DEMOGRAPHIC CHANGE, LAND USE AND LIVESTOCK DYNAMICS: TRADITIONAL FOOD PRODUCTS AS A CHANCE FOR RURAL DEVELOPMENT IN THE MUNICIPALITY OF PIROT

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ABSTRACT

Rural development in the Municipality of Pirot, Serbia, is influenced by demographic decline, land-use changes, and livestock reductions, all of which are closely tied to the production of traditional foods. Drawing on census data (1991-2022), official statistics, and field research, the study highlights a 26.7% population decline and pronounced aging, threatening agricultural sustainability. Although livestock numbers and milk production have decreased, traditional products: Pirot Kachkaval, Peglana Sausage, and Vurda retain vital economic and cultural roles. Branding and geographical indications would strengthen local competitiveness and present viable strategies for rural revitalization. CORINE Land Cover data reflect deagrarization through reduced pasture and arable land, alongside other climatic and anthropogenic influences. These combined dynamics underscore both the vulnerability and lasting potential of Pirot's rural areas. Traditional knowledge, product identity, and environmental adaptation are crucial to long-term sustainability.

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Introduction

Globally, agriculture remains a cornerstone of food security, rural livelihoods, and sustainable development, contributing to the Sustainable Development Goals related to hunger, climate, and biodiversity (FAO, 2023). In the Balkans, it sustains traditional landscapes and regional economies, while in Serbia, it supports GDP, rural employment, and cultural identity through authentic products that strengthen competitiveness (Nikolić et al., 2017). The Municipality of Pirot, located on the slopes of Stara Planina, combines rich natural resources with a strong livestock heritage 63,194 ha of the Stara Planina Nature Park's total area of 142,219 ha (Stankov et al., 2011). European and national frameworks emphasise ecological networks and biodiversity protection (Dobričić et al., 2017; Convention on Biological Diversity, 2018), while Pirot has demonstrated how protected landscapes have enhanced forage quality and the authenticity of traditional dairy products such as Pirot Kachkaval (Tomić et al., 2011). Livestock farming and indigenous breeds like Pirot Pramenka have underpinned PDO (Protected Designation of Origin)-protected products such as Pirot Kachkaval and Pirot Peglana Sausage (Ružić-Mušlić et al., 2011; Tasić et al., 2019; Grujović et al., 2024; Intellectual Property Office of the Republic of Serbia, n.d.-a; n.d.-b), supported by the Dairy School "Dr Obren Pejić", which produced 127.76 tons of cheese in 2024 (Dairy School "Dr Obren Pejić", 2025). Yet depopulation, ageing, and limited market visibility have weakened rural capacity (Marković et al., 2025; Užar, 2022).

In addition to alarming demographic trends, deagrarization has become clearly visible in the field, where many pastures have now been dominated by thorny shrubs and dense, inaccessible vegetation. Strengthening geographical branding can therefore enhance product value, cultural identity, and sustainable rural development by linking traditional practices, natural resources, and branding to regional competitiveness (Radivojević et al., 2024; Albaladejo-García et al., 2024; Babović et al., 2016). This study investigates the relationship between demographic change, land-use dynamics, and livestock farming in the Municipality of Pirot by integrating CORINE Land Cover analysis with official demographic and livestock statistics to assess implications for traditional food production and rural development. This approach links these processes at the municipal level, which has been largely overlooked in previous studies.

Materials and methods

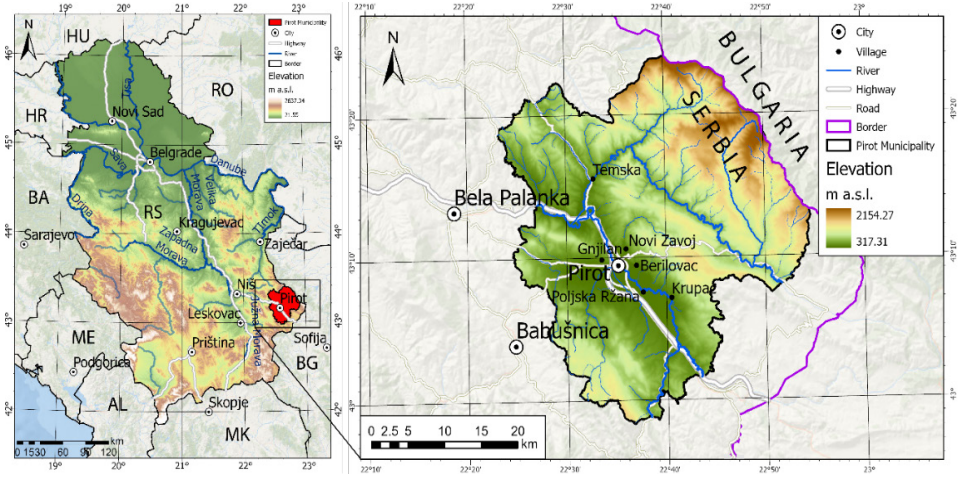
Study Area

The study area encompasses the Municipality of Pirot, located in southeastern Serbia along the Bulgarian border, covering 1,232 km² as the administrative, economic, and demographic core of the Pirot District (2,761 km²). The terrain ranges from 250 m a.s.l. in the valleys to 2,169 m a.s.l. at Midžor Peak on Stara Planina. The study area abounds in pronounced geomorphological diversity: valleys, basins, and ridges, which shape settlement and land use. The Nišava Valley, running southeast-northwest, forms the main settlement axis (Ivković & Todorić, 2013). The entire area falls within the

Carpathian-Balkan mesoregion, which is part of the Mountain-basin-valley macro-region of Serbia (Pavlović, 2019). Geological diversity provided the basis for the formation of different pedological types. There are pedological formations such as mountain soils, vertisol, smonica, and on the lower terrain, deposits of alluvial sediments. Most soils are characterised by a developed pedological structure and belong to the second and third soil quality classes. The continental climate with mountain influences creates ecological gradients that affect agriculture. Depopulation and labour shortages, coupled with rising temperatures, irregular precipitation, and summer aridity, lead to deagrarization, farmland abandonment and threaten rural sustainability (Martić Bursać et al., 2024; Manojlović et al., 2018). The Stara Planina Nature Park integrates biodiversity protection with traditional landscapes and supports ecotourism as a sustainable development model (Stankov et al., 2011; Cvetković et al., 2023).

Demographically, Pirot faces long-term population decline and ageing, driven by emigration and low fertility. This resulted in land abandonment and urban concentration (Petrović et al., 2024; Malinić et al., 2025). The municipality includes 72 rural settlements, where lowland villages such as Gnjilan, Berilovac, Krupac, and Poljska Ržana, with over 1,000 residents in 2022, exhibit relative resilience and agricultural vitality. In contrast, upland communities like Temska, Dojkinci, and Gostuša experience severe depopulation and farmland loss (Census, 1948-2022; City Population, 2022; EU PRO Plus, 2024; Marković et al., 2025). Between 1991 and 2022, Pirot's population fell from 67,658 to 49,601 (-26.7%), aligning with an average 28% decline across Serbia's border municipalities (Malinić et al., 2025). This contrast between productive lowlands and declining mountain zones encapsulates Pirot's spatial duality and illustrates the intertwined demographic, climatic, and agrarian challenges defining the region's development trajectory.

Figure 1. Geographical position of the Municipality of Pirot



Source: Authors'

Demographic, Land Use and Agricultural Data Gathering

Demographic data were obtained from the population censuses of 1948, 1953, 1961, 1971, 1981, 1991, 2002, 2011, and 2022, conducted by the Statistical Office of the Republic of Serbia. These datasets provide comprehensive information on population size, age structure, migration trends, and settlement distribution. In addition to descriptive statistics, the average age of the population was determined using the weighted mean formula:

where *Ni* is the number of inhabitants in each age group and *Mi* is the midpoint of the corresponding age interval (Shryock & Siegel, 1980; Siegel & Swanson, 2004). This approach enabled a precise assessment of demographic ageing across both lowland and highland areas of the municipality.

Agricultural data were drawn from national agricultural censuses (1960, 1980, 2012, 2023), statistical yearbooks, and municipal datasets documenting land use, livestock, and production structures. These sources enabled the identification of long-term trends in farmland abandonment and herd reduction. Demographic and agricultural indicators were correlated to examine the links between population decline, land-use change, and rural transformation.

Spatial patterns were analysed using ArcGIS Pro 2.5.0 and CORINE Land Cover (2006, 2012 and 2018) data, mapping settlement distribution, agricultural zones, and reforestation. Local dairy data from the Dairy School "Dr Obren Pejić" in Pirot supported the assessment of milk inflow and PDO-labelled Pirot Kachkaval, compared with traditional European cheeses to illustrate its broader significance.

The methodological framework follows EU CAP principles of sustainable rural development, indigenous breed protection, and valorisation of local products, integrating demographic, agricultural, spatial, and dairy-sector analyses to interpret rural sustainability in the Pirot region.

Results

This section presents the results of demographic, land-use, and agricultural analyses in Pirot, focusing on population trends, changes in land-use, livestock dynamics and dairy production. Special attention is given to rural depopulation, population ageing, and herd reduction, as well as their impacts on traditional products such as Pirot Kachkaval, Vurda, and Peglana Sausage.

Demographic Changes

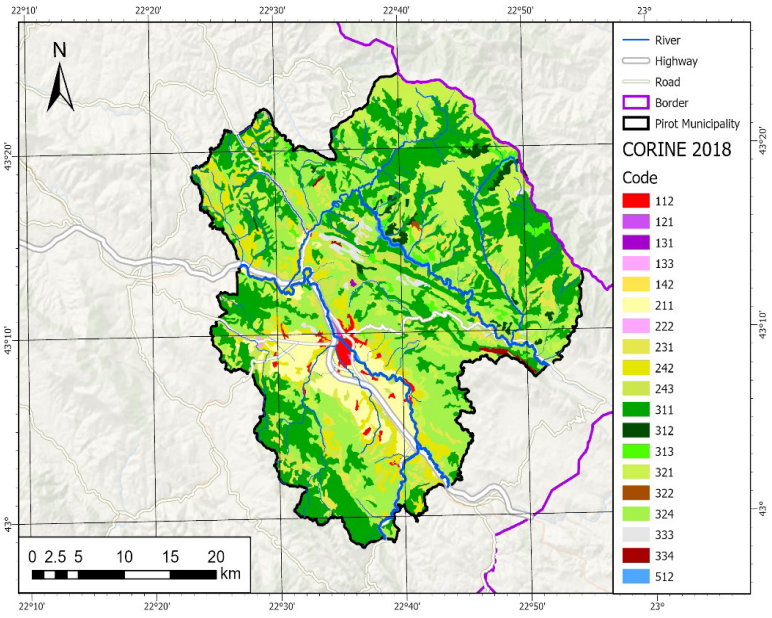
The long-term process of depopulation in Southeastern Serbia is particularly evident in the Pirot District, where census data indicate a continuous population decline across all municipalities (Table 1).

Land use change based on CORINE data and the number of livestock changes

Land use and livestock patterns in the Pirot District and the Municipality of Pirot have changed in recent decades. Agricultural land, including arable fields and pastures, shows a decline, while livestock numbers have decreased across all major categories, largely associated with depopulation, rural abandonment, and structural changes in the local economy. In particular, livestock numbers declined sharply in sheep and cattle herds.

The following tables present the key trends in land use categories and livestock numbers, showing the direction and magnitude of these changes. To provide a spatial perspective, CORINE Land Cover (2018) data were analysed for the Municipality of Pirot. These data show the distribution of forests, arable land, and pastures across lowland and upland zones, enabling visualization of how demographic decline and agricultural contraction have reshaped the local landscape.

Figure 4. Land use of the Municipality of Pirot based on CORINE Land Cover (CLC) data, 2018.



Source: Authors' elaboration based on CORINE Land Cover data (EEA, 2018).

CORINE Land Cover (2018) shows the spatial distribution of land use categories in the Municipality of Pirot (Figure 4). Forest areas are predominantly located in the mountainous parts of Stara Planina, while arable land and pastures are mainly concentrated in the Nišava Valley and in the vicinity of the town of Pirot. Differences in land-use composition are observed between lowland and upland settlements.

Table 4. Land cover changes in the Municipality of Pirot, 2006, 2012 and 2018 (ha)

Land cover class	2006 (ha)	2012 (ha)	2018 (ha)	Change 2006-2018 (ha)
112 Urban areas	1,348.2	1,499	1,522.9	174.7
211 Arable land	8,262.7	8,237.3	8,237.3	-25.4
231 Pastures	8,870.2	8,584.6	8,579.4	-290.8
242 Complex cultivation	8,440.6	8,747.5	8,693.1	252.5
311 Broad-leaved forest	39,528.8	39,333	39,255.9	-273
312 Coniferous forest	1,297.9	1,423.8	1,423.8	125.9
313 Mixed forest	1,646.3	1,733.3	1,733.3	87
321 Natural grasslands	15,731.9	16,008.3	16,003.1	271.2
324 Transitional woodland–shrub	31,642.6	31,021.0	31,029.3	-613.3
334 Burnt areas	0	231.6	295.9	295.9

Source: Authors' calculation based on CORINE Land Cover (EEA, 2018).

Table 4 shows that between 2006 and 2018, urban areas in the Municipality of Pirot increased slightly (+174.7 ha), while arable land (-25.4 ha) and pastures (-290.8 ha) declined. Complex cultivation mosaics expanded (+252.5 ha), whereas broad-leaved forests decreased (-273.0 ha). Natural grasslands expanded for 271.2 ha, while burnt areas also increased by 295.9 ha. The largest decrease was observed in Transitional woodland–shrub, which fell by 613.3 ha.

In 1955, sheep numbers in the Pirot District exceeded 270,000 head (the exact number is 272,309), while the number in 1960 was 268,865 head (Belić et al., 1960; Stevanović et al., 2016a). During the same period, cattle herds numbered 32,062 in 1937 and 41,662 head in 1960. Horse numbers decreased from 7,578 head in 1937 to 6,359 head in 1960. Pig production fluctuated over time, reaching 16,031 head in 1937 and 20,842 head in 1958. Poultry numbers amounted to 172,620 heads in 1937 and 209,539 heads in 1960.

According to official data from 2023, the total number of sheep in the Municipality of Pirot amounted to 11,216 heads. Horse numbers totalled 156 head. In addition, the livestock structure included 4,009 head of cattle, 7,798 pigs, and 46,303 poultry. Similar declining trends were recorded across other livestock categories. Beekeeping was the only agricultural sector that exhibited stagnation during the observed period (Radivojević et al., 2024).

Milk intake and dairy production in the Municipality of Pirot were analysed for the period 2019-2024. Average daily cow's milk intake decreased from 4,651.71 l in 2019 to 4,228.72 l in 2024. The largest monthly decreases were recorded in January (-15%) and May (-14%), with a total 2024/2023 production index of 94.56.

Between 2021 and 2024, cow's milk production decreased by 3.6%, while goat's milk production decreased by 21.8% and sheep's milk production decreased by 38.1%. Changes were also recorded in the structure of dairy products. Fresh cheese production

increased by more than 35%, while yoghurt and pasteurized milk decreased by 6-9%. Kachkaval and Pirot Kachkaval decreased by -4 to -7%. Organic dairy products decreased by more than 60%.

Discussion

Demography

Demographic trends in the Municipality of Pirot indicate a long-term and spatially differentiated process of depopulation, particularly pronounced in rural areas. Between 1991 and 2022, the Pirot District lost more than one third of its population, while the Municipality of Pirot recorded a decline of 26.7% (Census, 2002, 2011, 2022). During the same period, the average age increased from 39 to 46.4 years, reflecting strong population ageing driven by low fertility rates and sustained out-migration of younger cohorts (Jelić et al., 2019).

Despite this overall negative trend, clear contrasts exist between lowland and highland settlements. Lowland villages such as Gnjilan, Krupac, and Poljska Ržana have remained relatively resilient due to fertile soils, favorable agricultural conditions, and good accessibility within the Nišava Valley (Cartwright & Drobnjaković, 2021; EU PRO Plus, 2024). Gnjilan recorded 2,478 inhabitants in 2002, 2,520 in 2011, and 2,199 in 2022, while Poljska Ržana declined from 1,349 in 2002 to 1,181 in 2022 (Census, 2002, 2011, 2022; City Population, 2022). In contrast, highland settlements have experienced severe population losses. Temska declined from 3,745 inhabitants in 1931 to 908 in 2002 and fewer than 450 in 2022, illustrating a long-term depopulation trajectory (Cartwright & Drobnjaković, 2021; Leščešen et al., 2013; Stojsavljević et al., 2015; EU PRO Plus, 2024).

The Visok microregion, predominantly located within the Municipality of Pirot, represents an extreme case of rural depopulation. Across its 22 villages, the population decreased from 14,706 in 1948 to only 504 inhabitants in 2022, with an average age of 66.44 years, indicating an advanced stage of demographic collapse driven by long-term out-migration, ageing in place, and the decline of local economic functions (Marković et al., 2024; 2025).

These strong spatial disparities are also reflected in land-use patterns. CORINE Land Cover data show that arable land, dominant in lowland areas, declined by only 25.4 ha, while pasture areas, characteristic of highland zones, decreased by as much as 290.8 ha. This correspondence between demographic decline and land-use change confirms asymmetric rural development and highlights the need for territorially differentiated, place-based approaches that integrate demographic and land-use policies to support sustainable development across the entire region (Statistical Office of the Republic of Serbia, 2022).

Land Use Changes

Land use in the Municipality of Pirot closely reflects long-term demographic decline, but also major changes due to forest fires. Census and CORINE Land Cover data indicate that farmland abandonment follows rural depopulation, particularly in the villages of Stara Planina. Between 2006 and 2018, pasture areas decreased by nearly 300 ha, while arable land declined by approximately 25 ha in the Municipality of Pirot (Malinić et al., 2025). It is clearly visible in Table 4 that shrublands decreased the most. This result was obtained due to the vast mountain fire in 2007, when about 2,500 ha of the total area was caught by fire (Živanović & Gocić, 2023). Due to ongoing forestry activities, forest fires and complex climatic changes, the structure of forest cover is gradually changing, with a declining share of deciduous forests.

Traditionally based on sheep farming and the floristic diversity of Stara Planina pastures, the rural economy has weakened as a result of declining livestock numbers, particularly sheep, which threatens the production of traditional products such as Pirot Kachkaval, Peglana Sausage, and Vurda (Belić et al., 1960; Tomić et al., 2005, 2009, 2011). These trends demonstrate that sustainable land management in southeastern Serbia is closely tied to demographic, particularly in the context of agriculture and the cultural landscape.

Livestock dynamics

Historical livestock data indicate that sheep played a dominant role in the agricultural structure of the Pirot District and Municipality of Pirot (Stevanović et al., 2016a). The predominance of sheep, particularly breeding ewes in the past, reflects the region's long-standing pastoral orientation and represents the historical foundation of its dairy production. Today, the existence of sheep breeding, as well as the Pirot Pramenka breed, is seriously threatened, and substantial reforms are necessary to ensure the survival of sheep farming on Stara Planina.

The occurrence of wild horses, most likely abandoned as a consequence of pronounced depopulation, illustrates the near disappearance of horse breeding on Stara Planina. A comparable decline can be observed across almost all other segments of livestock farming.

The analyses of milk intake and dairy production in the Municipality of Pirot for the period 2019-2024 indicate a gradual decline associated with demographic ageing, climatic variability, and reduced livestock numbers. Overall, the results point to a contraction of the regional milk base. At the same time, traditional cheeses have shown relative resilience, retaining strong market relevance and cultural value, and continue to play an important role in rural sustainability in the Pirot region. Decline in cattle heads definitely endangers future production.

Products and Branding

Based on available natural resources, the area demonstrates potential for the development of diversified agricultural production. However, demographic potential and the existing economic environment represent the main limiting factors for further

development. The long-term prospects for the survival and revitalization of the region are primarily associated with the production of traditional products with geographical indication and the strengthening of the tourism sector. The integration of tourism with sustainable agriculture practices may contribute to a more balanced development model alongside the municipality's established industrial base, led by the Tigar Tire Factory, with potential positive effects on both demographic and economic trends in the Municipality of Pirot. Within this framework, analytical attention is directed toward products that emerged under specific environmental and socio-economic conditions and are produced using traditional methods, including Pirot Kachkaval, Peglana Sausage, and Vurda.

Brief History, Specificity and Significance of Pirot Kachkaval

Pirot Kachkaval, one of Serbia's most renowned traditional cheeses, has been produced for over a century and recognized beyond the Balkans. Rooted in ancient Hellenic, Roman, and monastic cheesemaking traditions, it likely reached the Balkans with Sephardic Jews in the 16th century and spread during the Ottoman period as kaşar, with parallels in Greece (kaseri) and Italy (caciocavallo). Its production was introduced to Stara Planina in the 19th century by Cincar shepherds from Epirus, becoming part of the local pastoral economy (Lazarević, 2021). By 1889, it earned acclaim at the Paris World Exhibition and was exported across the Mediterranean and to the U.S. (Belić et al., 1960). The cheese's distinctiveness lies in the pasta filata process and the mountain flora that shapes its aroma and durability (Satrić et al., 2023). Pirot Kachkaval is protected under the national geographical indication system of the Republic of Serbia, with the current product specification allowing production from cow's milk, although it was traditionally made from sheep's milk (Lazarević, 2021). This remains a cultural and economic emblem of southeastern Serbia, comparable to Parmigiano Reggiano, Manchego, and Roquefort in Europe's cheese heritage.

Peglana Sausage – Branding of a Traditional Meat Product

Pirot *Peglana* sausage is a traditional meat product of Eastern Serbia, closely associated with the Pirot region. It is neither smoked nor treated with additives but is manually pressed during the ripening process, which results in a specific texture and extended shelf life (Tasić et al., 2019). Nutritional analyses indicate a high protein and fat content, a predominance of saturated fatty acids, and the absence of nitrites, contributing to product safety and quality (Tasić & Pavlović, 2023). The product is protected under the national geographical indication system of the Republic of Serbia, which establishes its legal association with the local area and production specifications (Stevanović et al., 2016b). Beyond its physical and nutritional characteristics, *Peglana* sausage reflects regional food heritage and illustrates how traditional production methods and specific environmental conditions can contribute to value creation, tourism potential, and the preservation of cultural heritage.

Vurda – Traditional Soft Cheese and Regional Branding

Pirot Vurda is a traditional dairy product of southeastern Serbia, obtained through the natural draining of sheep's, cow's, or mixed milk, resulting in a soft, mildly acidic spread. Since 2023, Lužnica Vurda has held PGI protection and its products are made from Simmental milk in the Lužnica Valley under defined technological parameters, including fat content, salt concentration, and pH, with a seven-day ripening period at 20–30 °C (ZIS, 2023). Beyond its sensory quality, it symbolises authenticity and local identity, supporting rural branding and tourism (Urošević et al., 2018). Together with Pirot Kachkaval and white cheese, Vurda reflects the environmental conditions and pasture-based livestock systems of the Stara Planina area (Tomić et al., 2011; Ružić-Mušlić et al., 2011). The Dairy School "Dr Obren Pejić" continues to preserve these traditions and support geographical-indication protection, contributing to the long-term cultural and economic sustainability of the region (Stojsavljević et al., 2015; Albaladejo-García et al., 2024).

Comparative Analysis of Pirot Kachkaval and Selected World Cheeses

Pirot Kachkaval, a traditional sheep's milk *pasta filata* cheese, from southeastern Serbia, is produced by manual curd stretching and ripened for approximately 60 days, which results in a firm texture and mildly acidic flavour (Satrić et al., 2023). From a technological perspective, it shows similarities to Italian Caciocavallo but retains a distinct regional identity shaped by Stara Planina's pastures and microclimate (United States Department of Agriculture [USDA], 1978). When compared with long-aged European cheeses such as Parmigiano Reggiano and Grana Padano (9-36 months) or PDO-protected varieties like Manchego, Feta, and Roquefort, Pirot Kachkaval, with partial PDO status for cow's milk, stands out for its authenticity and cultural significance (FAO, 2013; Chandan, 2014; Fox et al., 2017; Tridge, 2025). Despite its shorter ripening, it remains a key emblem of Serbian pastoral and gastronomic heritage, aligned with Europe's tradition of geographically protected artisanal cheeses.

Conclusions

This study confirms that the Municipality of Pirot, despite severe demographic decline and pressures on land use, retains notable resilience rooted in natural resources, cultural heritage, and traditional production. Analyses of demographic and CORINE data clearly reveal structural weaknesses, particularly in mountain settlements, where the level of depopulation is so high that revitalization will not be possible without strong, targeted measures.

Practical recommendations for sustainable development should focus on an integrated approach:

1. Tourism and gastronomy can link rural food production with tourism potential and stimulate demographic and economic recovery. For example, mountain villages could become centres for gastronomic and eco-tourism, including tastings of

traditional products such as Pirot Kachkaval, Peglana Sausage, and Vurda. Abandoned buildings could be adapted into hubs for digital nomads or small tourist accommodations, thereby stimulating the local economy and reviving settlement.

2. Village specialisation, given the different capacities of lowland and mountain settlements, individual villages could develop specialised roles:

- Tourist-gastronomic (e.g., tasting centres, traditional craft workshops),
- Rural-agricultural and livestock (maintaining and valorising indigenous breeds and traditional products),
- Multifunctional, combining accommodation, tourism, and local production.

3. Support through subsidies and institutional measures - development potential can be significantly enhanced via national and European subsidies, including financial assistance for livestock preservation, modernisation of processing facilities, certification of geographically indicated products, and support for agrotourism projects.

4. Realistic approach to repopulation - given the extreme depopulation of higher-altitude villages, the goal should not be mass return, but gradual creation of sustainable, multifunctional communities. Selective attraction of young families, entrepreneurs, and professionals (e.g., digital nomads, agro-tourism operators) combined with economic opportunities, infrastructure, and local services will foster incremental revitalisation rather than an unrealistic demographic turnaround.

In conclusion, sustainable development in the Municipality of Pirot depends on a combination of demographic renewal, responsible land management, and strategic valorisation of traditional products, with a particular emphasis on tourism and gastronomy as key drivers of revitalisation and socio-economic resilience in mountain communities. A realistic, phased approach that focuses on creating viable, specialised communities is essential for long-term success.

The findings of this study should be interpreted in light of certain limitations. The analysis is based on a single case study at the municipal level and relies primarily on aggregated demographic, land-use, and agricultural statistics, which may limit the ability to capture finer-scale socio-economic processes. CORINE Land Cover data for the Pirot Municipality are limited by their 25 ha minimum mapping unit, generalization of complex landscapes, 6-year update intervals, difficulty capturing small or steep areas, and potential misclassification of transitional vegetation and post-fire sites.

Future research could build on these findings by expanding the spatial scope of analysis to include comparative studies of other rural and mountain municipalities, as well as by integrating more detailed farm-level and qualitative data. Such approaches would contribute to a deeper understanding of local development dynamics and provide a stronger basis for designing targeted rural development policies.

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Conflict of interest

The authors declare no conflict of interest.

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