan to invest in the next 3-5 years (AV±SD; Me)	4.0 ±1.2; 4.0

Note: AV – average value; Me – median; SD – standard deviation; *The total number of livestock units includes cattle, sheep, goats, pigs, goats, poultry, and horses

Data analysis

To determine the farm types, the authors used multivariate analysis as a very common technique applied in studies on farm typology (*Table 1*). The PCA was used to reduce the number of various variables to a smaller set of factors that will be used in CA. The objective of CA is to identify groups of farms that are relatively homogeneous within groups and heterogeneous between each other (Köbrich et al., 2003). The 23 quantitative variables obtained from the questionnaires were included in the PCA (*Table 3*). The selection was made taking into account previous research in rural areas (*Table 1*), while the variables that had low variability and did not contain enough

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relevant information were removed. Standardization of the original data was performed, so that the original variables had an arithmetic mean equal to zero and the variance equal to one.

Table 3. *Selected variables used in PCA*

Category	No	Name and description of the variable	Unit of measurement
Land	1.	Farm size	Ha
	2.	Intensive area* in the utilized agricultural area (UAA)	%
	3.	Meadows and pastures in the UAA	%
	4.	Leased UAA	%
Intensity of livestock production	5.	Livestock density index**	LSU/ha
	6.	Grazing livestock density index ***	LSU/ha
	7.	Cattles per 100 ha of the agricultural area	LSU/ha
	8.	Sheep and goats per 100 ha of the agricultural area	LSU/ha
Yield	9.	Small grains yield	kg/ha
	10.	Maize yield	kg/ha
	11.	Vegetable yield	kg/ha
	12.	Cow milk yield	lit/ dairy cow
	13.	Sheep milk yield	lit/ dairy sheep
Marketability	14.	Sold cow milk	%
	15.	Sold sheep milk	%
	16.	Sold cow cheese	%
	17.	Sold sheep cheese	%
	18.	Calves sold per cow	Number
	19.	Value of crop production	RSD****/ha
Characteristics of the farm holder	20.	Age of the farm holder	Number of years
	21.	Education of the farm holder	Number of years
Labour force	22.	Leased labour force	Working hours /ha
Subsidies	23.	Amount of subsidies	RSD/ha

Note: * An intensive area includes the area under arable land and gardens and the area under orchards and vineyards. ** The livestock density index is defined as the number of livestock units (LSU) per hectare of the utilized agricultural land. *** Number of grazing animals per hectare of the fodder area. **** Serbian dinar is the official currency of the Republic of Serbia. Source: Selection of authors based on the literature review; Papić, 2021

Prior to the PCA, the dataset was checked for the appropriateness of this technique. The assessment of suitability of the sample size for analysis was done by checking the ratio of the number of observations and the number of the variables. It is recommended to have 10 to 15 observations per variable (Nunnally, 1978; Kass and Tinsley, 1979), obtained from Field (2009) or to have at least 300 observations for the factor analysis (Tabachnick and Fidell, 2007). To test if the selected variables were appropriate and valid for PCA, the Kaiser-Meyer-Olkim measure (KMO>0.5) and Bartlett's test of sphericity were used (Field, 2009). Namely, if variables do not correlate, clusters cannot be found, and a very high correlation can lead to the problem of multicollinearity. The factors were retained in accordance with Kaiser's criterion. Namely, all factors exceeding an eigenvalue of one were retained. The criterion is said to be accurate if the number of the variables in the analysis is less than 30 (Bidogeza et al., 2009). In the process of retention of the main factors, the percentage of the explained variance was

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also considered. From the aspect of social sciences, the allowed limit which explains the percentage of the total variance is 60% (Hair et al., 2014). The factors were rotated using orthogonal (vari-max) rotation, to relate more easily the selected variables to the extracted factors. The PCA output was a completely new rotated factor matrix. For the interpretation of the PCs, the variables with high factor loadings (higher than ± 0,50) and high communality were considered (Costello and Osborne, 2005; Field, 2009; Hair et al., 2014; Goswami et al., 2014).

The factors retained from the PCA were used in the CA. To determine the number of clusters, a two-step cluster analysis was used. This analysis is recommended for large databases (the sample is large > 200; Schiopu, 2010) and it is used both for categorical and continuous variables (Trpkova and Tevdovski, 2009). The two-step cluster analysis was applied to the results of the PCA analysis (identified components) and two categorical variables: a) the most important household income; and b) farm specialization (*Table 4*). Previous research in rural areas indicates that the household income, as well as the farm income, are the variables that divide farms into different groups (Iraizoz et al., 2007; Madry et al., 2010; Pienaar and Traub, 2015).

Table 4. *Categorical variables used in two-step cluster analysis*

No.	Variable name	Categories
1.	Farm specialization	1 – Sale of plant products 2 – Sale of animal products 3 – Sale of processed plant products 4 – Sale of processed animal products 5 – Sale of wood 6 – Other (rural tourism; contract machinery services; leasing land; sale of forest products)
2.	The most important household income	1 – Income from agriculture 2 – Salaries 3 – Pensions 4 – Remittances

Source: Papić, 2021

The two-step method is specially designed and implemented in SPSS software and involves certain procedures: 1) pre-clustering; 2) solving atypical values (outliers) - optional; and 3) clustering (Schiopu, 2010). The clustering algorithm is based on a log-likelihood distance measure because mixed data were used in the analysis (Schiopu, 2010; Keča et al., 2017). The number of clusters is determined during two phases. In the first phase, Schwarz’s Bayesian Criterion (BIC) is chosen to determine the number of clusters. It is considered that lower values of the BIC criterion give the "best" solution. In the second step it is recommended to find the greatest change in the distance between the two closest clusters in each hierarchical clustering stage. Combining both the BIC and distance change provides a much better solution than using only one of these (SPSS, 2001; Vasić et al., 2008; Trpkova and Tevdovski, 2009). For assessing the clustering quality, the “silhouette measure of cohesion and separation” is used. The silhouette coefficient is ranging between -1 and 1, where the coefficient of less than 0.2 indicates that the data do not exhibit a cluster structure (Nelson, 2014). The whole dataset was prepared and analysed using IBM SPSS Statistic Amos 23.

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Results and discussion

PCA results and discussion

The identification of typical farms was carried out in accordance with all the steps required by the quantitative approach (Köbrich et al., 2003). The number of selected variables ranges from 20 to 30, which has been suggested in previous research (Weltin et al., 2017; Sinha et al., 2022). The appropriateness of the dataset for PCA is satisfied, having in mind that that ratio between the number of observations and the number of variables is 1:16. The results of the KMO gave the value of 0.599 (>0.5), while Bartlett's sphericity test was highly significant (p-value<.001) (*Table 5*). This implies that the variables included in PCA are sufficiently dependent on one another and, at the same time, not too strongly correlated. Also, the results show that the value of the correlation matrix determinant is higher than required (0.00001), which indicates that multicollinearity is not a problem. Therefore, the application of this technique is justified.

Table 5. *KMO and Bartlett's test*

Used tests	Measure
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Value.599
Bartlett's Test of Sphericity p-value	0.000

Determinant = 2.265E-12

The factors with eigenvalues greater than one were retained and 9 factors explained 73% of the variation within the original dataset. *Table 6* shows the PC, the variance that each factor explained, their eigenvalue, and the loading factor of the different variables with the PC and communalities. The variables with high factor loadings and high communality were considered from the rotated factor matrix (Goswami et al., 2014). Factor loadings of ±0.50 are highlighted and considered to be sufficiently correlated to the specific variable (Hair et al., 2014).

The first retained component from the PCA explaining 16.1% of the variation in the data is the factor which correlates positively with the intensity of livestock production and total subsidies received by farm holding. This can be explained by the fact that farms with a livestock receive a higher amount of direct payments, so the first component named "livestock production". PC 2 is positively correlated with the use of meadows and pastures and negatively correlated with the use of the intensive land area. This component is called "structure of land use" and identifies two groups of farms. The first group is more oriented to livestock production, and the land structure is characterized by a high share of permanent grasslands and meadows. Another group of farms mainly base their production on intensive areas and less on livestock production. These two components (PC1 and PC2) together explain 29.2% of the variation in the data.

PC 3 called "dairy cattle breeding" is positively correlated with the cow milk production and sales, while PC 4 "fodder from arable land" refers to maize and wheat yields that are mainly used for livestock nutrition. These components indicate on farms with more intensive cattle production. PC 5 is positively correlated with the production of sheep milk and sales of sheep cheese, so it is called "sheep production".

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DOI: http://dx.doi.org/10.15666/aeer/2202_10511073

Table 6. *Nine components resulting from the PCA analysis with loading for each of the 23 variables and percentage of cumulative variance explained*

Name of variables	Livestock production	Land use	Dairy cattle breeding	Fodder crops from arable land	Sheep production	Products of cattle breeding	Labour force in sheep breeding	Characteristics of the farm holder	Characteristics of plant production	Communality
Livestock density index (total LSU/ ha UAA)	**.93**			-.13			.13			.92
Grazing livestock density index	**.80**	.24				-.12			.21	.78
Cattle per 100 ha of the agricultural area	**.75**		.32	-.15	-.18	.21	-.23			.82
Subsidies (RSD/ha)	**.55**	.21	.37		.15	-.28	.23		-.14	.67
% meadows and pastures	-.10	**-.95**		-.17						.96
% intensive area	.10	**.95**		.17						.96
% sold cow milk	.14	.21	**.77**	.18	-.19	-.20				.76
Cow milk yield (l/cow)		.15	**.64**	.38	-.14	.38				.76
% leased UAA		-.31	.43	.34		-.25	.25	.16	-.18	.57
Farm size (ha)	-.31	-.18	.42	-.42	.14		.11	.19		.56
Maize yield (kg/ha)	-.12		.15	**.76**						.62
Small grains yield (kg/ha)		.36	.18	**.64**	-.12	-.14				.61
% sold sheep milk	.11			-.11	**.86**					.79
Sheep milk yield (l/sheep)					**.84**	.12				.73
Calves sold per cow per year				-.11		**.78**				.63
% sold cow cheese			-.27	.16	.23	**.74**				.71
Leased labour force (hours/ha)			-.11	-.29	-.13	.17	**.76**			.73
% sold sheep milk			.11	.21	.18	-,20	**.64**			.56
Sheep and goats per 100 ha of the agricultural area	.44	-.13	-.40		.30	-.30	.45		-.12	.77
Age of the holder				.10				**-.82**	.16	.73
Years of the farm holder education	.11			.13			-.12	**.81**	.17	.73
Value of plant production (RSD/ha)			-.12	.21	-.10		.11		**.83**	.78
Vegetable yield (kg/ha)		.16		-.20	.10	-.19	-.13	-.11	**.72**	.66
Eigenvalues	3.70	3.01	2.05	1.77	1.65	1.36	1.24	1.04	1.01	
Cumulative variance explained	16.09	29.16	38.06	45.76	52.95	58.85	64.24	68.76	73.16	

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This component reflects the second most important livestock production in ANCs. PC 6 named "products of cattle breeding" reflects farms that sell cow cheese and/or calves.

PC 7 is positively correlated with the working hours of the leased labour force as well as the sale of sheep milk. It indicates that sheep farms in these areas face labour shortages and if they want to sale more farm products, they need to lease additional labour force. Therefore, this component is named "labour force in sheep production". PC 8 named "characteristics of farm managers" is negatively correlated with the age of farm managers, and positively with their education indicating that farm managers are mostly old people with a low education level. PC 9 represents "characteristics of plant production" and identifies farms with high yields of vegetables, high marketability, and high value of plant production. In similar researches main components were highly correlated with similar variables: cultivated area, cattle owned, education, age, labour use, etc. (Wilkus et al., 2019; Mutyasira, 2020). The obtained main components were used further in the cluster analysis.

Cluster results and discussion

The auto-clustering statistics table in the SPSS output was used to assess the optimal number of clusters (*Table 7*). The results show that the best solution is the one with 3 clusters, because it gives the lowest value of the BIC and the highest value for the ratio of distance measures. The obtained number of clusters is in accordance with the recommendation that the optimal number of clusters should range from 3 to 6 (Castel et al., 2003).

Table 7. *Automatic clustering*

Number of Clusters	Schwarz's Bayesian Criterion (BIC)	BIC Change[a]	Ratio of BIC Changes[b]	Ratio of Distance Measure[c]
1	3658.627			
2	3340.774	-317.854	1.000	1.259
3	3120.063	-220.711	.694	2.614
4	3130.557	10.494	-.033	1.128
5	3157.272	26.716	-.084	1.037
6	3188.466	31.193	-.098	1.159
7	3236.478	48.013	-.151	1.244
8	3305.226	68.748	-.216	1.150
9	3385.034	79.808	-.251	1.060
10	3469.000	83.966	-.264	1.317
11	3569.783	100.783	-.317	1.097
12	3675.237	105.454	-332	1.006
13	3780.974	105.737	-.333	1.076
14	3890.105	109.131	-.343	1.104
15	4003.445	113.340	-.357	1.036

a. The changes are from the previous number of clusters in the table. b. The ratios of changes are relative to the change for the two-cluster solution. c. The ratios of distance measures are based on the current number of clusters against the previous number of clusters

The two-step analysis offers information about the importance of each variable in cluster formation (Mohamed and Awang, 2015; Harantová et al., 2023). The results show that the categorical variables (farm specialization and the most important source

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of household income) are the most significant variables for the cluster formation, while PC4 (fodder from arable land) and PC8 (characteristics of the farm holder) have almost no effect on the cluster formation (*Fig. 3*).

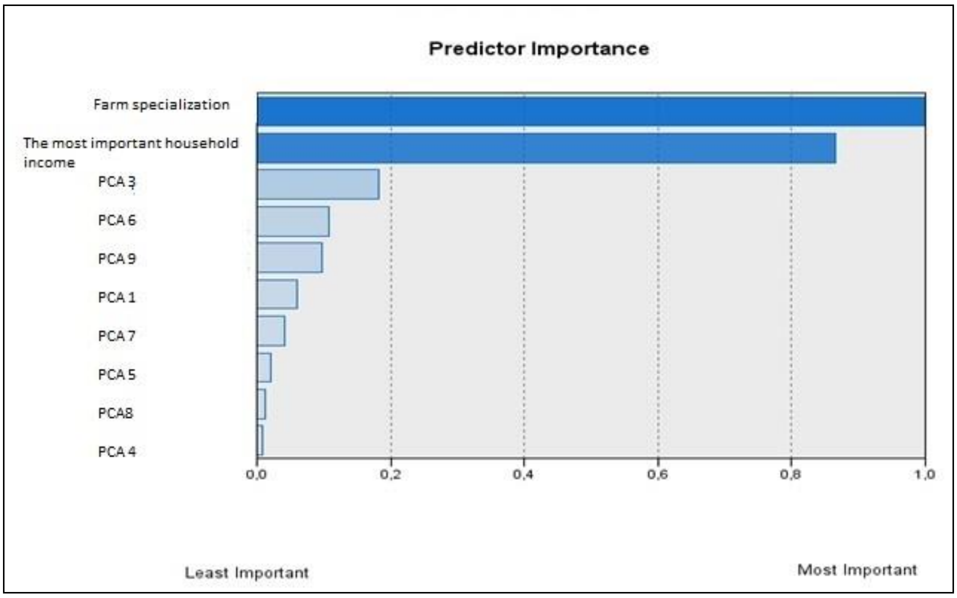

Figure 3. *Variable importance*

Previous research by using PCA and hierarchical cluster method also shows that main variables for classifying farms into groups were those related to income sources and dominant household livelihood (Goswami et al., 2014; Pienaar and Traub, 2015; Kumar et al., 2019; Sinha et al., 2022). Goswami et al. (2014) classified farms into groups based on income from different crop enterprise and off-farm income, while Pienaar and Traub (2015) show the importance of salaries, social grants, remittances, etc., in formation of clusters among smallholder farmers. Sinha et al. (2022) found that different income sources (agriculture, social security scheme and off-farm activities) are an essential factor for farm type identification. Also, Kumar et al. (2019) in farm typology analyses include farm income and income from off-farm activities, having in mind that lot of farmers chose to diversify because they faced number of uncertainties in agriculture production.

Characteristics of the identified clusters are described in *Table 8*, *Fig. 4*, and *Fig. 5*. *Table 8* shows the average values and standard deviation of the variables included in the PCA and additional continuous variables that are used for a better description of the clusters. *Fig. 4* and *Fig. 5* describe the clusters based on the categorical variables used in the analysis.

Cluster 1: Farms with intensive mixed livestock production dependent on income from agriculture

Cluster 1 is the largest and contains 53.2% farms from the sample (197 farms). The cluster is comprised of farms having a larger average farm size comparing with other two groups, high intensity of livestock production, high yields of small grains, maize, and cow milk. The farms from this stratum are mainly focused on the production and

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sale of cow milk (more than 60% of cow milk is sold on the market), while the sale of processed animal products is less represented (the fifth of the processed quantities are sold). When it comes to the structure of agricultural land, the arable land comprises 54.9% of the total agricultural area; pastures and meadows 43.7%; and lands under permanent crops 1.0%. The arable land is mostly used to produce feed for animals. The farmers from this cluster lease more land compared to the other two farm groups. However, the biggest percentage of leased land is used for free (instead for cash or in kind). Namely, the research area has a large number of abandoned farms, whose owners have no interest in engaging in agriculture. They usually give the land for use to the remaining farmers in the village without any compensation. Farms from this cluster receive more subsidies than farms in other clusters on average, given that they cultivate more land and have more livestock than the other groups.

Table 8. *Characteristics of clusters*

Variables	Cluster 1		Cluster 2		Cluster 3	
	AV	**SD**	**AV**	**SD**	**AV**	**SD**
Farm size (ha)	**14.5**	±11.7	10.5	±6.6	10.8	±7.2
Structure of the utilized agricultural area (%)						
% arable land	54.9	±22.7	49.4	±24.8	50.7	±26.1
% orchards and vineyards	0.8	±2.8	1.5	±4.2	**5.1**	±8.2
% meadows and pastures	43.7	±23.1	47.8	±24.4	43.1	±26.2
% Leased land	**29.6**	±26.1	10.7	±18.5	16.8	±25.9
Intensity of livestock production						
Livestock density index (LSU/ha)	**0.7**	±0.5	0.7	±0.4	0.6	±0.5
Grazing livestock density index (LSU/ha)	**3.0**	±2.3	2.2	±2.5	2.4	±3.0
Cattles per 100 ha of the agricultural area (LSU/ha)	**53.5**	±39.0	**42.4**	±27.8	17.5	±24.8
Sheep and goats per 100 ha of the agricultural area (LSU/ha)	**23.3**	±36.4	9.0	±16.0	**14.2**	±20.2
Yields						
Small grains yield (kg/ha)	**3334.0**	±1118.9	2956.7	±1269.0	3002.3	±1580.3
Maize (kg/ha)	**4141.8**	±2197.7	3684.6	±2745.0	4057.8	±1906.9
Vegetables (kg/ha)	1792.0	±4282.8	1099.0	±3082.9	**2860.0**	±4740.1
Cow milk yields (l/dairy cow)	**3455.2**	±2061.4	3304.9	±1682.0	2759.6	±2113.0
Sheep milk yields (l/dairy sheep)	26.3	±38.7	22.5	±42.7	**38.5**	±57.2
Marketability						
% sold cow milk	**64.2**	±44.9	**42.9**	±45.3	19.5	±38.4
% sold cow cheese	20.6	±35.1	39.0	±42.4	**49.3**	±43.6
% sold sheep cheese	**20.2**	±34.7	11.7	±28.4	18.6	±34.2
Calves sold per cow per year	0.4	±0.4	**0.7**	±0.4	0.4	±0.4
Lambs sold per sheep per year	0.2	±0.6	0.4	±0.5	**0.5**	±0.4
Value of plant production (RSD/ha)	4564.8	±10006.2	2009.5	±5898.0	**20976.5**	±45218.3
Labour force						
Number of farm members	4.2	±1.4	**4.8**	±1.3	4.3	±1.3
Leased labour force (hours/ha)	15.7	±49.8	**5.8**	±29.2	**38.2**	±154.9
% members engaged off-farm	21.6	±28.6	**40.6**	±29.8	28.9	±28.8
Characteristics of the farm holder						
Age of the farm holder	**53.1**	±12.3	55.9	±12.9	56.0	±11.8
Years of the farm holder education	**11.2**	±1.8	11.0	±1.9	11.1	±2.1
Subsidies (RSD/ha)	**30162.0**	±20821.6	15647.0	±12179.9	12436.0	±14351.2

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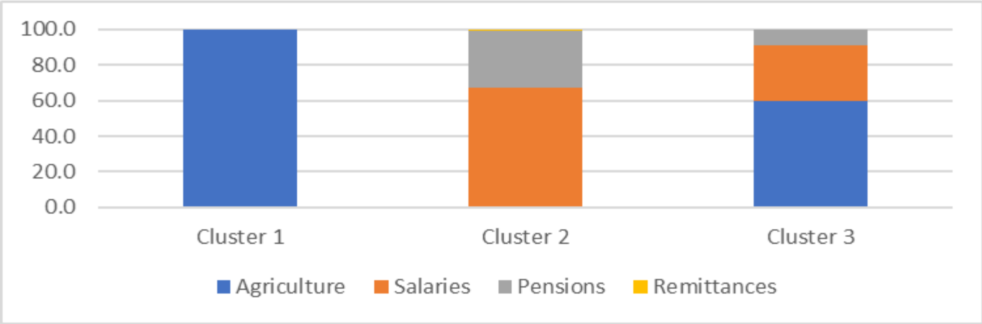

Figure 4. *The most important household income (%)*

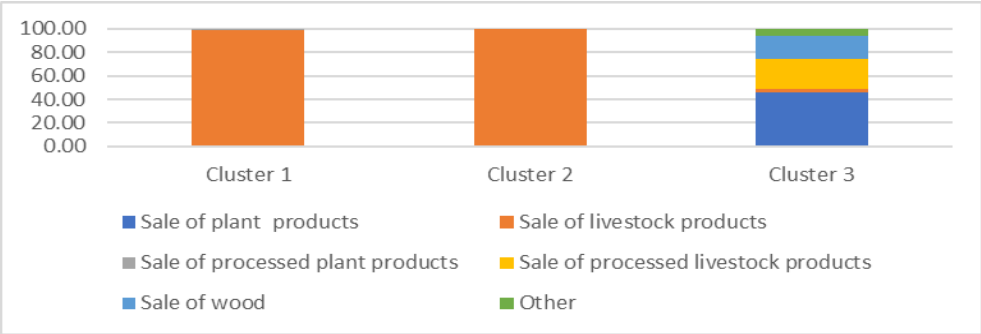

Figure 5. *Farm specialization (%)*

The households from this cluster have 4 members on average (fewer than other two groups), and more often lease labour force. Kuivanen et al. (2016) suggested that hired (leased) labour input per year was highest among households with larger areas and/or animals herds due to the correspondingly higher work and maintenance requirements. These farm holders are younger and have better education comparing to the farm holders from Cluster 2 and Cluster 3. All farmers from this cluster ranked the income from agriculture (mostly sale of animal products) as the most important income for their household. Similar previous research also distinguished a group of farms where agriculture production was the most important source of income (Madry et al., 2010; Goswami et al., 2014; Kansiime et al., 2018). Kansiime et al. (2018) found that more than 50% farm households located on high attitude pursued mainly farm-based activities, and they are characterized by larger farm size and family members engaged full time in farm activities. Madry et al. (2010) emphasize that farm households relying on agriculture income are the key group whose reactions influence the adoption of policy changes, while Graskemper et al. (2021) found that group of farmers oriented just to agricultural practices might react sensitive towards changes in politics. Farms that belong to this cluster are vital and their development strategies are related to agricultural sector, so in that sense they have potential for growth.

Cluster 2: Farms with mixed livestock production and income from salaries and pensions

Cluster 2 accounts for 27.8% of the farm households (103 farms). The farms from this group have a smaller average size and lease less land and labour comparing to the

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other two clusters. The farms from this cluster are mostly oriented towards cattle production, while crop production is mainly used for livestock feeding. Yields of small grains, maize and cow milk are lower compared to the yields of Cluster 1. The farms in this group sell cow milk and cheese (about 40% of the quantities produced). They are also characterized by a higher number of calves sold per cow. As expected, the farms from Cluster 2 use subsidies less than farms in Cluster 1. According to production characteristics, Cluster 2 has similarities with Cluster 1, but the intensity of production is lower.

The households from this group have more members (about 5 members on average), out of which 40.6% work off-farm. The importance of income from other activities (apart from agriculture) is more evident in this group than in the other two. Namely, these farmers ranked salaries (67.0%) and pensions (33.0%) as the main income sources of their households (*Fig. 2*, *Fig. 3*). Similar findings were confirmed in previous research in the Southern and Eastern Serbia region, where the importance of off-farm activities was characteristic of farm households that could not earn enough income from agriculture, as well as for those who wanted to reach a higher standard of living (Papić and Bogdanov, 2015). Serrano-Martinez et al. (2006) highlighted that the possibility of farms in ANCs to achieve sustainable farming often depended on their socio-economic characteristics, and particularly their capabilities for gaining additional off-farm income. Also, Weltin et al. (2017) explained that decision to diversify economic activities on or off the farm heavily depend on the agricultural business and household characteristics. They argue that off-farm diversification plays an important role for the persistence of small farms which need to look out for new business opportunities in other sectors of the rural economy (Weltin et al., 2017). It is evident that for this group agriculture is not the main activity and it is not certain that they will continue to work in agriculture and invest in the business related to the farm.

Cluster 3: Farms with mixed livestock and crop production and diversified income

Cluster 3 is the smallest and contains 18.9% farms from the sample (70 farms). The third group of farms differs from the two previously described, because the value of plant production is significantly higher (five to ten times). In this group, farms have more areas under orchards (cherries, plums) and a higher yield of vegetables. The farms from this group hire more seasonal labour than farms from the other clusters, mostly used for fruit production or as shepherds. Sheep production is significant for the farms in this cluster. Namely, sheep milk yield is higher than in the other groups, as well as the number of lambs sold per sheep. In addition, the farms from this cluster sell animal processed products, such as cow and sheep cheese. Regarding the farm specialization, it is important to note that these farms are more focused on the sale of fruit and vegetable products than animal products (*Fig. 4*).

On average, the households from this group have 4 members, out of which 28.86% are employed outside the farm. The most important income of the households from this group is from agriculture (60.0%), followed by salaries (31.4%). Given that all households in this group have diverse income sources, they are less dependent on subsidies compared to the farms in the first and second clusters (*Table 8*). Previous research also established a group of farms which diversified activities in order to improve income and reduce financial uncertainty (Riveiro et al., 2013; taken over by Rivas et al., 2015; Kuivanen et al., 2016). Also, Madry et al. (2010) pointed out that a group of farms with diverse activities had been identified as a group that could ensure

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economic stability in the long run. Farmers with diversified on farm activities and strong market linkages, are more capable to deal with external factors (Douxchamps et al., 2016).

Conclusion and policy implications

Serbia, as well as other Western Balkan countries is under the EU accession negotiation process which requires substantial reforms of its agricultural and rural policy concept to make it compatible with CAP. Nevertheless, efforts to formulate and execute an agri-environmental scheme, along with support for ANC, modeled after the CAP, have encountered only modest success, both due to unclear objectives and mechanisms of implementation. Considering that a high percentage of farms in Serbia are concentrated in ANCs and that these farms face many challenges due to climate change, demographic decline and geographical isolation, reforming and improving the effectiveness of policy towards ANC is one of the national priorities.

This research show that livelihood strategies of family farms in ANCs vary widely. Therefore, to properly address the complex and interrelated needs and challenges they face, and to develop effective policy solutions tailored to their characteristics, predominant types of farms are identified and characterized. Determination of typical farms and description of their features represents an initial system for formulation evidence-based policy.

This research shows that the use of multivariate statistical techniques can determine typical farms in mountain areas with natural constraints in Serbia. Instead of classical clustering method, we have applied two-step cluster analysis in quantitative approach to farm typology development and proved it's adequacy.

Results showed that farms in ANCs are highly diverse and have different survival strategies. While some of them are gradually disappearing, other are trying to improve their competitiveness. The research has produced three types of farms that mainly differ on the basis of farm specialization and the most important household income. The dominant farm type highly relies on the agricultural income generated from the sale of livestock products (manly cattle products). These farms have the potential for productivity growth, but yet they are highly dependent on direct payments, and to some extent they hardly survive without incentives. The second largest group of farms is more dependent on salaries from other sectors and pensions, rather than agricultural income. It represents smallholder farms that rely on their own workforce, and their income from agricultural surpluses is sporadic. Therefore, for them salaries provide a more stable income, while agriculture is mostly seen as a guarantee of food security. The third specific group includes farms with both off-farm and on-farm income. They mostly deal with small greenhouse production and leased seasonal labour force. This group of farms is located near to the consumer centers and large settlements, and their agricultural income is less dependent on agricultural support. Although it was expected that in Serbian mountain areas rural tourism is dominant farm survival strategy, results showed that tourism is not the primary source of farm's income and does not affect the attractiveness of rural landscape and preservation of environment.

Scientific contribution of the paper is both national (given that there are no research studies in this field) and universal because research findings enable overall understanding of farms in ANCs. Identification of farms characteristics and their livelihood strategies is an important finding for agricultural policy makers. Based on

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these results they could create agricultural and rural measures tailored to the specific needs of the determined farm types and design adequate policy mix (economic, social, environmental, and other policies).

The next step in research would include the construction of mathematical programming models based on the typical farms, which can be used to evaluate the impact of different policy solutions. Furthermore, the use of new technologies (GIS, etc.) can advance future studies on farm system typology.

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REFERENCES

[1] Alemu, A. W., Amiro, B. D., Bittman, S., MacDonald, D., Ominski, K. H. (2016): A typological characterization of Canadian beef cattle farms based on a producer survey. – Canadian Journal of Animal Science 96(2): 187-202.

[2] Bacher, J., Wenzig, K., Vogler, M. (2004): SPSS Two Step cluster – a first evaluation. – In: RC33 Sixth International Conference on Social Science Methodology: "Recent Developments and Applications in Social Research Methodology". Amsterdam, 16-20 August.

[3] Berger, T., Schreinemachers, P., Woelcke, J. (2006): Multi-agent simulation for the targeting of development policies in less-favored areas. – Agricultural Systems 88(1): 28-43.

[4] Bidogeza, J. C., Berentsen, P. B., De Graaff, J., Oude Lansink, A. G. J. M. (2009): A typology of farm households for the Umutara province in Rwanda. – Food Security 1: 321-335.

[5] Bogdanov, N. (2007): Small Rural Households in Serbia and Rural Non-farm Economy. – UNDP, Belgrade.

[6] Bogdanov, N. (2014): The development of support for less favoured areas and deprivileged regions: challenge of agricultural policy in Serbia. – In: EAAE Congress: "Agri-Food and Rural Innovations for Healthier Societies". Ljubljana, August 26-29.

[7] Bogdanov, N., Meredith, D., Efstratoglou, S. (2008): A typology of rural areas in Serbia. – Economic Annals 53(177): 7-29.

[8] Castel, J. M., Mena, Y., Delgado-Pertinez, M., Camunez, J., Basulto, J., Caravaca, F., Guzman Guerrero, J. L., Alcalde, M. J. (2003): Characterization of semi-extensive goat production systems in southern Spain. – Small Ruminant Research 47(2): 133-143.

[9] Costello, A., Osborne, J. (2005): Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. – Practical Assessment, Research & Evaluation 10(7): 2-9.

[10] Cots-Folch, R., Martínez-Casasnovas, J. A., Ramos, M. C. (2009): Agricultural trajectories in a Mediterranean mountain region (Priorat, ne Spain) as a consequence of vineyard conversion plans. – Land Degradation and Development 20: 1-13.

[11] Dax, T. (2005): The redefinition of rural Areas. – MPRA Paper No. 711, London.

[12] Douxchamps, S., Van Wijk, M. T., Silvestri, S., Moussa, A. S., Quiros, C., Ndour, N. Y. B., Buah, S., Somé, L., Herrero, M., Kristjanson, P., Ouedraogo, M., Thornton, P. K., Van Asten, P., Zougmore, R., Rufino, M. C. (2016): Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. – Reg Environ Change 16: 1305.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2202_10511073

[13] Emtage, N. (2004): An investigation of the social and economic factors affecting the development of small-scale forestry by rural households in Leyte Province, Philippines: A typology of rural households in relation to small-scale forestry. – Doctoral Dissertation. School of Natural and Rural Systems Management, University of Queensland, Australia.
[14] Escobar, G., Berdegué, J. (1990): Tipificación de sistemas de producción agrícola. – Centro Latinoamericano para el Desarrollo Rural (RIMISP), Santiago, CL.
[15] European Commission (2005): Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). – Official Journal of the European Union 277: 1-38.
[16] Field, A. (2009): Discovering Statistics Using SPSS. – SAGE Publications Ltd, London.
[17] Goswami, G., Chatterjee, S., Prasad, B. (2014): Farm types and their economic characterization in complex agro-ecosystems for informed extension intervention: study from coastal West Bengal, India. – Agricultural and Food Economics 2: 2-24.
[18] Graskemper, V., Yu, X., Feil, J-H. (2021): Farmer typology and implications for policy design – An unsupervised machine learning approach. – Land Use Policy 103(2): 1-10.
[19] Hair, J. F., Black, W. C., Babin, B. J., Anderson, J. E. (2014): Multivariate data analysis. – Harlow: Pearson Education Limited.
[20] Harantová, V., Mazanec, J., Štefancová, V., Mašek, J., Foltýnová, H. B. (2023): Two-Step Cluster Analysis of Passenger Mobility Segmentation during the COVID-19 Pandemic. – Mathematics 11(3): 1-17.
[21] Institute for European Environmental Policy – IEEP (2006): An evaluation of the less favoured area measure in the 25 Member States of the European Union. – Brussels, Belgium.
[22] Iraizoz, B., Gorton, M., Davidova, S. (2007): Segmenting farms for analysing agricultural trajectories: a case study of the Navarra region in Spain. – Agricultural Systems 93(1-3): 143-169.
[23] Janeska-Stamnekovska, I. (2015): Model na povekekriteriumska optimizacija pri donesuvanje odluki na zemljodelskite stopanstva vo Republika Makednija. – Doctoral dissertation. University “St. Cyril and Methodius, Faculty of Agricultural Sciences and Food, North Macedonia.
[24] Kansiime, M., Van Asten, P., Sneyers, K. (2018): Farm diversity and resource use efficiency: Targeting agricultural policy interventions in East Africa farming systems. – NJAS: Wageningen Journal of Life Sciences 85(1): 32-41.
[25] Kaouche-Adjlane, S., Ghozlane, F., Mati, A. (2015): Typology of dairy farming systems in the Mediterranean basin (case of Algeria). – Biotechnology in animal husbandry 31(3): 385-396.
[26] Kass, R. A., Tinsley, H. E. A. (1979): Factor analysis. – Journal of Leisure Research 11: 120-138.
[27] Keča, L. J., Marčeta, M., Posavec, S., Jelić, S., Pezdevšek–Malovrh, Š. (2017): Market characteristics and cluster analysis of non-wood forest products. – Šumarski list 141(3-4): 151-162.
[28] Köbrich, C., Rehman, T., Khan, M. A. (2003): Typification of farming systems for constructing representative farm models: Two illustrations of the application of multi-variate analyses in Chile and Pakistan. – Agr Syst 76(1): 141-157.
[29] Kotevska, A., Bogdanov, N., Nikolić, A., Dimitrievski, D., Martinovska Stojcheska, A., Tuna, E., Milić, T., Simonovska, A., Papić, R., Petrović, L., Uzunović, M., Bećirović, E., Anđelković, B., Gjoshevski, D., Georgiev, N. (2015): The impact of socio-economic structure of rural population on success of rural development policy. – Association of Agricultural Economists of the Republic of Macedonia (AAEM).
[30] Kuivanen, K. S., Alvarez, S., Michalscheck, M., AdjeI-Nsiah, S., Descheemaeker, K., Mellon-Bedi, S., Groot, J. C. J. (2016): Characterizing the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2202_10511073

the Northern Region, Ghana. – NJAS - Wageningen Journal of Life Sciences 78: 153-166.
[31] Kumar, S., Craufurd, P., Haileslassie, A., Ramilan, T., Rathore, A., Whitbread, A. (2019): Farm typology analysis and technology assessment: An application in an arid region of South Asia. – Land Use Policy 88(2): 1-14.
[32] Lohr, S. L. (2010): Sampling: design and analyses. – Brooks/Code, Cengage Learning, Boston.
[33] Mądry, W., Gozdowski, D., Roszkowska-Mądra, B., Dąbrowski, M., Lupa, W. (2010): Diversity and typology of farms according to farming system: a case study for a dairy region of Podlasie province, Poland. – Electronic Journal of Polish Agricultural Universities: EJPAU 13(2).
[34] Madry, W., Mena, Y., Roszkowska-Madra, B., Gozdowski, D., Hryniewski, R., Castel, M. (2013): An overview of farming system typology methodologies and its use in the study of pasturebased farming system: a review. – Spanish Journal of Agricultural Research 11(2): 316-326.
[35] Maletić, R., Bucalo-Jelić, D. (2016): Definisanje homogenih užih područja Republike Srbije. – Agroekonomika 45(69): 13-24.
[36] Mohamed, N., Awang, S. R. (2015): The multiple intelligence classification of management graduates using Two-step cluster analysis. – Malaysian Journal of Fundamental and Applied Sciences 11(1): 48-51.
[37] Mutyasira, V. (2020): Prospects of sustainable intensification of smallholder farming systems: A farmer typology approach. – African Journal of Science, Technology, Innovation and Development 12(6): 1-8.
[38] Nelson, K. (2014): Student motivational profiles in an introductory MIS course: An exploratory cluster analysis. – Research in Higher Education Journal 24: 1-14.
[39] Nunnally, J. C. (1978): Psychometric theory. – New York: McGraw-Hill.
[40] Ortyl, B., Kasprzyk, I. (2022): Land abandonment and restoration in the Polish Carpathians after accession to the European Union. – Environmental Science and Policy 132: 160-170.
[41] Papić, R. (2021): Politika ruralnog razvoja prema područjima sa prirodnim ograničenjima – efekti na porodična gazdinstva i ruralne sredine u Republici Srbiji. – Doctoral dissertation. University of Belgrade, Faculty of Agriculture, Serbia.
[42] Papić, R. (2022): Rural development policy on areas with natural constraints in the Republic of Serbia. – Economics of Agriculture 69(1): 75-89.
[43] Papić, R., Bogdanov, N. (2015): Rural Development policy - A perspective of local actors in Serbia. – Economics of Agriculture 62(4): 1079-1093.
[44] Papić, R., Bogdanov, N. (2021): Attitudes of farmers from the areas with natural constraints toward agricultural and rural development support. – AGROFOR International Journal 6(3): 94-102.
[45] Pienaar, P. L. (2013): Typology of Smallholder Farming in South Africa's Former Homelands: Towards an Appropriate Classification System. – Master's thesis. Faculty of Agri Sciences at Stellenbosch University. South Africa.
[46] Pienaar, L., Traub, L. N. (2015): Understanding the smallholder farmer in South Africa: Towards a sustainable livelihood's classification. – In: International conference of Agricultural Economist: "Agriculture in interconnected world", Milan, 8-14 August.
[47] Rivas, J., Perea, J., Angón, E., Barba, C., Morantes, M., Dios Palomares, R., García, A. (2015): Diversity in the dry land mixed system and viability of dairy sheep farming. – Italian Journal of Animal Science 14(2): 179-186.
[48] Riveiro, J. A., Mantecón, A., Álvarez, C. J., Lavín, P. (2013): A typological characterization of dairy Assaf breed sheep farms at NW of Spain based on structural factor. – Agr. Syst. 120: 27-37.
[49] Robles, R., Vannini, L., Nistal, R. V. (2005): Typification of dairy farms according to criteria of a socio-economic nature: an illustration in "El Páramo" of Leon (Spain). – In:

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2202_10511073

XIth EAAE Congress: “The Future of Rural Europe in the Global Agri-Food System”. Copenhagen, 24-27 August.
[50] Rozakis, S., Alexandrs, S., Kostas, T. (2012): Estimating utility functions of Greek dairy sheep farmers: A multicriteria mathematical programming approach. – Agricultural Economics Review 13(1): 111-120.
[51] Ruben, R., Pender, J. (2004): Rural diversity and heterogeneity in less favoured areas: the quest for policy targeting. – Food Policy 29(4): 303-320.
[52] Schiopu, D. (2010): Applying Two Step Cluster Analysis for Identifying Bank Customers’ Profile. – Buletinul 62(3): 66-75.
[53] Serrano Martínez, E., Cerdeño Sánchez, A. I., Vieira Aller, C., Ruiz Mantecón, A. (2006): Cattle farm evolution in disadvantaged mountainous areas of North-Western Spain. – New Medit 5: 32-39.
[54] Shrestha, S., Hennessy, T., Hynes, S. (2007): The effect of decoupling on farming in Ireland: A regional analysis. – Irish Journal of Agricultural and Food Research 46: 1.
[55] Sinha, A., Basu, D., Priyadarshi, P., Ghosh, A., Sohane, R. K. (2022): Farm Typology for Targeting Extension Interventions Among Smallholders in Tribal Villages in Jharkhand State of India. – Frontiers in Environmental Science 10: 1-18.
[56] Sklenicka, P., Kottová, B., Šálek, M. (2017): Success in preserving historic rural landscapes under various policy measures: Incentives, restrictions, or planning? – Environmental Science and Policy 75: 1-9.
[57] SPSS (2001): The SPSS Two Step cluster component - technical report. – IBM SPSS Statistics, pp. 2-9.
[58] Statistical Office of the Republic of Serbia (2012): Census of agriculture database. – Available online: https://popispoljoprivrede.stat.rs/ (Accessed 20/07/20).
[59] Statistical Office of the Republic of Serbia (2012a): Census of agriculture database. – Internal data.
[60] Tabachnick, B. G., Fidell, L. S. (2007): Using multivariate statistics (5th ed.). – Allyn and Bacon, Inc., Boston,
[61] The Government of the Republic of Serbia (2016): Regulation on Areas with difficult working conditions in agriculture. – Official Gazette of RS, No. 39/16.
[62] The Government of the Republic of Serbia (2018): Regulation on Areas with difficult working conditions in agriculture. – Official Gazette of RS 102/18.
[63] Trpkova, M., Tevdovski, D. (2009): Twostep cluster analysis: Segmentation of largest companies in Macedonia. – In: Kovács, P., Szep, K., Katona, T. (eds.) Challenges for analysis of the economy, the businesses, and social progress. Szeged: Universitas Szeged Press, pp. 302-20.
[64] Van der Poleg, J. D., Lauerat, C., Blondeau, F., Bonnafous, F. (2009): Farm diversity, classification schemes and multifunctionality. – Journal of Environmental Management 90(2): 124-131.
[65] Vasić, V., Banićević, D., Vojvodičan, N. (2008): Algoritam dvostepene klaster analize u identifikaciji grupa klijenata banke. – In: XIV naučno-stručna konferencija YU INFO, Kopaonik, pp. 6.
[66] Weltin, M., Zasada, I., Franke, C., Piorr, M., Raggi Viaggi, D. (2017): Analysing behavioural differences of farm households: An example of income diversification strategies based on European farm survey data. – Land Use Policy 62: 172.
[67] Wilkus, E., Roxburgh, C., Rodriguez, D. (2019): Understanding household diversity in rural Eastern and Southern Africa. – Australian Centre for International Agricultural Research, Canberra, pp. 184.
[68] Yilma, T. (2005): Modeling farm irrigation decisions under rainfall risk in the White-Volta Basin of Ghana: A tool for policy analysis at the farm-household level. – Doctoral dissertation. Faculty of Agriculture, University of Bonn.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2202_10511073