

Babeş-Bolyai University Cluj-Napoca

Faculty of Geography

Doctoral School of Geography

Summary of the PhD Thesis

**DYNAMICS OF SPATIAL AXES FOR SUSTAINABLE
ECONOMIC DEVELOPMENT - MUREŞ COUNTY**

Keywords: geographical axes, territorial cohesion, territorial dynamics, territorial disparities,
spatial organization

PhD supervisor

Prof. univ. dr. habil. Călin-Cornel POP

PhD Candidate

Teodora SOMEŞAN

CLUJ-NAPOCA

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INTRODUCTION

The evolution of territorial knowledge has been closely linked to the development of forms of human thought and action. Consequently, a transition can be observed from the empirical description of spatial phenomena and the adaptive response to existing realities, towards a more complex approach to organization and planning, grounded in the interpretation of territorial relations and the configuration of spatial structures. This shift in the way space is conceptualized has generated structural transformations of the environment and has led to a progressive increase in the impact of human activities. The intensification of this impact, alongside the expansion of human capacity to intervene in spatial structures, has produced imbalances and vulnerabilities with cumulative effects. Identified as potential threats or systemic risk factors, these dysfunctions have required a reorientation of practices aimed at limiting harmful interventions. Within this framework, the need to ensure a balance between transformation processes and the carrying capacity of the environment becomes evident, promoting a type of development oriented towards maintaining human continuity under optimal conditions, namely the sustainable development of the human–environment relationship.

In the current context, sustainable development is a necessity, a general, widely accepted and normatively assumed objective, regardless of the field of manifestation, the spatial or temporal framework. Thus, research approaches, as well as actions and interventions on space, must be based on the use of instruments compatible with the principles and objectives of sustainable development. This approach is capable of supporting coherent, responsible decision-making processes and limiting the effects of human evolution.

In scientific approaches, geographical axes are conceptualized as analytical and modelling tools for spatial organization, enabling integrated, inter- and transdisciplinary perspectives. Through their structural nature, geographical axes support the configuration and understanding of territorial relations, with a defining feature being their capacity to sustain functional balance or, from a dynamic perspective, the tendency of territorial systems to converge towards equilibrium states. The functioning of geographical axes provides a relevant and necessary basis for territorial diagnosis, allowing the identification of vulnerable areas, the guidance of corrective interventions, as well as the valorization of territorial strengths.

The present paper, "The Dynamics of Geographical Axes for Sustainable Economic Development – Mureș County", completes the scientific approaches of studying the actions of geographical axes at the level of an administratively delimited space. Mureș County represents a dynamic, complex and diverse space, and its functionality is closely linked to the natural

premise that favours the displacement of flows and inter-county relations, but also to the modification of the anthropogenic component.

Purpose, structure and objectives of the research

The paper is structured into four chapters, starting with an analysis of the theoretical concepts and key notions relevant to the research, presented in the chapter "*The state of research at international and national level*". The scientific approach has as its next point the analysis of the geographical space of study, undertaken in the classical descriptive-monographic perspective, with subchapters aimed at the historical evolution, the relevant physical-geographical and socio-economic factors, summarized in the chapter entitled "*The historical, natural and socio-economic framework of the study area*". Chapter three, "*Research Methodology*", presents the methods used in the study and the way in which they are integrated and combined within the research framework. Chapter four, "*Analysis and interpretation of geographical axes: typology, status and territorial role*", aims to present the relationship between geographical axes and environmental elements related to the study area, in accordance with the spatial footprint and matrix generated by the action of these geostructures. Also, this chapter is the basis of the paper, thus presenting the results of the research. In the chapter "*Conclusions*", the role played by geographical axes, depending on their type, is examined at the level of the study area.

The sequence of methods and the entire scientific approach underlying this study is ultimately designed to provide a reliable answer to the question: "*What is the relationship between the geographical axes and the sustainable economic development of Mureș County?*". In order to achieve the aforementioned goal, four general objectives of the research were established:

- O1 - Analysis of the concept of geographical axis and their role in sustainable economic development;
- O2 - Analysis of the spatial components of Mureș County;
- O3 - Identification of county-level geographical axes and their development role;
- O4 - Identification of territorial management issues and axis-based solutions.

In addition to the general objectives, specific objectives are established at the level of the subchapters, which function as intermediate stages, configuring a rigorously structured methodological sequence, clearly defined and oriented towards achieving the assumed goal.

STATE OF RESEARCH AT NATIONAL AND INTERNATIONAL LEVEL

1.1. Geographical axes - theoretical and conceptual bases

1.1.1. Theoretical considerations regarding the notion of axis

The concept of axis in territorial planning is initially used by Pottier (1963) who builds the "theory of development axes", based on the analysis of transport infrastructure that creates mobility corridors as spaces for concentrating economic activities, which leads to the gradual transformation of traffic routes into spatial development axes. Hilhorst (1972) resumes and reinterprets the theory of axes, emphasizing the role of these lines of force in creating and supporting growth poles, which leads to the outline of the "theory of poles". Paelinck and Nijkamp (1978) introduce the concept of development axes, outlined along the main access routes, as the basis of an "alternative theory of growth". Dauphiné (1979) considers that the main element of an anisotropic space is the privileged central axis, this constituting itself as a development axis with a complex role in managing material, energy and information flows. Richardson (1978, 1981) continues the scientific approach aimed at development axes, presenting them as useful tools in analysing the spatial distribution of economic activity.

In Romania, the concept of axis in the field of geographical study appeared in the early 2000s. P. Cocean (2005) and Cocean and Filip (2011) use the concept of axis in their works on the regional geography of Romania to mark the dominant lines at the level of a territory (Cocean, 2005; Cocean & Filip, 2011).

The geographical axis is presented by Pop. C. C. (2003, p. 78) as "a line of spatio-temporal force, a line that allows, in a temporal-spatial way, the geographical diagnosis and forecasting of a territory, a territory that can take on different geometric conformations and dimensions in accordance with the capacity of component polarization".

1.1.2. Geographical axes at the level of the study area

The Mureş axis is a development axis that drains an anisotropic region, determined by its longitudinal corridor character, having direct influences on geomorphology, transport, microclimate, but also on socio-economic development (Conțiu, 2010).

At the level of Mureş County, the close connection between the physical-geographical factors and the geographical axes can be observed, the main axes are served by the courses of the main or collector rivers at the county level, the secondary ones by their tributary rivers, and

the tertiary ones by the hydrographic units that flow into the county tributary rivers. This natural hierarchical structure is completed by anthropogenic logic and necessity, through the east-west (natural) and north-south (anthropic) complementarity, consolidated in the territory through transport axes (Someșan & Pop, 2024).

Târgu Mureș Municipality represents the main convergence centre, and its recurrent development axes are: in the NE-SW direction, along the Mureș Valley, and in the SE-NW direction, towards Sighișoara, along the European road E60. The median position at the county and regional level leads to the continuous development of the metropolitan area, offering multiple possibilities for collaboration with centres such as Cluj-Napoca, Alba Iulia and Sibiu (Togănel, 2019).

1.1.3. Types and meanings of geographical axes

Brunet (1973) presents axes as the structural directions that shape and orient space, serving major routes of mobility, connections and influences. Along these axes, spatial poles or centres of power and attraction are located, playing a role in organizing and stratifying the surrounding space. Axes and poles create spatial systems within which they generate directions, linkages, and flows, while poles function as nodes of concentration, attraction, or marginalization.

The axes are elements of territorial cohesion. The axis is thus defined by the active and development-oriented dimension through communication and collaboration (Savala, 2024).

Typologizing axes is a complex process, as there are a multitude of terms for them in the specialized literature.

The development axis is one of the most common such phrases. Development axes represent a response to the human component's tendency towards interaction, functioning as elements of connectivity between urban centres, areas, and geographical regions (Geyer, 1987).

Development axes connect urban centres to nodes, and through transport infrastructure, territorial polarization and regional development are stimulated (Christofakis & Papadaskalopoulos, 2011).

Transport axes support territorial connectivity, define communication routes that play a dominant role in inter-community development, a well-known model being the "EU Pan-European Transport Axis" (Papadaskalopoulos et al., 2005).

The urban axis is represented by the circulation route with the highest degree of spatial integration, structuring the urban form and concentrating its functions (Srinurak & Mishima, 2017).

The tourist axes occupy an important place in the phrases that are based on the axes. These are strong lines of the territory that constitute tourist propagation routes, served by main poles, which support tourism, and secondary axes and poles (Simon, 2011; Cocerhan, 2012).

1.1.4. Geographical axes and complementary concepts

Geographic axes and corridors are concepts found in geographical literature and in territorial planning documents, where they define spatial development patterns. Both concepts are most often seen as useful tools for regional economic development, associated with the idea of decentralizing urban functions, territorial balancing, traffic decongestion, etc (Iurea, 2011).

The concept of the development corridor emerged in relation to communication axes in spatial planning studies, representing a hierarchical and concentric relationship aimed at creating favourable conditions for linear and nodal development by generating synergies and facilitating the rapid movement of goods and information (Brand & Geyer, 2017).

Less frequently, the concept of a corridor is used alongside that of a geographical axis. The corridor is a particular space where a complex of internal relations emerges, managed by an axis for the flows of mass, energy and information. The corridor is thus a major polarizing axis that stands out from the neighbouring spaces. The emergence and transformation of a corridor is linked to favourable conditions, in particular the substrate-relief-hydrography triad (Conțiu, 2010).

1.2. Sustainable economic development

For more than half a century, since the 1972 "United Nations Conference on the Human Environment" in Stockholm, sustainable development, through environmental, social, and regional development strategies and policies, has provided principles, objectives, and targets that states need to consider in pursuing sustainable transformation (Rădoiu, 2020).

At the national level, regional disparities in development persist, and these inequalities can be addressed through sustainable development strategies. As a member of the international community and of the European Union, Romania has both a direct interest in and an obligation to implement the principles of sustainable development from economic, social, and environmental perspectives (Rădoiu, 2020).

1.2.1. The relationship between geographical axes and sustainable economic development

Geographical axes identify the existing and potential vegetation elements (optimality, hazards and risks) with the aim of participating in achieving the objectives of sustainable development of the territory. Premise of balancing and aiming at behavioural improvement, the geographical axis foresees agglomeration that leads to the installation of defective or risky states (Pop, 2016).

Geosystems such as geographical axes must be guided by the "principle of maximum efficiency with minimum consumption of substance and energy". Moreover, geographical axes have the capacity to converge and are based on the principle of synergism, with beneficial effects and links with sustainable development objectives and the three general areas: natural, social and economic (Pop, 2016).

Geographic axes are catalysts of sustainable development, and in relation to poles and dominant urban centres, they generate economic potential and favour the emergence of urban communities. The relationship between axis and pole is interdependent, axes stimulate economic growth, while poles contribute to their consolidation and valorization (Ekladios & Elshafei, 2019).

Geographical axes are structural elements with direct influences on sustainable development. These structural entities organize existing space, mobility, functions, densities, and relationships. The effects of these entities are reflected in energy efficiency, accessibility, equity, cultural identity and environmental quality, and their morphological analysis reveals the degree to which a space is or can be sustainable (Hasan et al., 2017).

THE HISTORICAL, NATURAL AND SOCIO-ECONOMIC FRAMEWORK OF THE STUDY AREA

2.1. Historical landmarks

2.1.1. Historical stages of formation

Mureş offers evidence of inhabitation in stable settlements since the Neolithic. On their structure, the proto-Thracian settlements crystallized, which diversified with the Bronze Age. Mureş is an area of early settlement, since the era of the primitive commune, being a space advantaged by the existence of varied natural resources and suitable lands for the location of human settlements. Initially, the sheltered valleys and terraces of the main rivers at the level of the current county were preferred (Lupu et al., 1980).

The earliest traces of human settlement in the territory of the present-day county date back to the Neolithic period and have been identified in more than 30 localities located between the Mureş Valley and the Târnave valleys.

2.1.2. Historical and spatial transformations

The change in the shape of Mureş County is related to the multiple transformations undergone by the national space. Until its current form, Mureş County went through various stages of formation, completed by stabilization in 1968. Following the revision of the administrative system in 1968, the former administrative organization was reinstated. This revision established Mureş County in the form in which it largely exists today. Târgu Mureş and Sighişoara became municipalities, while Reghin, Târnăveni, Luduş, and Sovata became towns within the county. The communes established at that time have, broadly speaking, remained in place to this day, with some minor modifications (Benedek et al., 2016).

2.2. Physical-geographical framework

2.2.1. Geographical position and regional setting

As part of the Carpathian–Danubian–Pontic geographical space, Mureş County is located in the central-northern part of Romania, in the central area of the Transylvanian Plateau (Benedek et al., 2016).

Mureş County has a descending, step-like orographic profile, extending from the ridges of the Eastern Carpathians towards the Transylvanian Plain and the Târnave Plateau, and covers an area of 6,714 km² (Consiliul Judeţean Mureş, 2021).

Part of the centre development region, Mureş County can represent an inter-county bridge, the inter-county geographical axes being able to ensure the exchange of flows.

2.2.2. Peculiarities of the relief

The relief of the county can be considered harmonious, being characterised by a general step-like arrangement from east to west, with hilly and plateau relief predominating and covering approximately 50% of the total area of Mureş County. The remaining half is divided relatively evenly between the Transylvanian sub-Carpathian hills and the Călimani-Gurghiu volcanic mountains (Şoneriu & Mac, 1973).

This distribution of the relief created two geographical spaces and consequently two general types of orographic axes: mountainous and hilly.

The topographic profile of the terrain takes the form of an ascending hypsometric curve, ranging from a minimum elevation of approximately 300 m to a maximum of 2,100 m, and is integrated at the macro-scale level into three morphological steps:

- Mountain morphological step: Călimani Mountains and Gurghiu Mountains;
- Hilly morphological stage: piedmont, subcarpathian, depression, plateau and plain;
- Morphological stage of valley corridors (Benedek et al., 2016).

2.2.3. Geology and soils

The geotechnical characteristics of the county include strata with low to moderate stability, a relatively uniform geological structure, and a general inclination towards the north-west. The area is characterised by the successive arrangement of thick layers of friable sedimentary formations alternating with erosion-resistant strata, such as sandstones and volcanic tuffs. In the terrace, floodplain, and riverbed areas, Holocene formations are also present, consisting of recently deposited alluvial sediments resulting from flooding events (Benedek et al., 2012).

Soils vary, from mountain ridges to low river meadows, with a wide range of zonal, intrazonal and zonal soils (Lupu et al., 1980).

2.2.4. Subsoil resources

Methane gas stands out as one of the most important resources at county and even macro-regional level. At a macro-regional level, in the Transylvanian Basin, there are three large areas with gas fields or domes, Mureş County overlapping two of them (Mediaş-Târgu Mureş Area and the Transylvanian Plain) (Benedek et al., 2012).

Industrial rocks are the second most important resource at the county level. In the mountainous area, andesites and andesitic agglomerates predominate. In the Subcarpathian, plateau, and plain areas, sedimentary deposits of sands, marls, and clays are predominant. The terraces of the main rivers contain considerable reserves of unconsolidated detrital deposits, including boulders, gravel, and ballast (Şoneriu & Mac, 1973).

Of lesser importance, compared to the aforementioned resources, are the salty mineral waters. At the level of Mureş County, they are related to the area of the diapire folds and the salt diapirs in the Inner Subcarpathians (Şoneriu & Mac, 1973).

2.2.5. Climatic characteristics

The climatic features of Mureş County are the consequence of its positioning in the central area of Transylvania, in an area of temperate-continental climate of hills and plateau in transition to the mountainous climate, with some climatic nuances determined by the landforms. The climate is humid and cool in the mountainous area and mild, warmer and drier in the plateau and plain area, and in the west of the county the climate has shades of aridity, with dry and hot summers. The layering of the relief causes significant variations in the air, temperatures drop from west to east, with differences of up to 5-6°C (Consiliul Judeţean Mureş, 2021).

2.2.6. Hydrographic network

At the county level, there are 214 coded watercourses with a total length of 2727 km and a density of approximately 0.40 km/km² (edums.ro, 2022).

Through its orientation and morphology, the hydrographic network is an asset of communication with the outside, a connection facilitated by the penetration corridors in the plain and sub-Carpathian area (Benedek et al., 2016).

2.2.7. Biogeographical elements

Mureş County exhibits significant differences in terms of its environmental characteristics, being particularly defined by altitudinal zonation. Several altitudinal belts can be identified: alpine, montane, hill and plateau, anthropogenic steppe, and plant associations. The fauna is directly related to the vegetation belts in terms of its spatial distribution (Benedek et al., 2012).

2.3. Anthropogenic component: population and settlement system

2.3.1. Population numerical evolution

At the level of Mureş County, the number of people is constantly decreasing (see table 1), the percentage of decrease from 1992 to 2024 being almost 6.5%.

Table 1. Population change rate at the level of Mureş county

	1 January 2004	1 January 2010	1 January 2014	1 January 2020	1 January 2024	Total population 2024 / 2014
Total - county	608289	603708	598872	590756	578574	-3,39%
Total population%	-0,75		-1,36			

Data Source: Institutul Național de Statistică, 2025

The percentage of population decrease almost doubles at an interval of 6 years, and at 10 years this percentage is almost 2.5 times higher.

2.3.2. Population density

Regionally, Mureş County ranks third at the level of Macroregion I and 2nd at the level of the Centre Region. The temporal evolution of the population density indicator is outlined at the level of the study county in descending form, from 90.6 people/km² in 2004 to 86.17 people/km² in 2024.

2.3.3. Natural population change

In terms of the number of live births, Mureş ranks 11th nationally, 4th in Macroregion I and 2nd in the Central Region. Fertility is decreasing, the rate reaching from 57.4‰ in 1990, to 40.8‰ in 2010 and to 34.9‰ in 2024.

The county-level mortality rate had an average value of 11.7‰ in 2024, being higher in rural areas (12.2‰) than in urban areas (11.2‰). The value of this indicator places the county above the national (11.2‰) and regional averages.

In 2024, the natural increase recorded in Mureş County was –2,179 persons, placing the county 16th nationally, 2nd within Macroregion I, and 1st within the Central Region. With a natural increase rate of –3.8‰, Mureş County ranked 16th nationally and 2nd regionally.

The average life expectancy in Mureş County in 2024 is 76.82 years, lower for males (73.32 years) and higher for females (80.43 years). This value places the county below the national average (National Institute of Statistics, 2025).

2.3.4. Territorial mobility of the population

In Mureş County, the very high value of the external exodus after the fall of communism and the acquisition of the right of free movement can be observed. It can be considered that

after 2004 the desire to emigrate decreases, although there is a new growth trend after 2020, but less intense. A very high percentage, over 56%, of temporary emigrants from Mureș County are young people aged between 20-44, which signals a problem related to the increase in the demographic dependency ratio in the county.

2.3.5. Demographic structure by age and gender

The age structure of Mureș County indicates an accelerated process of demographic ageing. The share of older people increased from 10.9% in 1990 to 20% in 2024 and is projected to reach 27.9% by 2060. Conversely, the share of young people declined from 23.3% in 1990 to 17% in 2024 and is projected to fall to 13.9% by 2060 (Consiliul Județean Mureș, 2021).

Figure 1 shows the demographic dynamics by age group.

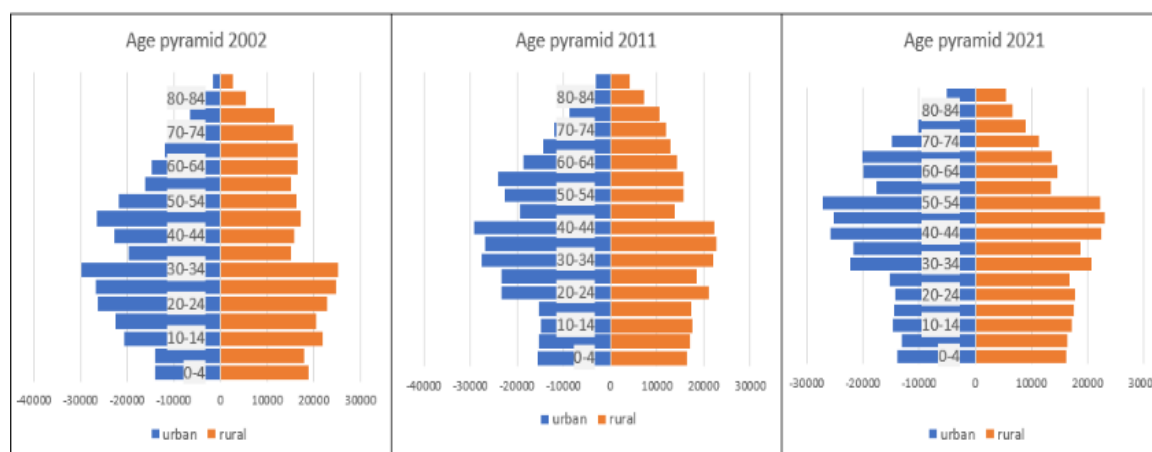


Figure 1. Diachronic perspective on the population structure at urban and rural level
(Data Source: Institutul Național de Statistică – Direcția Județeană Mureș, 2025a)

The gender structure at the level of Mureș County is relatively balanced, the female gender being slightly more numerous at the county level (approximately 51%).

2.3.6. Ethnic and religious structure

The ethnic composition of Mureș County has historically been characterised by a Romanian–Hungarian majority. Currently, Romanians account for almost 50% of the population, while ethnic minorities represent only about 0.24%, comprising 13 ethnic groups. Historically, Greek Catholicism was predominant among Romanians, but following its suppression during the communist period, it was largely replaced by Orthodoxy.

2.3.7. Marriage balance

Within Mureș County, there is a negative evolution, in relation to the number of marriages, which decreased from one year to another. Mureș County registered a number of

2397 marriages in 2024, which represents about 2.4% of the national total. Thus, Mureş County ranks 15th nationally, 4th at the level of Macroregion I and 2nd place at the level of the Centre Region.

In 2024, Mureş County registers a number of 568 divorces, ranking 14th nationally, 5th in Macroregion I and 2nd in Centre Region (recensamantromania.ro, 2023).

2.3.8. County-level settlement system

The settlements forming the Mureş County system have an uneven spatial distribution. The cause of this imbalance is determined by a combination of factors: the orography and hydrography of the terrain, local natural conditions, soil and subsoil resources, historical development, land use, the occupations of the inhabitants, transport networks, as well as strategic considerations. This unevenness leads to the differentiated development of settlements, resulting in territorial disparities, with areas of high territorial cohesion existing alongside areas of low territorial cohesion (Ministry of Environment, Waters and Forests, 2014).

The main problem faced by the county is determined by the increase in the demographic pressure of peri-urban areas and the massive depopulation of isolated areas.

2.4. Socio-economic component of the territory

2.4.1. Geographical-economic setting of Mureş County

Mureş County is one of the six counties at the level of the Centre Region and one of the 12 counties at the level of Macroregion I (Benedek et al., 2016).

The share in terms of the contribution to GDP at the level of the Centre Region of Mureş County in 2022 is shown in Figure 2.

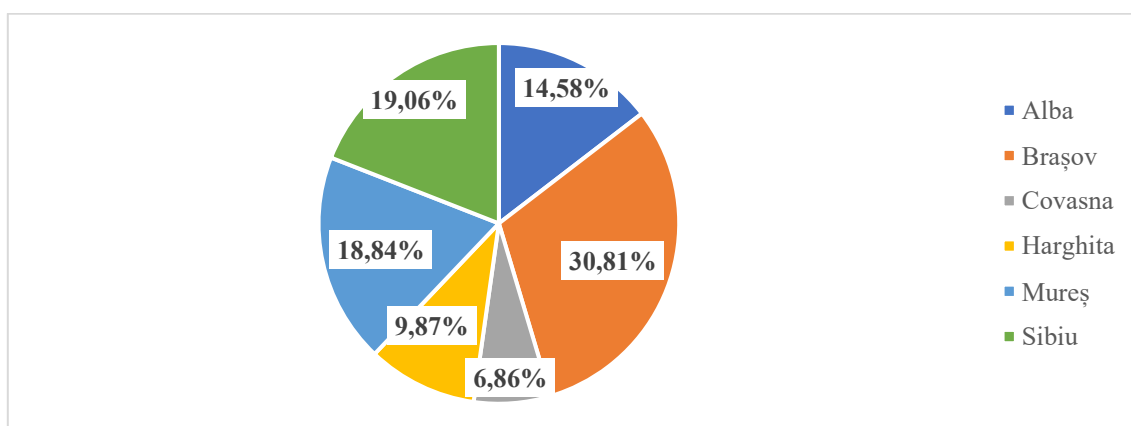


Figure 2. Contribution of counties to the GDP of the Centre Region
(Data source: Comisia Naţională de Strategie şi Prognoză, 2022, p. 3)

2.4.2. County technical and utility infrastructure

According to the "Anuarului statistic al județului Mureș anul 2024", over the last six years, the situation of settlements in terms of drinking water supply has remained relatively constant, with 100% of dwellings in urban areas connected to the water supply network and approximately 76% of rural settlements having access to it (Anuarul statistic al județului Mureș, 2024).

The total number of UATs connected to the sewage system has been at its maximum in urban areas since 2004, whereas in rural areas the percentage did not reach 51% in 2024. According to statistical data for 2024, the length of the natural gas network in Mureș County is 3,494.7 km, ranking first nationally for this indicator. Regarding gas distribution by residential area and time period, the number of units with access to this utility was 83 in 2020, with the connection rate reaching 100% in urban areas and 78% in rural areas.

The most recent census revealed that 98.93% of conventional dwellings in Mureș County have access to electricity; however, no statistical data on its territorial distribution are provided (Consiliul Județean Mureș, 2021).

2.4.3. Health infrastructure

Mureș County represents, through the municipality of Târgu Mureș, a national health brand, a traditional, well-known and well-equipped centre for emergency admissions and medical treatment, but also for the training of specialists. At the level of the municipality of Târgu Mureș there are 9 hospitals (3 public and 5 private) out of the total of 18 at the county level.

2.4.4. Educational infrastructure

The number of school population in Mureș County is constantly decreasing, with significant reductions forecast, between 11.9% and 15.6% by 2030 and between 30.3% and 34.3% by 2060. By 2030, a decrease in the school population aged 0-23 is forecasted at the county level by 12.3%, and by 2060 this percentage will reach 31.2% (Consiliul Județean Mureș, 2021).

2.4.5. Economic sectors

At the level of the Centre Region, Mureș County is one of the largest producers of cereals, being also among the first counties to cultivate sugar flakes.

Fruit growing has high favourable conditions, especially in the central-western part of the county (Benedek et al., 2012).

Livestock farming is an important activity for the county, having as assets both the variety of natural conditions that favour the diversification of natural and cultivated feed sources, and the existence of an extensive agropastoral field.

Fish farming has favourable conditions at the level of Mureş county where the relative surface of the water surface is 589 ha (Benedek et al., 2012).

Forestry is the next component of the primary economic sector, with a slightly decreasing forest fund in Mureş County.

The share of the active population and the professional structure is strongly affected by the demographic decline. Table 2 shows the professional structure by sectors of activity.

Table 2. The professional structure of the county in 2021 compared to 2002

2021	Employed population (thous. pers.)	Employed %	Primary sector %	Secondary sector %	Tertiary sector %
Total	201,3	34,2	11,6	27,5	60,9
Urban	106,7	35,1	2,06	29,1	68,8
Rural	94,5	33,2	16,6	30,6	53,8
2002					
Total	185,7	32	15,8	42,7	41,5
Urban	108,8	38,4	2,7	46,8	50,6
Rural	76,8	25,9	34,4	37,0	28,7

Date source: Institutul Național de Statistică – Direcția Județeană Mureş, 2025b

2.5. Tourism potential and its development

2.5.1. Tourism potential at county level

Mureş County has a diversified tourist potential, the rich natural offer being combined with an anthropogenic heritage. Figure 3 presents the analysis of the tourism potential of Mureş County, in accordance with the information from the 2012 PATJ.

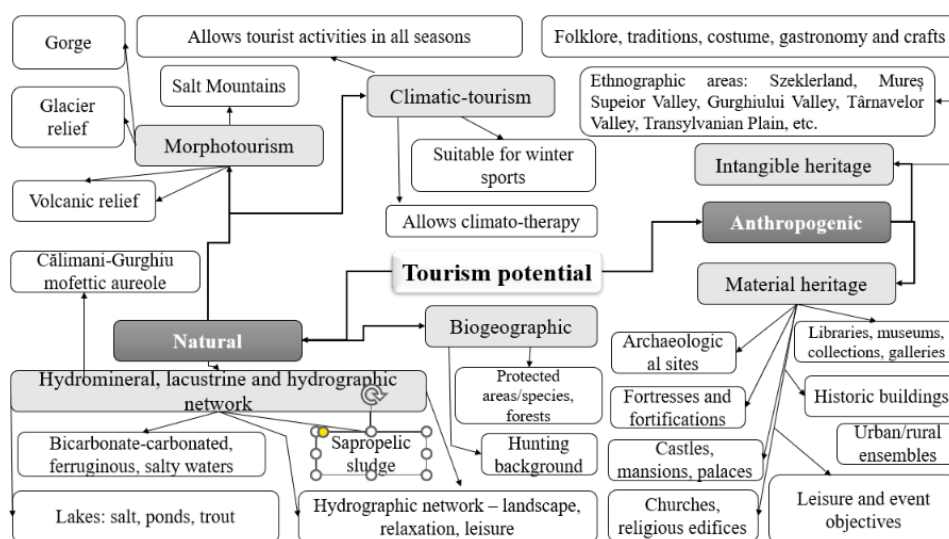


Figure 3. Tourism potential of Mureş County by category

2.6. Communication routes and spatial relations

The quantitative report for 2024 totals 2233 km of public roads, 52 km of highway, 310 km of railway network and an airport within the county (see figure 4).

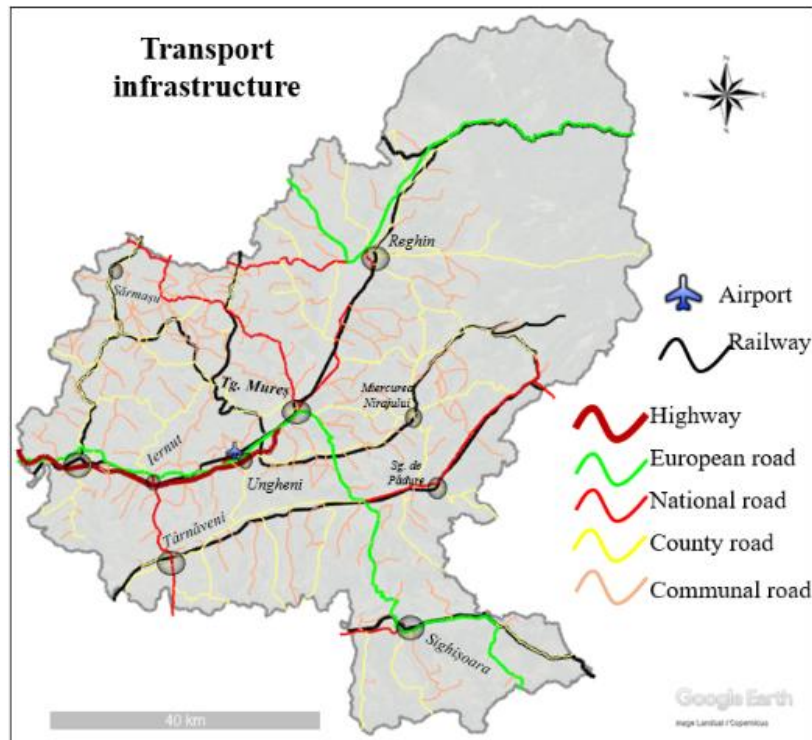


Figure 4. Communication routes - Mureș county

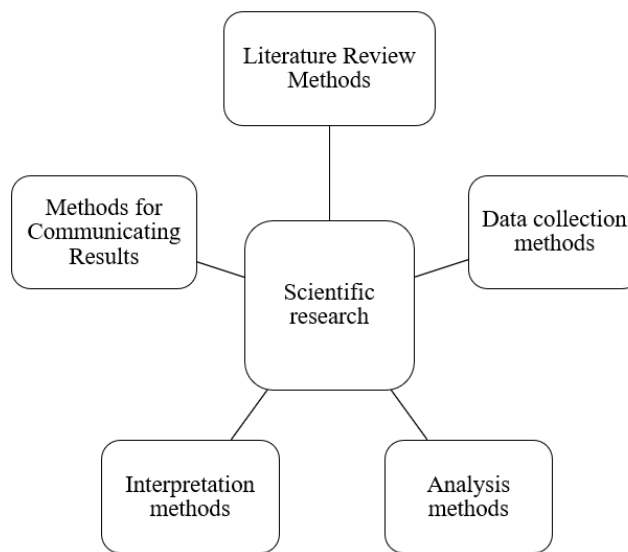
At the level of Mureș County, the railway transport infrastructure is composed of: main line 300 of European importance, main line 400 of national importance, 3 secondary railway routes and two narrow-gauge routes Târgu Mureș-Sovata, Târgu Mureș-Band-Lechința-Șăulia (Benedek et al., 2012).

The length of public roads in relation to the county's surface places Mureș on the 5th place at the level of Macro-Region I and on the 2nd place at the level of the Centre Region.

Air traffic is represented at the level of Mureș County by Transylvania International Airport. Transylvania International Airport is located about 15 km from the city of Târgu Mureș, on the territory of Vidrasău.

RESEARCH METHODOLOGY

The purpose of this thesis is to highlight the possible links between the geographical axes at the level of the study area and the sustainable economic development, as a result of the functioning of these intelligent territorial systems in Mureş County. In order to achieve this goal, a meticulous and multifaceted approach is necessary, which combines quantitative and qualitative methods, resulting in a pragmatic and complex vision, in accordance with the characteristics of the elements that make up the geographical space of study. Figure 5 shows the classification of research methods.



*Figure 5. Categories used to frame the research methods applied in this paper
(Adapted after: Nagarale et al., 2022)*

The method of literature analysis includes both sources that treat the research space as unitary, i.e. Mureş County, but especially regional studies, which deal with parts of the county or even the region to which it belongs. Research that supports the established objectives and the ideas substantiated in the thesis is also targeted.

The methods used to collect the necessary data follow the logical framework of the research. These methods are based on both direct and mediated observation. While direct observation typically involves fieldwork, mediated (indirect) observation relies on additional tools and resources to obtain the required information.

Analysis methods are a fundamental part of research because they put the researcher in relation to the targeted geographical space and offer his perspective on reality. The method of analysis comes in tandem with that of synthesis because the existence of a database with exhaustive information does not necessarily mean qualitative research, the ability to synthesize and interpret the materials being equally important.

The territory under study, namely Mureş County, is systematized with the help of the regional method, by delimiting some functional areas, in this case geographical axes, which are constituted as optimal forms of territorial management of flows.

Statistical and mathematical methods, tailored to the thematic subchapters, constitute a key component of the research, as they capture both the reality and the spatial-temporal dynamics of the study area under investigation.

The cartographic method is a source of documentation and a material for the analysis of the geographical realities of Mureş County, being frequently used in this work. It is also a method of communicating the results at the level of the studied area.

The GIS technology and method occupy an important place in the research, being present at every stage and in almost all chapters of this work. This method provides a visual support of the situation of the territory concerned and of the results of the research, thus being indispensable to the work, as well as to geographical studies in general. Google Earth Pro 7.3 and ArcGis 10.8.2 are the programs used to create the graphical map support in this work.

"MCDM" (Multi-Criteria Decision Making) methods or multi-criteria decision-making methods are frequently used in territorial planning studies, spatial analysis, potential assessment and decision support. Among the most established multi-criteria decision methods are AHP, TOPSIS or VIKOR, which are based on comparing alternatives to an ideal solution, respectively on identifying an optimal compromise between conflicting criteria.

a) AHP method

The main objective of this analysis is to rank the county, at the level of the LAU2, according to the tourist potential. The evaluation criteria are: natural potential, anthropogenic potential and reception infrastructure.

b) TOPSIS and VIKOR methods

The main objective of this analysis is to rank the county's LAU2 according to the state of socio-economic indicators, in relation to their position relative to the county's geographical axes.

The first stage of these methods involves constructing the decision-making matrix. The present study includes nine indicators: four of cost type (average altitude, soil fertility, demographic dependency ratio, and economic dependency ratio) and five of benefit type (demographic trend, natural balance rate, technical-urban infrastructure, tourist potential, and migratory balance rate).

ANALYSIS AND INTERPRETATION OF GEOGRAPHICAL AXES: TYPOLOGY, STATUS AND TERRITORIAL ROLE

Historical axes and the evolution of the county

The configuration of Mureş County is the result of a process based on an accumulation of historical, geographical and political-administrative factors. The current configuration of the county is the result of the combined influence of historical heritage, the natural axis of the Mureş River, and the political decisions of the communist period aimed at the territorial distribution of national minorities.

Also, Mureş County is crossed by two other rivers to whose existence political-administrative formations at national level are linked. These are the two Târnava river and the Târnava County, later divided into two counties (Târnava Mică County and Târnava Mare County), transformed into counties after the Great Union.

The location of the human settlements in Mureş, in the context of chronological time, reveals the attractiveness of certain areas for the human factor. Figure 6 shows the geographical axes at the county level in relation to the documentary attestation of the localities.

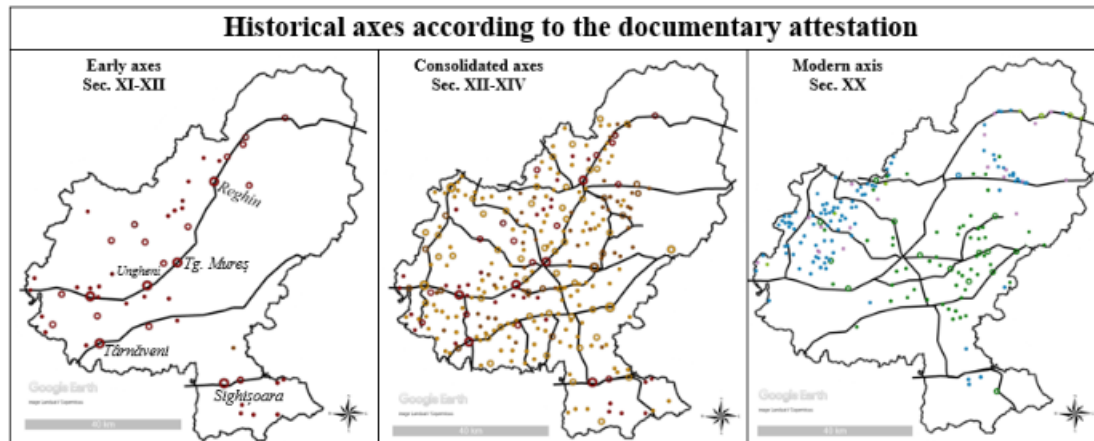


Figure 6. Residential axes in relation to the attestation of localities

Regardless of the form of administrative organization, the geographical axes have represented and represent areas of attractiveness due to the favourable housing conditions. The Mureş axis continues, but also begins outside the borders of the homonymous county and will remain an area of attractiveness regardless of the administrative-territorial organization of the country. This statement also lends itself to the other inter-county axes at the level of the study area. This observation does not diminish the role that an adequate management of the axis at the county level has in sustainable economic development, but only strengthens the position of lines of force that the geographical axes hold within a territorial system.

County physical-geographical axes

The relief is a determining element of the territorial organization, with a multiple role in the formation and functioning of a geographical space. The relief, presented in the classical, descriptive-monographic sense, defines the natural zoning of the territory. At the mesoscale level, the county's relief can be divided into five zones: zone 1 - Mureș Corridor, zone 2 - Transylvanian Plain, zone 3 - Carpathian-Subcarpathian, zone 4 - Niraj and Târnava Mici Hills, zone 5 - Târnava Mari Hills (Benedek et al., 2016). Figure 7 shows this zoning of the county territory, having the relief as a decisive factor.

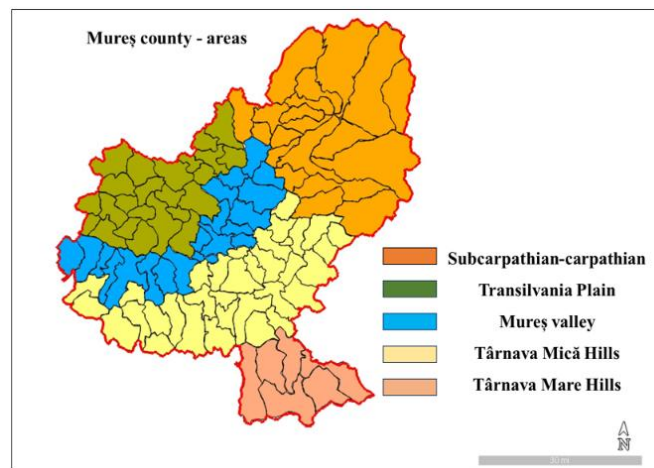


Figure 7. Zoning of Mureș County according to relief (Adapted from: Benedek et al., 2012)

Among the morphometric parameters, relevant for the local relief conditions in relation to the extension of the settlements are the slope and altitude. At the level of the county of study, altitude is the most relevant factor. Figure 8 presents the result of the analysis and the classification of the LAU2 according to the established altitudinal grade.

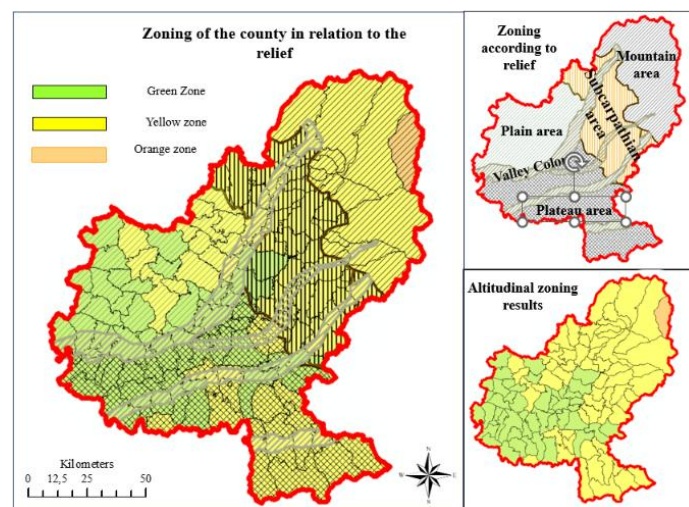


Figure 8. The result of the relief analysis at the level of the study area

Mountainous, submontane and plateau/hilly areas are the least permissible. At the other end are the plain areas and valley corridors. Regarding the vertical structure of the relief, there

is a relatively large altitudinal range, nevertheless, this does not significantly affect the accessibility of the study area, which remains very good (Benedek et al., 2012).

In addition to the morphological analysis of the relief, a morphodynamic analysis of the risk factors is carried out in order to support or invalidate the hierarchy of the axes according to the altitudinal gradient of the relief. The most favourable areas in terms of geology are those of the valley corridors and the mountain area, at the opposite pole being located the plain area and the southern area of the county. Figure 9 shows the degree of geomorphological vulnerability at the level of Mureş County.

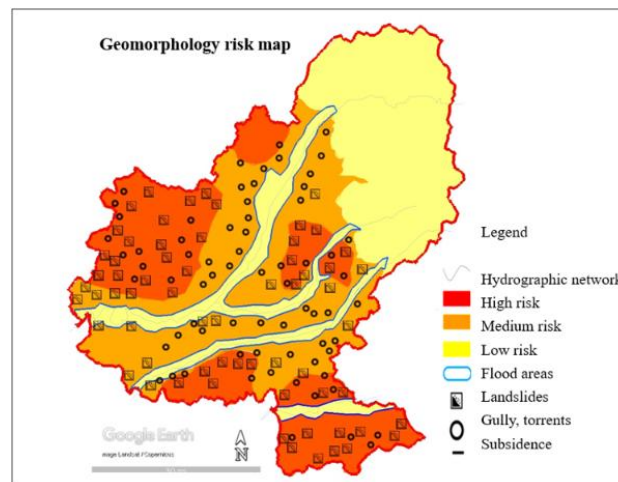


Figure 9. Geomorphological risk map (Adapted from: Benedek et al, 2012, pp. 67-69)

From a geological point of view, expressed through soils and fertility, the most qualitative area for agriculture is the plain area of the county, followed by the Mureş Corridor. Figure 10 shows the four dominant fertility classes in the study area.

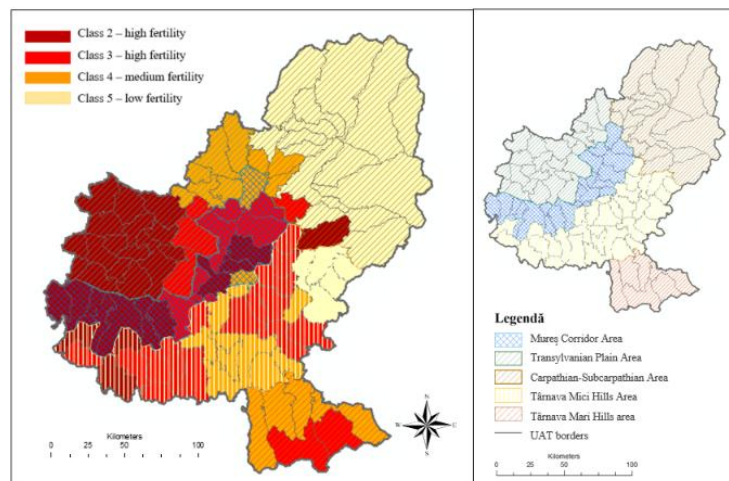


Figure 10. Fertility classes and zonal classification (Adapted from: Benedek et al., 2012, p. 5)

Depending on the subsoil resources factor, the most favourable area is that of the Transylvanian Plain, followed by the Mureş Corridor and the Târnava Mici Hills, on the last places are the Carpathian-Subcarpathian Area and the Târnava Mari Hills.

Hydrography represents, along with relief, a defining factor of the county axial equation. The Carpathian-Subcarpathian area and the Mureş Corridor are the two areas that stand out in terms of hydrography, thus resulting in the fact that the Mureş river axis is the most important at the county level. Hydrography imposes itself in the territory and through risk factors. Figure 11 shows the classification of the LUAs units, unitarily, according to the vulnerability to floods.

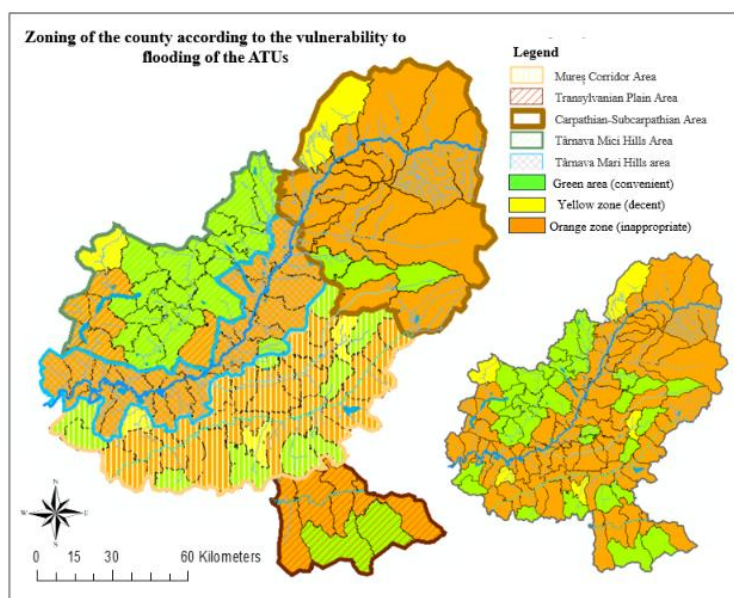


Figure 11. Zoning of the county according to flood risk

The relief and hydrography are the determining factors of the formation of the physical-geographical axes at the county level. The other environmental factors have the role of consolidating the county hierarchical position, but from a secondary perspective in terms of importance.

The link between the physical-geographical factors and the geographical axes represents the link between the natural and the human factor. At the level of Mureş county, it can be seen that the main axes are outlined by the collector rivers, the secondary axes by the tributary rivers at the county level, and the tertiary axes are outlined by the tributaries of the tributary rivers of the three county collectors. (Someşan & Pop, 2024). Figure 12 shows the classification of the physical-geographical axes at the level of Mureş County.

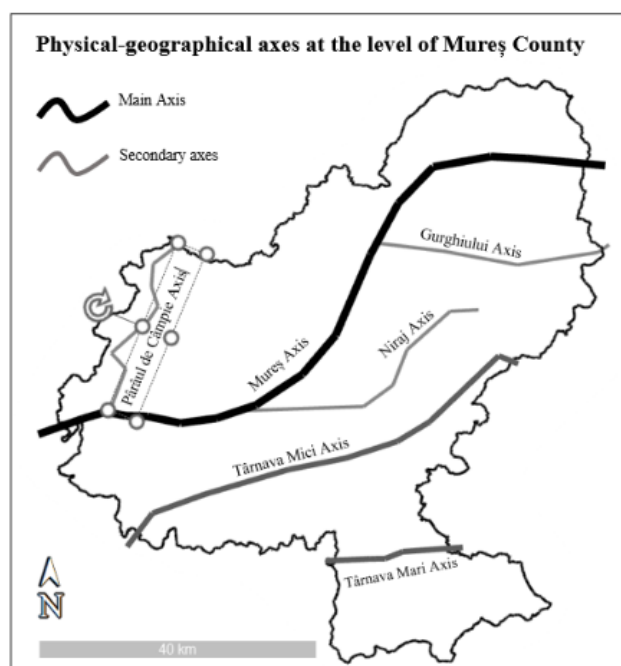


Figure 12. Axes outlined by the physical-geographical elements at the level of Mureş County

Residential axes, poles and nodes

At the level of Mureș County, the demographic processes of risk fit into the European and national pattern, targeting both the sharp decline and the aging of the population, determined by the couple, the decrease in the birth rate and the amplification of the migratory phenomenon. The forecasts show the intensification of these processes, which will determine a series of negative effects on social structures: the continuous degradation of the population structure by age, the accentuation of the demographic pressure on the active population, the increase in morbidity, etc (Rațiu, 2013).

A) Number of populations

In 2024, approximately 46.8% of Mureș residents live in urban areas, the most populated city being Târgu Mureș with about 27% of the county total.

Figure 13 shows the axial structure of Mureș County in terms of population size, based on a comparison between 2014 and 2024.

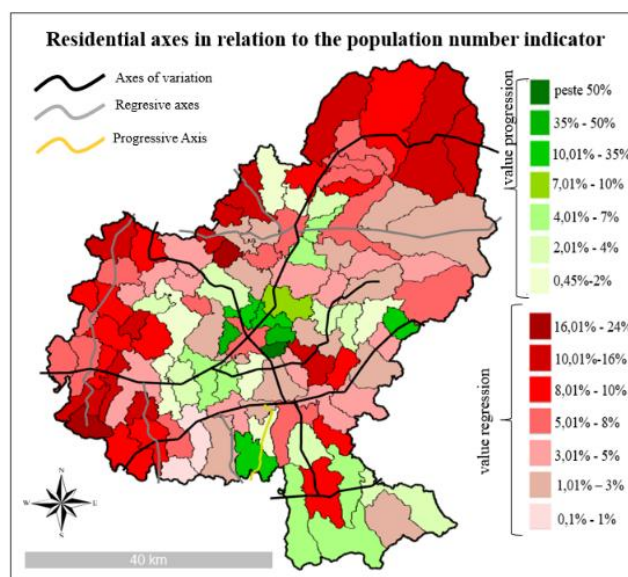


Figure 13. Residential axes, comparison 2024/2014

The Mureș axis is characterized on the one hand by effervescence in the middle area and on the other hand by ends of axes in demographic regression. The Târnava Mici axis is a regressive axis in terms of population, however, it is found as at the level of the main axis in the county, a more stable central or median part and ends of axes in a more pronounced decrease. The Târnava Mare axis presents an inverse situation compared to those presented above, with the central or urban area in regression. The Niraj axis can be considered a contrasting axis, with the downstream area increasing, the median area in regression and the upstream area in opposition. The Gurghiului axis and especially the Pârâul de Câmpie axis are regressive axes.

B) Population density

The decrease in the average population density is directly proportional to the decrease in the number of populations. Figure 14 shows the residential axes according to the evolution of population density in 2024, compared to 2014. The decreasing axes or the extinguishing axes stand out: the Gurghiului Axis and the Pârâul de Câmpie Axis.

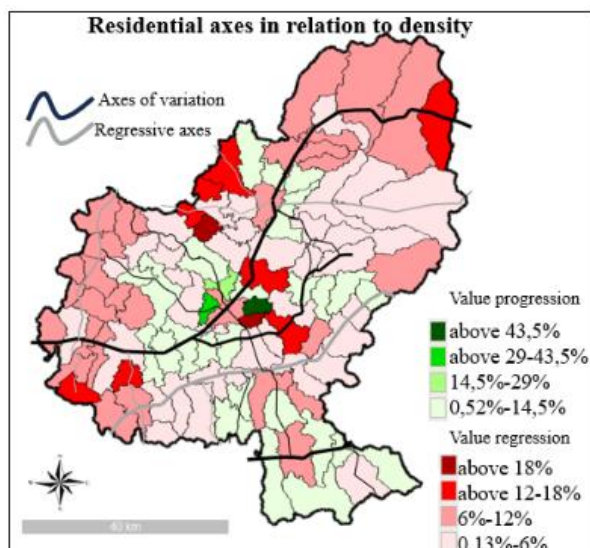


Figure 14. Residential axes outlined by the population density indicator 2024/2014

C) Birth rate

Most of the county, about 71.5%, registers a decrease in the birth rate. All areas of the county are affected, the spatial patterns being poorly outlined, only the Târnava Mari Hills standing out from this point of view. The urban environment is also affected, excluding Iernut, with a weak growth. Figure 15 shows the percentage of the difference determined by the 10-year time difference, in relation to the territorial distribution and the county axial situation in terms of birth rate.

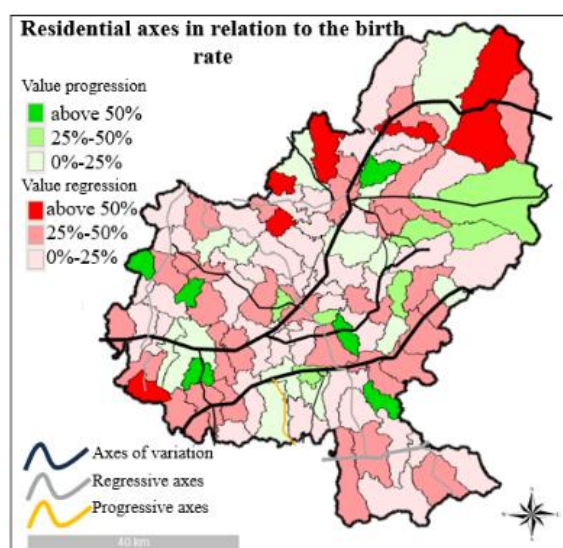


Figure 15. Result of the analysis, 2024/2014 (Data source: Institutul Național de Statistică, 2025)

Most geographical axes at the county level are axes of variation, but they predominantly show negative values. The regression axes dominate the landscape, with the Târnava Mici axis, the Pârâul de Câmpie axis or the county longitudinal axis standing out. The axes of progress represent exceptions.

D) Mortality

There are alternations between the increasing and decreasing LAU 2 at the level of each physically-geographically delimited area in terms of the mortality indicator. Figure 16 shows the result of the comparative analysis between 2024 and 2014.

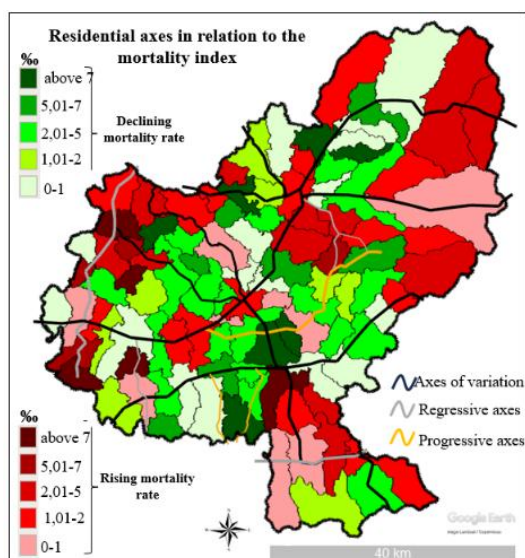


Figure 16. Evolution of the mortality rate according to the comparative situation 2024/2014

The Mureș axis represents an axis of contrast in relation to the mortality indicator, with a number of LAU2 divided relatively equally between the two categories. The Târnava Mică axis is also an axis of contrast, but in its case the communes where there is an improvement in the mortality rate values dominates. At the opposite pole is the Târnava Mare Axis, a regression axis, which registers an increase in the values of this indicator. The Pârâul de Câmpie axis also falls into the category of regression axes, as also a series of smaller recurring axes that start from the Luduș or Reghin area. The Niraj Axis is the most representative axis of progress. In this evolutionary situation there are only a few recurring axes from the first half of the Târnava Mici Axis.

E) Natural population increase

The territorial inconsistency that dominates the county in relation to the natural increase rate can be observed, but there are representatives of the growth category in each area. Figure 17 presents the residential axes outlined following the comparative analysis, 2024 and 2014.

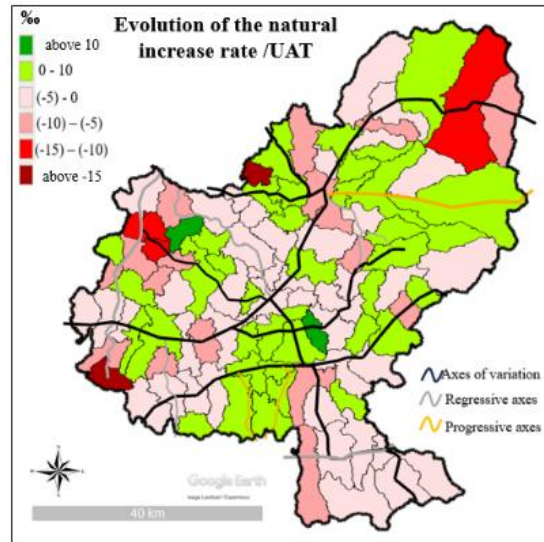


Figure 17. Residential axes based on the 2024–2014 natural increase analysis

The Mureș axis, the backbone of the county, is an axis of variation, but negative variation predominates. On the other hand, the Niraj Axis is an axis of variation, but in which the LAU2 with an improvement in the value of the natural increase rate predominate. The Târnava Mici axis is also an axis of variation, but with a pseudo-equality in terms of the classification of the LAU2 units in one of the categories presented. Regressive axes are: Târnava Mare Axis, Pârâul de Câmpie Axis and DN15E Road Axis, to which are added a series of recurring or tertiary axes. Progress situations are rarer, the Gurghiului Axis being the most representative, to which are added two recurring axes of Târnava Mică axes.

F) Territorial mobility of the population

The migration balance index varies, figure 18 shows the result of the comparative analysis and the situation of the residential axes, by comparing the years 2024 and 2014.

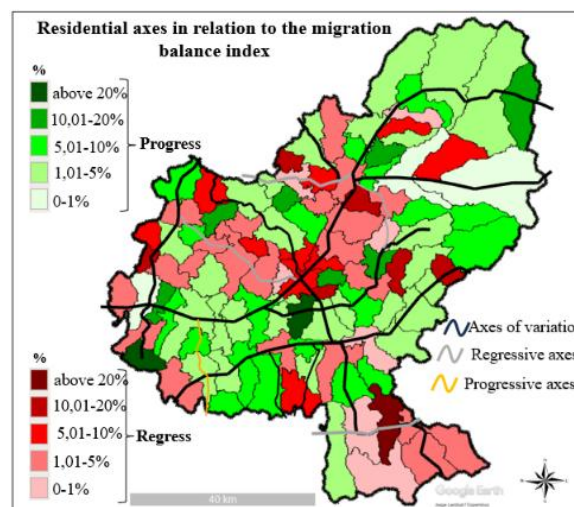


Figure 18. Migration balance rate, 2024–2014 comparison at LAU2 and axial level
(Data Source: Institutul Național de Statistică, 2025)

At the axial level, the axes of variation dominate, and there are few situations of integrality in a single category. The Niraj axis, one of the most representative axes at the county level, has a situation of variation, but in which progress in this indicator predominates. A similar situation is recorded at the level of the Gurghiului Axis. On the other hand, the Târnava Mare Axis, although it has a green LAU2, registers a significant regression. The Mureș axis is an axis of variation, but with an extended area, especially between Târgu Mureș and Reghin, in regression. The axis of the Pârâul de Câmpie presents a certain balance, being an axis of variation.

G) Demographic dependency ratio

The demographic dependency ratio is an indicator derived from the analysis of age group distribution and is relevant for assessing demographic structure and identifying potential risks to the smooth functioning of society within a given geographical area. At the level of Mureș County, there is only one axis of progress—the Gurghiu Axis—which records the lowest values of demographic dependency. The vast majority of axes are variation axes, including the main county axis, the two Târnava axes, and the longitudinal axis. However, there are also several regressive axes, notably the Pârâul de Câmpie Axis and the Niraj Axis. Figure 19 shows the residential axes according to the demographic dependency ratio.

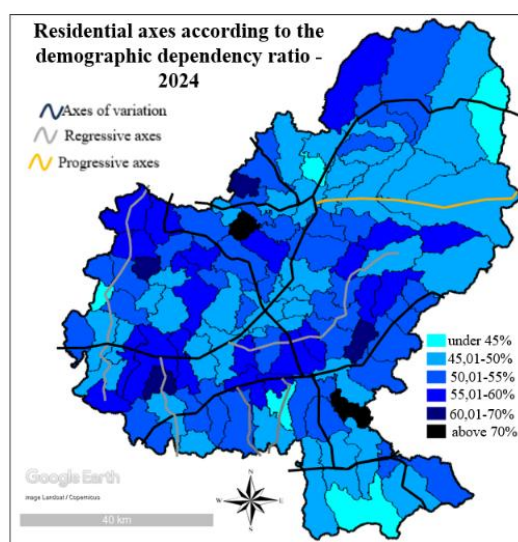


Figure 19. Residential axes – Mureș county

H) Population gender structure

Most of the axes are predominantly male, however, the female population dominates in cities and at a general level with the approximate value of 51%. Figure 20 shows the territorial distribution of the two categories according to the dominance recorded at the level of the LAU2.

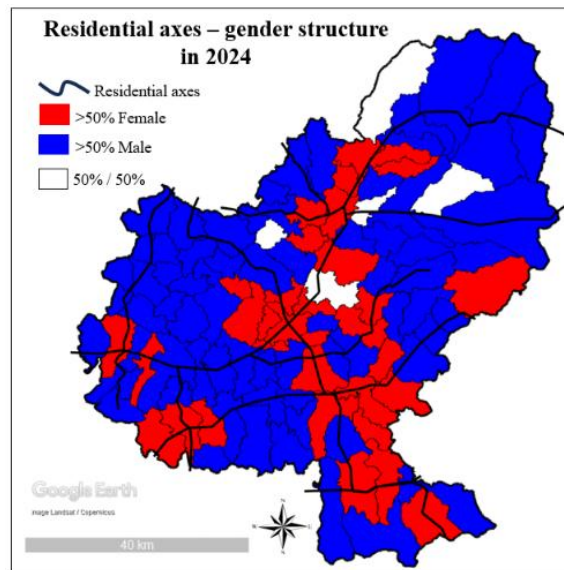


Figure 20. Gender percentage (Data Source: Institutul Național de Statistică, 2025)

I) Population ethnic structure

Spatial patterns define some areas of the county in terms of ethnicity. The status of ethnic mosaic mainly defines urban space, former fairs and industrial areas. The Mureș axis is the most colourful axis from an ethnic point of view, all the ethnicities at the county level are found here. The specific axes are either predominantly Hungarian (e.g. Nirajului Axis) or Romanian (Pârâului de Câmpie Axis, Gurghiului Axis, etc.). Figure 21 shows the housing axes according to the ethnic component, in 2021.

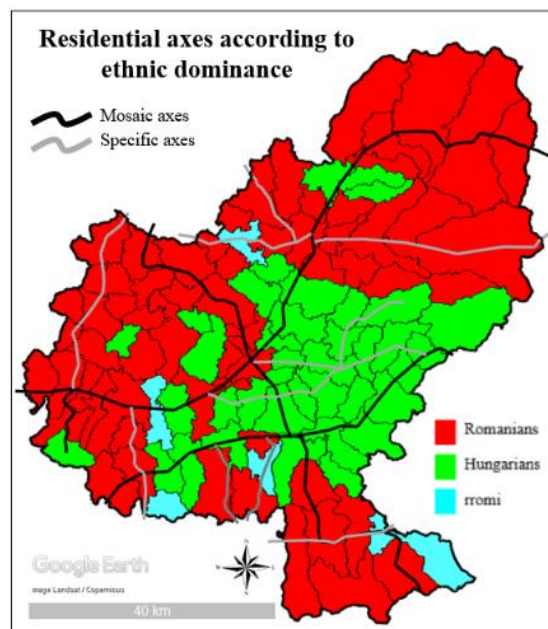


Figure 21. Residential axes defined by the ethnicity indicator

J) Population religious structure

The mosaic axes include at least two dominant religions, to which less widespread denominations are added. The specialized axes overlap the plain areas, the southern area, and

the Carpathian–Subcarpathian region for the Orthodox religion, and the Târnava Mică and Niraj Hills area for the Reformed religion. Figure 22 shows the residential axes according to the confessional structure.

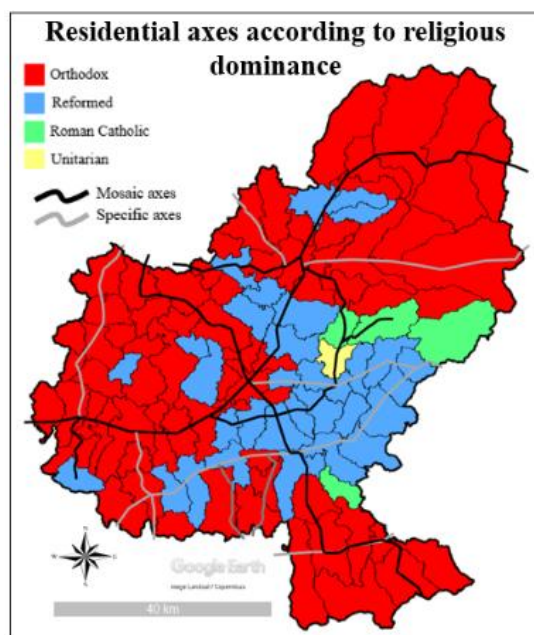


Figure 22. Spatial modelling of axes according to religious dominance

K) Marriage–divorce balance

Mureș County is a stable county in terms of the civil indicator. Figure 23 shows the balance calculated by the difference between the marriage and divorce rates in 2024.

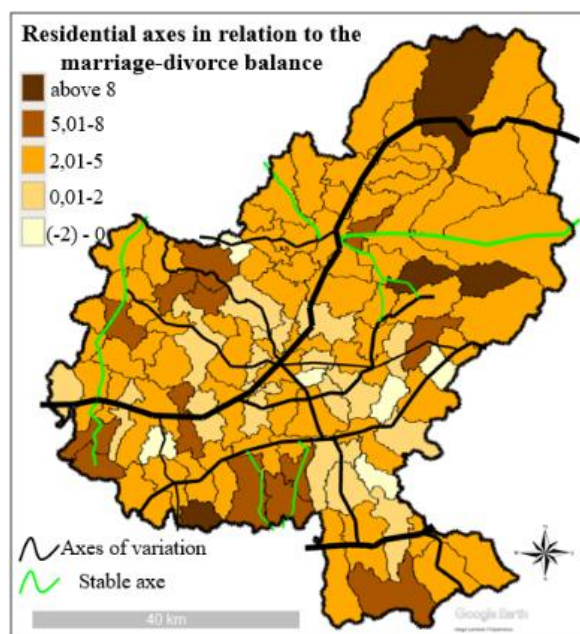


Figure 23. Residential axes in relation to the marriage-divorce balance

The vast majority of axes are in the category of variation, however there are no unstable axes. The stable axes that stand out are the Pârâul de Câmpie Axis and the Gurghiului Axis.

L) Establishment of the settlement system

The settlement system at the county level is the result of the action and relationships between a combination of factors of natural and/or anthropogenic origin.

The Mureş axis represents the main axis at the county level in relation to the demographic dimension, being supported by the median space where the largest commune residences at the county level meet in the area bordering Târgu Mureş. Figure 24 shows the distribution of commune according to population and the main axes at county level.

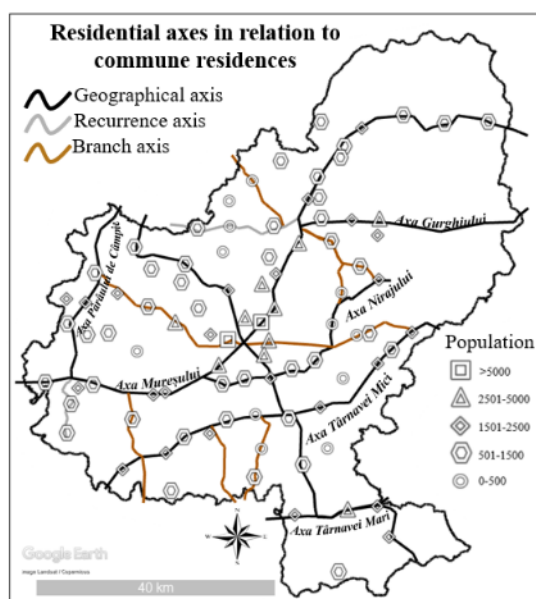


Figure 24. Residential axes in relation to the demographic size of the commune residences

The density of localities is another criterion that brings useful clues in establishing the territorial hierarchy and the role of the axes at the level of the study area. The average density of localities in Mureş County is among the highest at national level. At the axial level, the Pârâul de Câmpie axis stands out as the axis with the highest density of localities.

Another relevant indicator in terms of the classification of localities is *the relief*. The axes of variation have an amphitheatre configuration in which the altitude decreases from the northeast to southwest direction. The specific axes are actually hilly axes, which almost entirely comprise settlements located in the hypsometric range 300-400 m. Figure 25 shows the classification of the most important axes according to the altitudinal deviation.

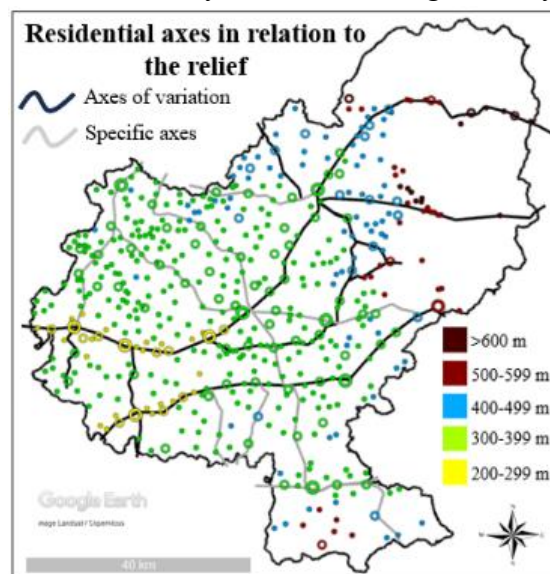


Figure 25. Residential axes framed according to relief

Axes and public utility infrastructure

The public utility infrastructure of a county is a major indicator of the territorial development. At the level of Mureș County there are relevant territorial differences between the LAUs units, which leads to the existence of a territorial inconsistency (see figure 26).

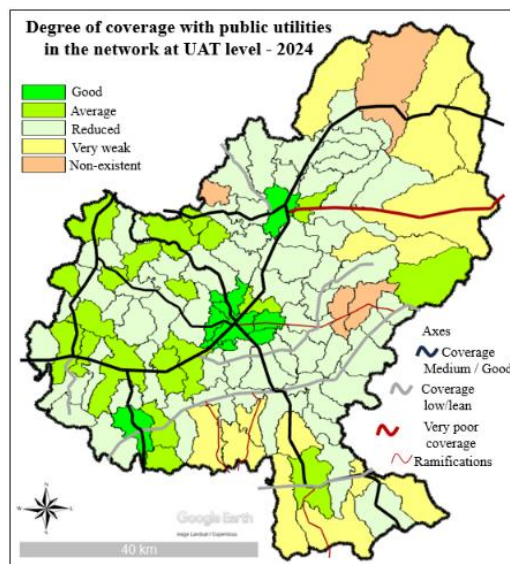


Figure 26. The local and axial situation of the public utility infrastructure at the level of Mureș County

There are significant differences between urban and rural areas. Zonally, the mountainous area, along with the sub-Carpathian area, but also the southern part of the county represents the most deficient areas in terms of public utility infrastructure. Differences are also evident between the northern and southern parts of the county, separated by the Mureș River, with higher coverage in the north. The Mureș corridor stands out, despite uneven coverage, with the highest average value in the county.

Axes, poles and energy flows

Two of the four main gas transport corridors in Romania pass through the territory of Mureș County: the North-South Corridor and the East-West Central Corridor. These two corridors represent the main axes that transport natural gas in two directions: north-south with the city of Sărmașu as its pole and on the east-west direction with the village of Coroi as its pole. Thus, two types of axes are formed: latitudinal and longitudinal, the inequality of their distribution being ascertained. The energy axes are non-existent in the north-eastern half of the county, the best covered area being the middle one.

Figure 27 shows the route of the natural gas main pipelines at the county level and the direction of transmission of flows according to the data provided by the Gas Transmission Map (gazderomania.ro, 2024).

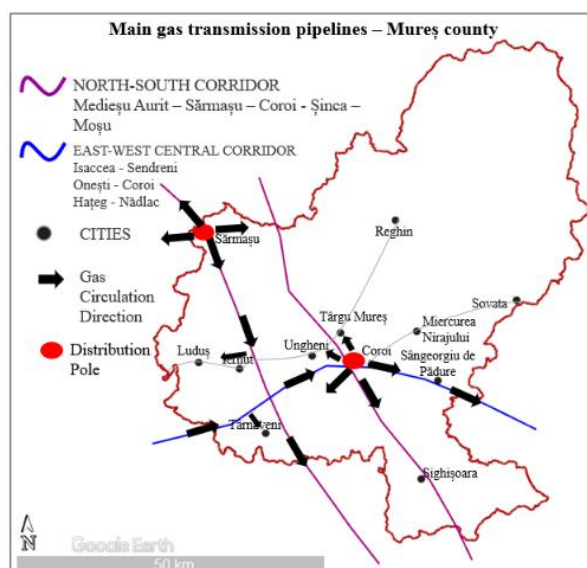


Figure 27. Gas transport at county level

The electricity is distributed at the level of Mureș County by the "Transylvania Sud Electricity Distribution Company" which holds the monopoly and manages the Transylvania Sud region. On the county map, the electricity transmission lines and pylons can be seen. Two types of axes for the transport of energy flows at county level are outlined, having as primary determinant the direction and geographical coordinates: horizontal axes and vertical axes. Figure 28 shows the county's electricity infrastructure.

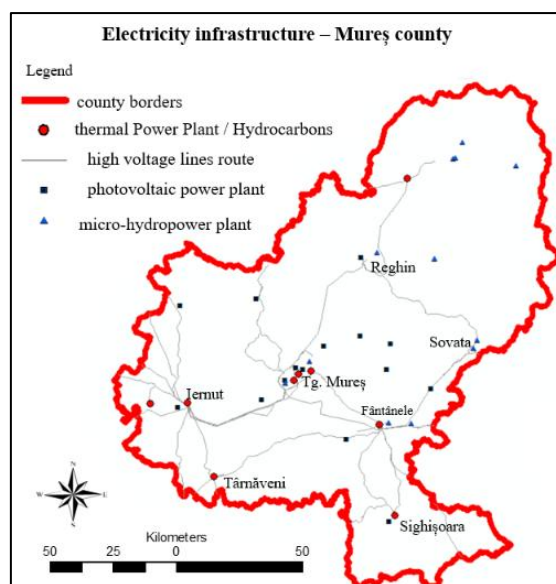


Figure 28. Electricity infrastructure route

Healthcare axes, poles and cores

The health centres are, as expected, the urban centres, and the main pole is Târgu Mureș, a relevant medical centre in Transylvania. The spatial road connections converge towards Târgu Mureș and the medical facilities available to this centre. The greatest distances to hospitals are

observed in the mountainous area and at the eastern edge of the plain. The secondary poles that serve emergencies in strategic points in the county are Târnăveni, Reghin, Luduș and Sighișoara. The main healthcare axis, in terms of both the number of facilities and the number of hospital beds, follows the Mureș corridor, particularly along the urban axis of Reghin–Târgu Mureș–Luduș. Figure 29 shows the zoning of the county according to access to emergency medical units.

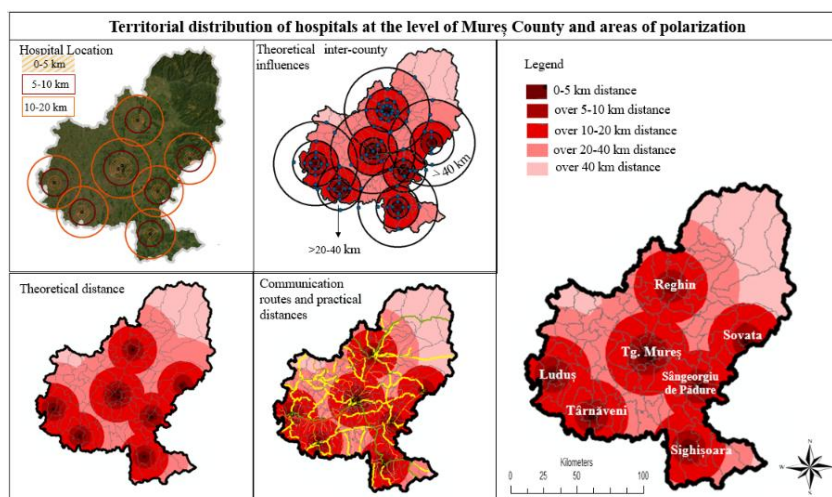


Figure 29. Zoning of the county according to proximity to public hospitals

Educational axes, poles and nodes

The educational nodes in Mureș County include all urban localities acting as attraction poles, along with three rural nodes located in strategic areas. Figure 30 illustrates the county zoning based on distance to the nearest high school.

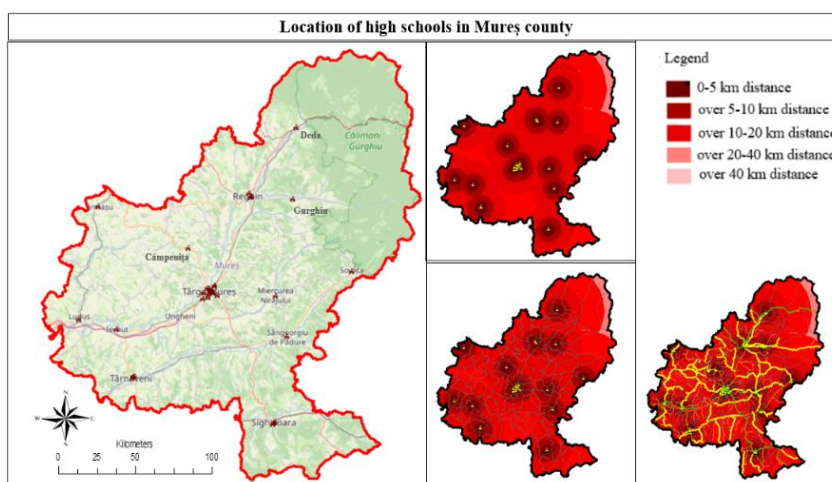


Figure 30. Territorial distance between high schools and localities in the county

The main educational axis is the Mureș axis, with high schools largely aligned along the county's main physical-geographical axes. Thus, each physical-geographical axis also has at least one educational pole. There is only one exception, the unit in Câmpenița, which is not located on a physical-geographical axis.

Economic axes, poles and nodes

Agricultural axes, poles and nodes

At the level of Mureş County, the agricultural potential is fluctuating. The lowest values are found in the mountainous and sub-Carpathian areas, while the highest potential is concentrated along the main river corridors, particularly in the plain regions. At the axial level, most axes have a fluctuating potential, being axes of variation. However, some axes show a more stable pattern. For example, the Târnava Mare Axis is characterized by consistently high agricultural potential, whereas the Gurghiu Axis exhibits persistently low potential. Figure 31 shows the agricultural potential at the LAU2 and axial level.

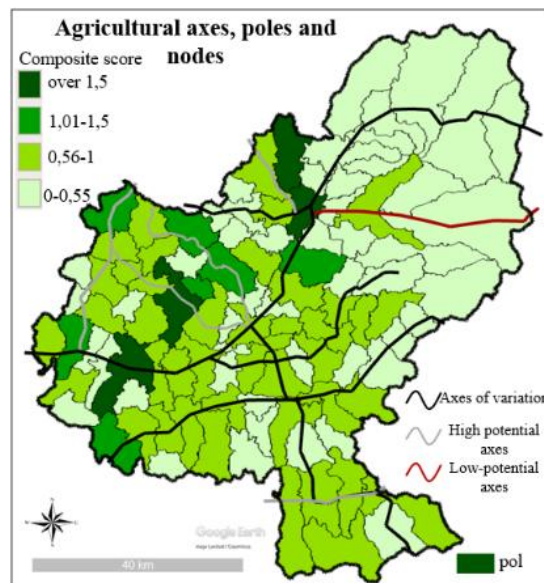


Figure 31. Agricultural potential and axial situation

Industrial axes, poles and cores

In Mureş County, five major industrial centres can be identified, corresponding to the industrial platforms developed during the communist period: the Târgu Mureş Industrial Centre, the Reghin Industrial Centre, the Sighişoara Industrial Centre, the Luduş–Iernut Industrial Area, and the Târnăveni Industrial Centre (Benedek et al., 2016).

Figure 32 presents a schematic model of the economic axes at the level of Mureş County.

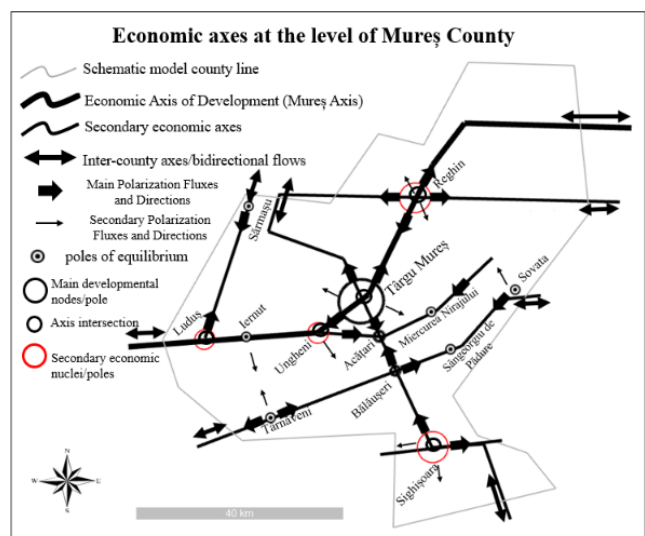


Figure 32. Schematic analysis of Mureş County from economy perspective

Tertiary axes, poles and nodes

The municipality of Târgu Mureş is the main commercial pole in Mureş County, with an impressive number of commercial units. Figure 33 shows the territorial distribution of commercial units such as national and international chains.

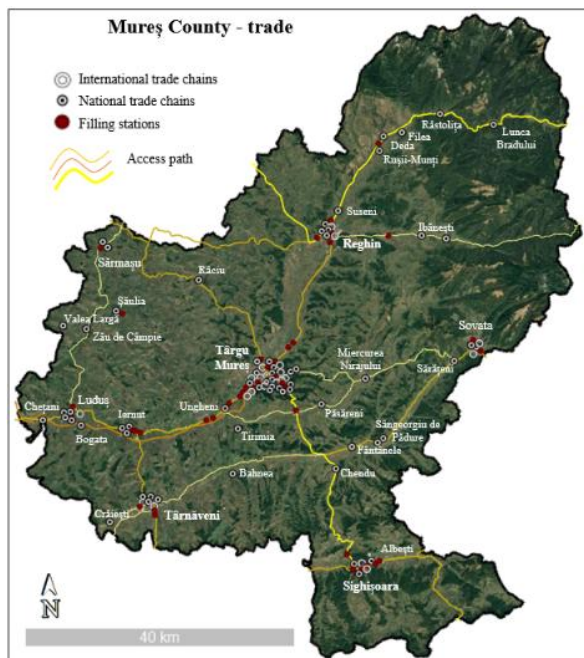


Figure 33. Commercial units in Mures County, national and international chains

The localities bordering the municipality represent a fertile ground for large commercial units and warehouses, Târgu Mureş acting as a commercial convergence zone that constantly expands its dimensions and polarization zone. The presence of international commercial units at the level of the municipalities of Reghin, Sighişoara and Târnăveni makes these units secondary commercial poles at county level. As far as trade is concerned, the Mureş Axis stands out by far as the main commercial axis at the county level.

Quaternary axes, poles and nodes

If the county seat municipality, Târgu Mureș, does not have a monopoly, the Mureș Axis does, being the only research and development axis at the county level, with the Târgu Mureș pole and Iernut and Reghin heads. An area of urbanization and polarization is formed in this area, in which Târgu Mureș has the central and primordial position, with a shadowing effect towards the neighbouring entities.

Economic situation and structure – county economic axes

The highest density of economic enterprises is recorded at the median level of the county (see figure 34). At the opposite pole is the plain area and a good part of the Târnava Mici and

Niraj Hills. The economic state and the previous spatial pattern are reinforced by the unemployment situation at the level of LAU2. In relation to these indicators, the role of the area over which the Mureş Axis overlaps, the dominant axis and the only axis of development, is outlined, imprinting its direction and rhythm (Someşan & Pop, in press).

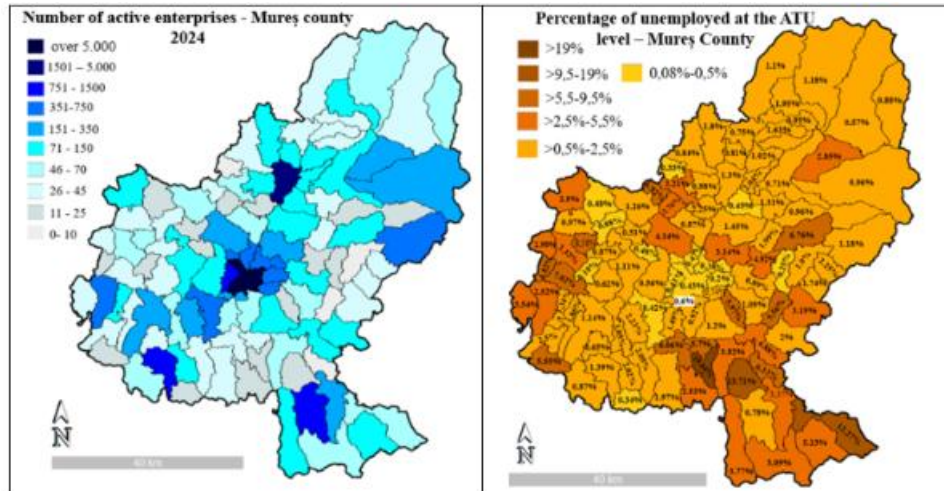


Figure 34. Existing enterprises / unemployed, 2024 (Source: Someşan & Pop, in press)

The value of the economic dependency ratio is, at the level of Mureş county, between 102.4% in Corunca and 395.6% in Zagăr. The metropolitan area of Mureş County registers the best values, which extend to the entire Mureş Corridor. The hills of Târnava Mici and Târnava Mare are the most vulnerable areas. All the axes at the county level register situations of imbalance, but the Mureş Axis with the urban centre of Târgu Mureş has the most favourable position (see figure 35).

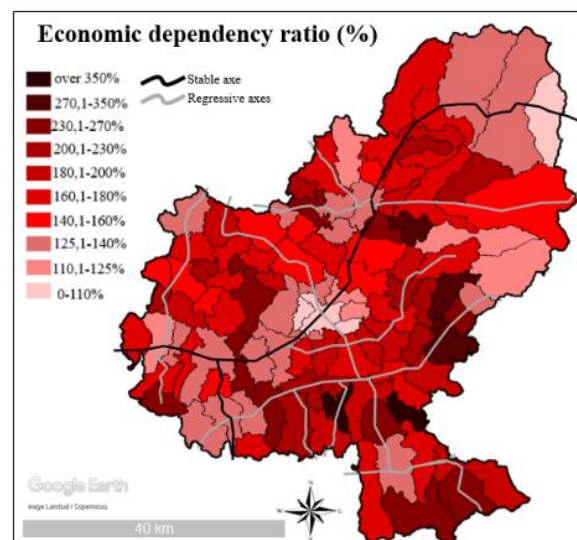


Figure 35. Residential axes economic dependence

Although the dominance of the tertiary sector is univocal at the territorial level, the traditional profile of some axes at the level of Mureş County can be observed. Figure 36 shows the geographical axes outlined by the traditional economic profile at the level of Mureş County.

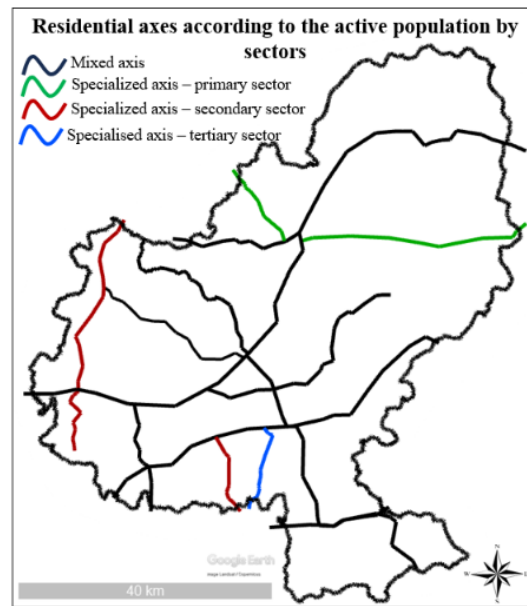


Figure 36. Residential axes outlined according to the active population by dominant sectors

The Mureș axis represents a mixed axis, with areas of domination for each sector of activity. The upstream area of Reghin stands out for its primary sector, the Reghin-Ungheni area for services, and the downstream area for Ungheni-Chețani for its secondary sector. Mixed axes are also the Târnava Mici Axis, the Târnava Mari Axis, the Nirajului Axis and the longitudinal axis of the county. The specialized axes have either a primary profile (Gurghiului Axis, the latitudinal axis of the county) or a secondary profile (Pârâul de Câmpie Axis).

Axes, poles and tourist flows

The territorial distribution of the natural potential is uneven at the level of Mureș County. The highest natural potential is found in the mountainous and sub-Carpathian areas, within the communes of Sovata, Lunca Bradului, Răstolița, Stânceni, Deda and Ibănești. At the level of Mureș County, there is a clear value differentiation between the over 1000 elements present in the list of historical monuments. The fortified urban ensemble in Sighișoara together with the Medieval Fortress of Sighișoara, included in the UNESCO World Heritage Site, are the most valuable objectives.

Distribution of tourism potential by forms of tourism

The most developed individual tourist destinations are the cities of Târgu Mureș, Sighișoara and Sovata. Târgu Mureș is the tourist pole that stands out due to the varied tourist offer, Sighișoara is the pole of cultural tourism, and Sovata the pole of spa and relaxation tourism. Figure 37 shows the classification of the LAU2 according to the tourist potential.

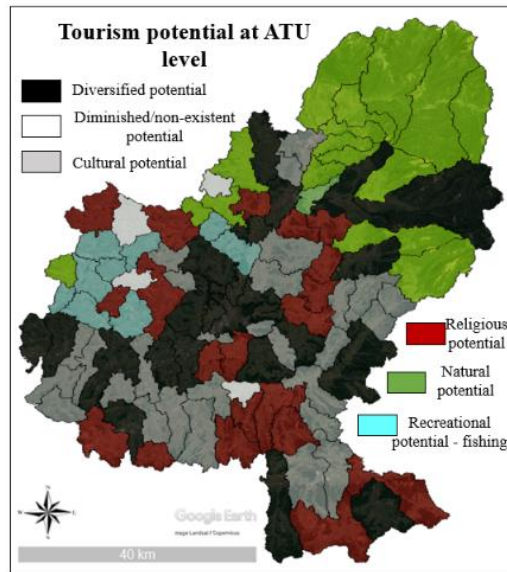


Figure 37. Dominant tourism potential at LAU2 level

At the county level, the city of Târgu Mureș is the main pole, followed by Sighișoara, the communes of Lunca Bradului and Răstolița. Figure 38 shows the tourist axes at the county level and their situation in relation to the score determined by the AHP method.

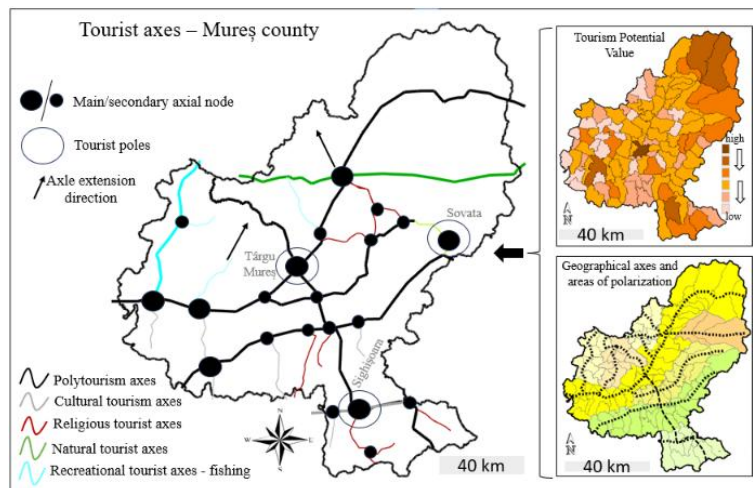


Figure 38. Tourist axes at the level of the study area

The main axes are most often poly-tourism axes, from which recurrence axes are detached in the form of specialized tourist axes. Thus, axial nodes are formed at the level of each axis, which can develop as secondary poles and direct flows.

Axial tourism and sustainable development

Tourism axes are useful tools for the sustainable development of tourism because they can decisively intervene in the achievement of at least 4 of the 5 major objectives for sustainable development.

1. Creating a distinct regional tourism identity:

Tourism axes have the capacity to integrate and structure the tourism offer, facilitating the transition from isolated tourism development (focused on individual destinations) to a more extensive and interconnected form of tourism. In this way, they combine dispersed attractions into a coherent and attractive package, generating significant benefits for locations that lack a high concentration of tourism resources. This linearity can manifest itself due to the geographical deployment of the axis or due to the similarity of the objectives.

At the national level, in order to create a country brand, it is envisaged to create thematic routes that are actually tourist axes. The "Attractive Romania" project aims to develop sustainable cultural tourism by creating a network of 12 thematic cultural tourist routes at national level (romania-atractiva.ro, 2025).

2. Diversification and modernization of the tourist offer:

The diversification of the tourist offer can be achieved by accumulating the isolated potential at the level of a geographical space. For example, the Niraj Valley in Mureș County comprises 13 communes, of which only one commune has an approximately varied tourist potential. The presentation of the tourist offer in the form of the "Niraj Valley" brand leads to the transformation of an area with a low potential into an area with an attractive potential. This cumulative and complementary management mode makes the unitary management, the "Niraj Valley", a model at micro-regional level in terms of sustainable tourism (Someșan, 2024).

3. Improving tourism infrastructure and tourism services:

Due to the dispersion of the tourist offer and the guidance of tourists to isolated areas in terms of location and tourist potential, the development of specific and associated infrastructure is promoted. This connection is logical, a constant tourist flow supports the development of accommodation, public catering and leisure units, and this economic opportunity, often supported by European and national funds, is a tempting offer for investors.

4. Harnessing sustainable tourism, environmental and heritage protection:

Specialized tourist axes, such as the cultural routes presented above, aim at preserving heritage and restoring it. Moreover, axial tourism also incorporates isolated tourist attractions into the overall tourism offer, which leads to a dispersion of tourist flows. This, in turn, reduces the concentration of visitors at the most popular sites—an accumulation that often exceeds the environmental carrying capacity. Some forms of axial tourism target tourist routes that promote environmental protection and connection with nature, as is the case of the "Via Transilvanica" route. The result is a type of sustainable tourism that includes vulnerable communities due to isolation and leads to economic and intellectual growth through tourism and human interaction.

Axes of communication and spatial relations

The communication axes correspond mostly to the main valley corridors: Mureș Corridor, Târnavei Mici Corridor and Târnavă Mari Corridor. Thus, the network of roads and railways follow the main valleys and sometimes connect them. Figure 39 shows the classification of the localities at the level of Mureș County according to territorial accessibility.



Figure 39. Classification of localities according to accessibility

The road network is better developed and serves the county more balanced, compared to the railway network which is undersized.

Functional role of communication axes in established spatial relationships

Railway axes are communication routes through which flows travel on a predetermined route from one point to another. Railway axes establish spatial relationships between different points by facilitating exchanges. The frequency of movement and its direction indicate the importance of the axes and the type of relationships that are established at the level of the transport or communication axis.

The Târnavă Mici axis has the most unfavourable position, being a divided axis in terms of rail transport, and its functionality can be questioned. The railway communication axis outlined in the area of the Pârâul de Câmpie is also questioned. The Târnavă Mare axis is a functional axis that connects with the southern part of the country. Sighișoara is the pole of this axis, but the locality of Vânători is constituted as a railway junction. Figure 40 shows the status and situation of the rail-type communication axes.

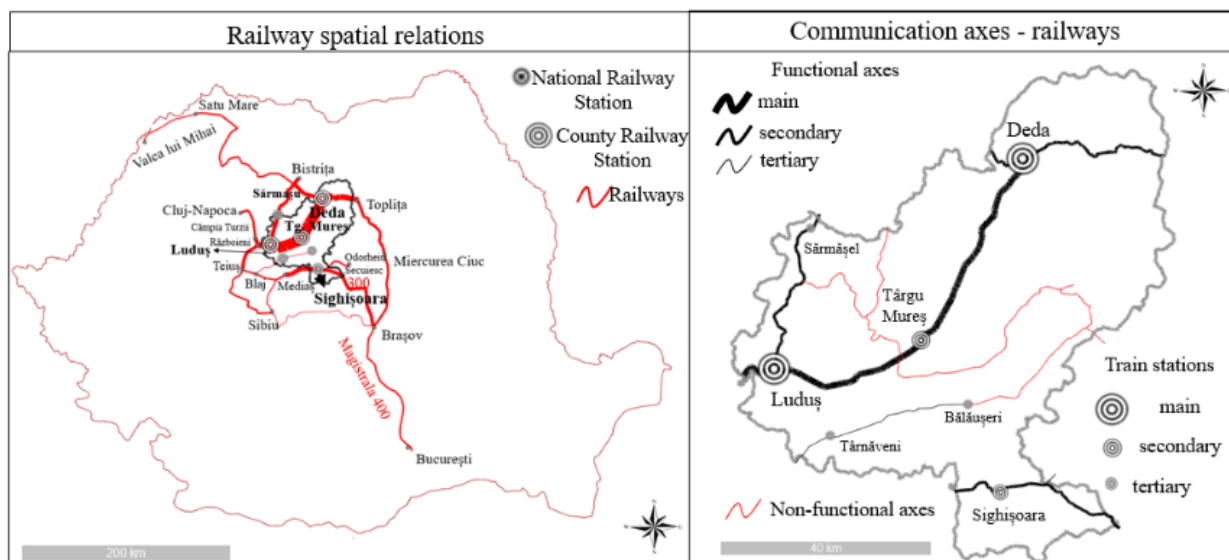


Figure 40. Types of relationships and axes from a technical point of view

Major communication routes most often serve important cities and economic centres within a region. In Mureș County, particularly along the first section of the Mureș Axis, a doubling or even tripling of communication routes can be observed, reflecting the transport infrastructure that serves these physically and geographically defined axes. This couple allowed the construction of communication routes that facilitate county and inter-county relations, emerging as favourable factors for economic development and expansion. A good relationship is observed in the natural direction of flow, on the three relatively parallel axes: the Mureș Axis, the Târnavea Mici Axis and the Târnavea Mari Axis. Most large enterprises at the county level are located in the area bordering these axes. The functionality of these axes is ensured by both road and rail access.

Regarding freight transport, the location of the main enterprises (see figure 41) shows the areas most targeted in the location of economic activities.

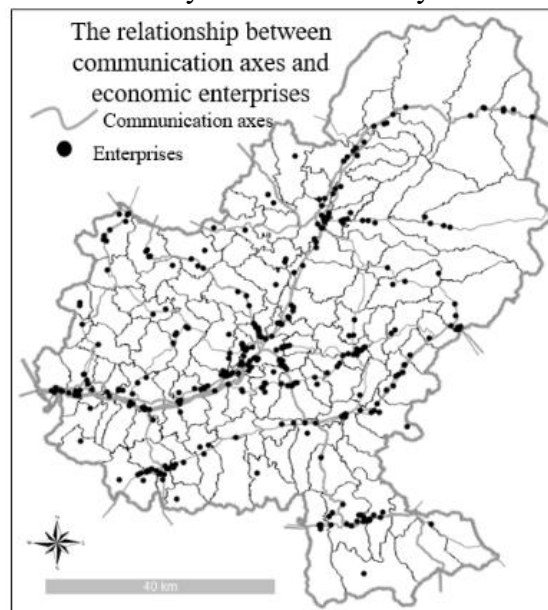


Figure 41. Location of main enterprises in relation to communication axes

In relation to the connectivity with the main national and European routes, Mureș County is in a median position, but does not have a direct connection with the main European corridors. Figure 42 illustrates the position of Mureș County within the TEN-T network and the strategic axes supporting improved territorial connectivity.

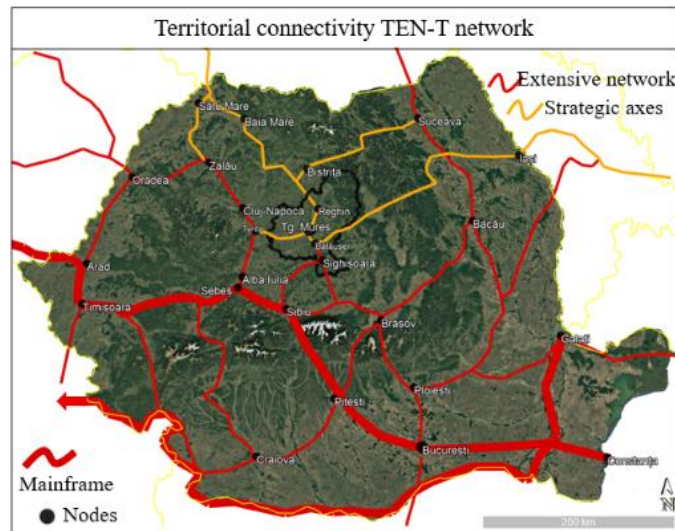


Figure 42. Mureș County's position in relation to European connectivity
(Data Source: <https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home>)

Geographical axes and the situation of Mureș County

Synthesizing the county-level results in relation to the geographical axes requires a critical analysis of the factors involved in territorial formation and consolidation. The analysis carried out led to the ranking of the LAU2 and geographical axes according to their potential and role. Figure 43 presents the result of the analysis according to the "TOPSIS Method".

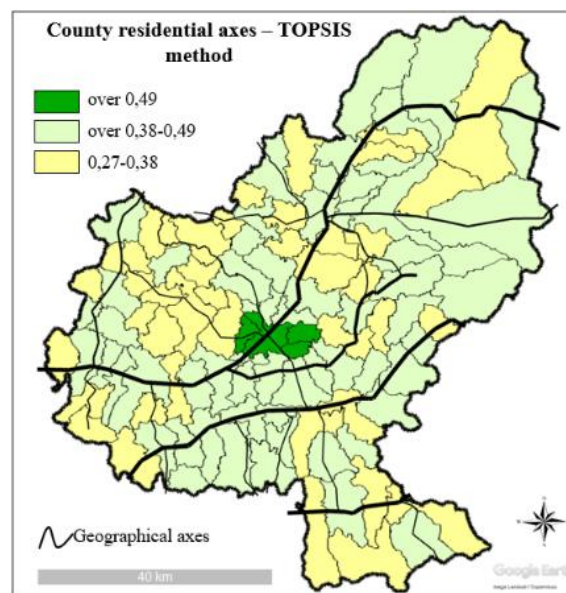


Figure 43. Geographical axes and classification of LAU2 according to the TOPSIS

In addition to the previous method, it is applied at the level of the study area "VIKOR Method" (see figure 44). Although they present two different ways of analysing reality, resulting in significant differences, the role of geographical axes in the context of the county system is emphasized. The application of the TOPSIS and VIKOR methods allows a rigorous and complementary multi-criteria evaluation of the analysed alternatives.

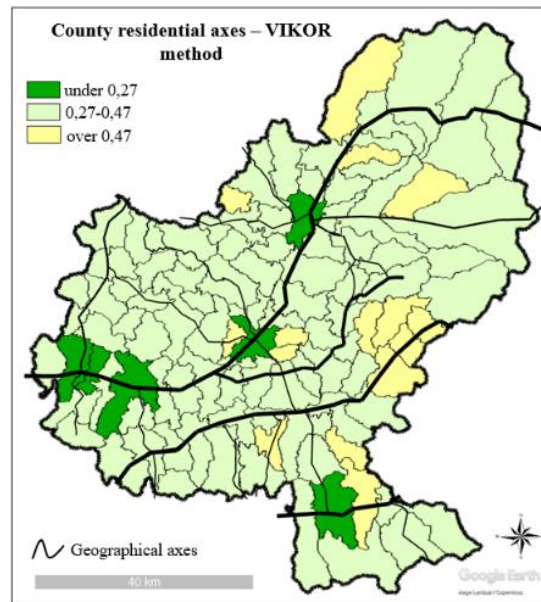


Figure 44. Geographical axes and classification of LAUs according to the VIKOR method

TOPSIS provides a clear ranking based on proximity to the ideal solution, while VIKOR highlights the optimal compromise solution. The combined use of the two methods helps to increase the credibility and consistency of the results.

Territorial differences are highlighted, and the link between the local situation and geographical axes is clear. The potential position is directly related to the geographical axis and its status at the territorial level. The Mureș Corridor and the Mureș Axis represent the best positioned area, regardless of the method used. If in the case of the TOPSIS method the cities or poles at the level of the axis have a predominantly positive role in propagating development, as far as the VIKOR method is concerned, their "shading" effect on the proximal areas is also highlighted.

In terms of vulnerabilities, there is a clear difference in the framing between the two methods, but also strong commonalities. First of all, the main poles are clearly outlined: Târgu Mureș, Sighișoara, Reghin, Luduș and Târnăveni, although with a weaker position. Secondly, the stronger position of the middle area of the county can be observed. Thirdly, and most relevant to the analysis, it is noted that some of the territorial administrative units outside an axis have a vulnerable position and status.

Geographical axes can be outlined as tools for territorial diagnosis and spatial classification. EU cohesion policy (Regulation (EU) 2021/1057 for 2021–2027) classifies regions as less developed, in transition, or more developed, based on economic and social criteria guiding financial support and investment, with GDP per capita as the main indicator. In this context, geographical axes provide objective criteria for spatial assessment and support targeted policy intervention.

CONCLUSIONS

Mureş County should be aligned with sustainable development objectives, aiming to become a “green, digital, and innovative county” with well-developed and economically efficient infrastructure. Granting the title of single solution and completely adapted to the county needs to the axial approach and the application of axial strategies is an exaggeration. However, the axes as a generic title for a concept explored and used in this work, offer solutions, and within the study area they can: supports the green county by avoiding congestion and directing flows, promoting digitalization and innovation by developing medical and educational hubs in relation to territorial needs, highlighting vulnerable areas and possible links for infrastructural development, amplifying the tourism potential by involving the isolated offer, balancing the territory by avoiding sensitive points and isolated areas, cultivating sustainable economic development by stimulating the county balance.

Geographical axes are those areas that support, from multiple points of view, economic development. Combined with the right strategies, they bring balance, which provides a bridge for sustainable economic development. At the level of Mureş County, the role of supporting the geographical axes is very clearly observed. These are already developed areas, and their role as bridges is achieved by directing flows to isolated areas. This role is fulfilled by means of the poles towards which the recurring axes or ramifications converge.

Thus, geographical axes can be defined as linear trajectories of development and directed propagation of material and immaterial flows, their role being directly proportional to the polarization capacity based on physical-geographical factors and supported by anthropogenic ones through poles, strategies and targeted interventions.

In conclusion, the potential of Mureş County is directly proportional to the axial potential, and its spatial division reflects the status of the axis. The development/main axes of the county hold the monopoly and represent areas of attraction with positive effects for the neighbouring area and negative effects for the outdoor space.

The limitations of the present study overlap with the limitations determined by the study of geographical axes and are represented by:

- the dynamic character of the axes and their situation, the sensitivity to the time factor and the changes brought about by it;
- excessive generalization, being a study aimed at the county situation, some local particularities are excluded;

- the quantitative and qualitative inconsistency of the statistical data provided by the competent institutions;
- the artificial truncation of axes that do not end at the county level;
- the lack of clear quantitative indicators for measuring the 'functionality' of an axis;
- results sensitive to changing weights (e.g. multi-criteria methods);
- subjectivity that can overlap over the name of some types of axes, which can create interpretative ambiguities, but which cannot be avoided because there is no clearly defined conceptual framework;
- not all territorial relationships are axially structured.

The limitations of this study concern both the scale of work and the ambiguity that sometimes accompanies the concept of "geographical axes". The lack of a clearly defined and accepted conceptual framework makes the study of axes a challenge that requires an interdisciplinary approach.

The needs identified in terms of geographical axes are related to the creation of a clearly defined and accepted conceptual framework, and as far as the study area is concerned, they are related both to the usefulness of axial analysis at micro-scalar level, for identifying the local specificity that is neglected in regional studies, and to the focus on inter-county relations.

This study represents a territorial analysis of the degree of development of Mureș County in accordance with the position potential determined by the location in relation to a line of force, a line that in this case represents the director of potential and development. This type of study can be adapted to any area and provides useful information that targets both the current situation and the development potential, being ultimately a trilateral diagnosis-prognosis-intervention study, with practical utility and considerable adaptability.

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