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MULTITEMPORAL ANALYSIS OF THE RELATIONSHIP BETWEEN LANDFORMS AND URBAN EXPANSION. CASE STUDY: CLUJ-NAPOCA, ROMANIA

Maria HOSU[1*], Flavia-Oana NAN[2]

ABSTRACT. – Multitemporal Analysis of the Relationship between Landforms and Urban Expansion. Case Study: Cluj-Napoca, Romania. Given the current trend of urban development in Cluj-Napoca, the growing demand for land, and the expansion of the built-up area, this study aims to analyze the effects of urban development on landforms, while also establishing their functionality in an urban context. A multitemporal and multidisciplinary approach is essential for understanding the dynamics between relief and urban expansion, combining data from geomorphology, history, and urban planning. Field research is fundamental to this study for observations and direct verification of data. The analysis method exploits the principles of data overlay and spatial analysis using GIS (Geographic Information System). The starting point was the premise that within the urban area, the dynamics of the relief and/or the evolution of the geomorphological landscape are strongly influenced by anthropogenic action. The multidisciplinary integration of data facilitated the recognition and reconstruction of geological and geomorphological characteristics and changes in the function of the relief during urban expansion and the reconfiguration of land use: areas that were previously classified as unsuitable for construction and delimited as extra-urban, used mainly for agriculture, are now revalued as buildable land as a result of pressure from urban expansion. In other words, land is undergoing a process of functional reevaluation, in which the values and roles of landforms are reinterpreted according to the needs of urban development.

Keywords: *urban geomorphology, multitemporal analysis, multidisciplinary approach, Cluj-Napoca*

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1. INTRODUCTION

Cities around the world have developed on different geological and geomorphological structures, which has led to urban geomorphology studies being of great interest worldwide. This is due to the challenges that contemporary society must respond to in relation to the increase in urban population density and the intensification of anthropogenic activities in cities, and implicitly, the increase in the rate of urbanization. 70% of the world's population will live in cities by 2050, the growing demand for land will favor the uncontrolled expansion of built-up areas, affecting and disrupting any type of natural system surrounding the urban area itself (United Nations, Department of Economic and Social Affairs, Population Division. Revision of the World Urbanization Prospects, 2018).

Urban geomorphology is a recent subject, and its theory and practice require continuous updates. However, few studies have focused on issues specifically related to historical changes in landforms in urban areas, with the aim of reconstructing and clarifying the physical landscape, as well as determining the role attributed to landforms by the population. The IAG has set up an Urban Geomorphology Working Group with specialists from several countries with the aim of developing research methodologies to better understand the effects of urban development on geomorphological processes and landforms, in the context of increased hydrogeomorphological risk, also linked to climate change scenarios (P. Brandolini *et al.*, 2012). An additional theme is the assessment and consolidation of cultural geo-heritage in urban areas (Z. Zwoliński *et al.*, 2018).

In the field of urban geomorphology, there are specific studies and methodologies at the national level for analyzing the relationship between urban planning and geomorphological support in terms of favorability and/or restrictiveness. Among the major collective field works, one should mention those relating to the "systematization" plans of over 66 cities (initially), guided by the Institute of Geography, under the coordination of researchers V. Mihăilescu, V. Tufescu, and N. Pop (1949), and T. Morariu (1978).

In the field of urban geomorphology, humans act as geomorphic agents that transform the natural morphology into an urban landscape. Urban geomorphology represents the surface component of urban geology and constitutes an important subfield of environmental geology (D. Coates, 1976). Human settlements in general, and urban settlements in particular, expand in accordance with the configuration of the topographic surface, which undergoes changes depending on planning and construction needs (F. Ahnert, 1996). Other factors influencing geomorphological processes in urban environments include the degradation of building material due to air pollution (H.A. Viles *et al.* 1993).

F. Anhert (1996) argued that the geography of human settlements is incomplete without taking into account the morphology and hydrology of the area. Thus, it is essential to understand the dynamic interaction between different aspects of urban expansion, such as: the expansion of built-up areas, construction activities that affect natural elements, leading to the diversion and destruction of aquifers and geomorphological features specific to the urban area. Local landforms or geomorphic features have played a fundamental role in the location and development of human settlements throughout the history of civilization (A. Łajczak *et al.* 2021). In order to prosper, human communities have always assessed the local topographic configuration and favorable hydrological conditions.

With urban expansion and construction activities carried out over the years, the topography of the area is gradually changing (A. Łajczak and R. Zarychta, 2024). These transformations ultimately influence the rate of geomorphological processes such as erosion, areal processes, and weathering of rocks (H. A. Viles *et al*., 1993).

Recent studies have attempted to propose new strategies for detecting and mapping human-induced changes in topography, and the classification of anthropogenic landforms has recently been further developed in the revised Italian national guidelines for geomorphological mapping proposed by AIGeo (Italian Association of Physical Geography and Geomorphology) and ISPRA (Institute for Environmental Protection and Research). Geomorphological studies in urban environments allow the reconstruction of the physical landscape before human changes and the implementation of innovative methodological tools, as well as an effective legend to represent urban landforms and their evolution over time (F. Vergari *et al*., 2022).

Therefore, at the international level, current research focuses on developing methods and tools for assessing, defining, and monitoring the impact of metropolitan growth on geomorphology (P. Mozzi *et al.*, 2016; M. Del Monte *et al.*, 2016), the constraints imposed by geomorphology on urban development (R.U. Cooke 1976); the suitability of different landforms for areas of urban functionality (M. Del Monte, 2022); the creation of anthropogenic landforms in the urban landscape (I. Douglas 2016; J. Szabó *et al.,* 2010; M. Del Monte *et al.,* 2013); geomorphological risks in urban environments (F. Pratesi *et al.,* 2016); methods of geomorphological research and mapping in urbanized areas and/or areas profoundly modified by human activities (P. Brandolini *et al.,* 2018; Z. Zwoliński *et al.,* 2018); relationships between geomorphological changes in urban areas and archaeological and historical data (P. Mozzi *et al.*, 2016; M. Del Monte *et al.*, 2016); the geological model of anthropogenic resources (and their interactions with geotechnics, hydrogeology, and underground infrastructure design) (G.M. Luberti *et al.*, 2019).

Given the current trend of urban development in Cluj-Napoca, the growing demand for land, and the expansion of the built-up area, this study aims to analyze the effects of urban development on landforms, while establishing their functionality in an urban context. A multitemporal and multidisciplinary approach is essential for understanding the dynamics between landforms and urban expansion, combining data from geomorphology, history, and urban planning.

2. STUDY AREA

Cluj-Napoca has an area of around 179.5 km² and borders the local administrative units of Feleacu, Tureni, Apahida, Chinteni, Baciu, Florești, and Ciurila (fig. 1a).

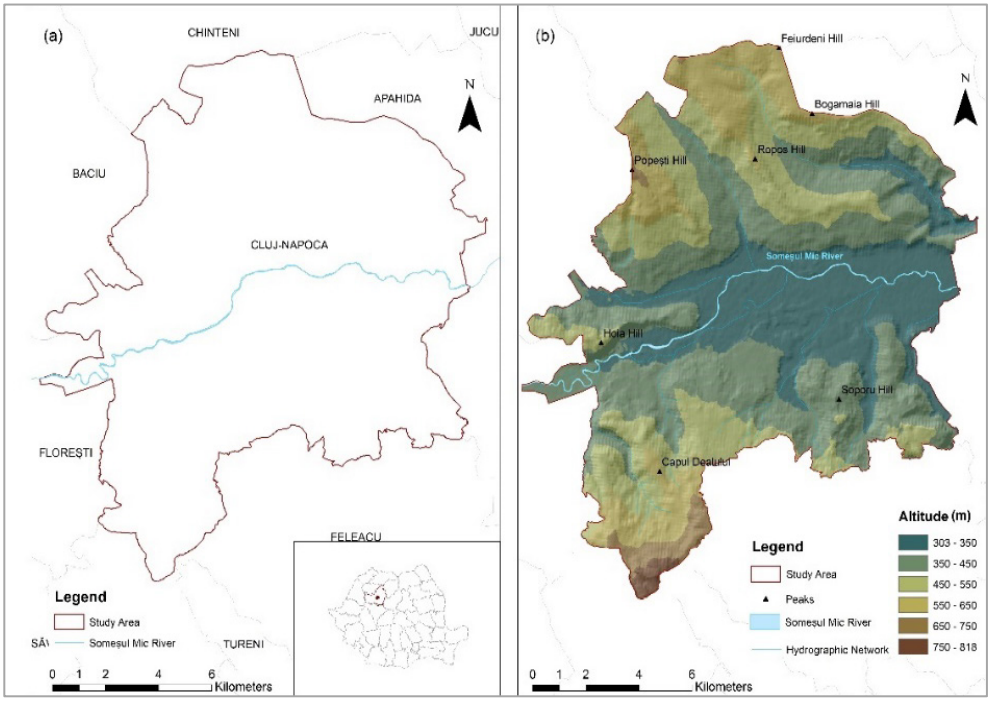

Fig. 1. a. The study area in relation to neighboring administrative units. The map shows the location of the study area within Romania;
b. Hypsometric characteristics of the study area.
Source: the authors

A note of originality can be found in the contact between several landform units, as is the case with the territory surrounding the city of Cluj-Napoca. It is located at the confluence of Someşul Mic and Nadăşul rivers, at the contact point of three major morphological units - the Apuseni Mountains, the Someş Plateau, and the Transylvanian Plain - borrowing from the characteristics of each, which leads to a combination of landform features and makes it difficult to decipher the different geomorphological sectors.

In the study area, from a hypsometric point of view, there are values between 300-350 m a.s.l., which correspond to the floodplain and lower terraces of Someşul Mic River and the floodplain of Nadăş River; 350-450 m. a.s.l, representing the upper river terraces and limited portions of the low-lying areas. The altitude level of 450-650 m above sea level is attributed to the high-lying areas, structural areas, and slopes. These altitudes occupy the northern, southern, and southeastern parts of the study area. Altitudes higher than 650-700 m above sea level cover a small portion, in the form of peaks, developed on resistant rocks within the high interfluvial areas (fig. 1b).

We chose to study the municipality of Cluj-Napoca because it represents one of the urban structures with the most dynamic urban expansion in Romania, with an increasing demand for land and expansion into extra-urban areas. All of this leads to significant pressure on the relief with major changes in the initial surfaces.

3. MATERIALS AND METHOD

3.1. Multitemporal and multidisciplinary approach

Urban geomorphological studies on European cities have contributed substantially to the development of a methodological approach. In this paper, we will use the methodology developed and proposed in 2016 (M. Del Monte et al., 2016) and improved in 2020 (G.M. Luberti et al., 2020) by the Working Group on Urban Geomorphology of the Italian Association of Physical Geography and Geomorphology (AIGeo). The methodological approach is structured in three sequences: (a) storage of data from scientific literature and cartographic materials; (b) multitemporal and multidisciplinary interrogation; (c) field research and data completion.

The multitemporal and multidisciplinary methodological approach is based on: (a) interpretation of aerial photographs; (b) analysis of historical cartographic documents and comparison of data with current morphology; (c) analysis of rock types and deposits from data taken from geotechnical studies; (d) morphographic and morphometric evaluation; (e) data collection from historical documents and archaeological reports.

The strength of the method lies in its multidisciplinary approach: it integrates historical data on urban evolution in relation to the relief, field data, and multi-temporal geological, geomorphological, and geognostic data. Furthermore, this method, which is well known in Western and Mediterranean Europe, can be applied to all expanding European urban areas. The municipality of Cluj-Napoca is an example of such an urban area, so we would like to apply this methodological approach to this city as well. More specifically, we want to apply a method that is highly useful in international urban geomorphology studies to a territory in Romania. The GIS environment allows for the management of data overlay and the morphometric processing of historical data. ERDAS Imagine is used to interpret satellite images.

Field research is fundamental to this study for observations and direct data verification. The analysis method exploits the principles of data overlay and spatial analysis using GIS software. We start from the premise that in urban spaces, the dynamics of the relief and/or the evolution of the geomorphological landscape are strongly influenced by anthropogenic action. Multidisciplinary data integration allows for the recognition and reconstruction of geological and geomorphological characteristics and changes in relief function during urban expansion.

3.2. Data

In this study, the methodological approach described above was based on consultation, analysis of cartographic materials, interrogation, and superimposition of data layers (table 1).

Table 1. Summary of the cartographic supports used in this study

Data type	Year	Producer/ Provider	Process	Result
Map of the Roman site	2012	Acta Musei Napocensis, 49/I, 2012, pp. 83–108	Establishing the boundaries of the Roman city	Layer with the boundaries of the built-up area
The 2011 Cluj-Napoca PUG Baseline Study for determining protected areas with significant cultural value	2010	Cluj-Napoca	Establishing the boundaries of the first medieval enclosure and the medieval fortress	Layer with the boundaries of the built-up area
Historical map (Josephine)	1763	First Habsburg topographic campaign. Arcanum Maps	Georeferencing digitization	Layer with built-up area boundaries

Data type	Year	Producer/ Provider	Process	Result
Historical map (Franciscan)	1853	Second Habsburg topographic campaign. Arcanum Maps	Georeferencing digitization	Layer with the boundaries of the built-up area,
Historical map (Neue Aufnahme)	1869	Third Habsburg topographic campaign. Arcanum Maps	Georeferencing digitization	Layer with the boundaries of the built-up area
General Urban Plan	1976–1998	Cluj-Napoca City Hall	Georeferencing digitization	Layer with the boundaries of the built-up area
General Urban Plan	1998–2011	Cluj-Napoca City Hall	Georeferencing digitization	Layer with the boundaries of the built-up area
General Urban Plan	2011	Cluj-Napoca City Hall	Georeferencing digitization	Layer with built-up area boundaries
General Urban Plan	2014	Cluj-Napoca City Hall	Georeferencing digitization	Layer with built-up area boundaries
Geological Map of Romania 1:200,000	1964	Romanian Institute of Geology	Geoprocessing	Geological map of the study area
EUDEM_ STEREO70	2000	Copernicus Land Monitoring	Geoprocessing	Hypsometric map of the study area
CLC 1990	1990	Copernicus Land Monitoring	Geoprocessing	Land use map 1990
CLC 2018	2018	Copernicus Land Monitoring	Geoprocessing	Land use map 2018
P199R027_2X19750430 (satellite image)	1975	Earth Explorer. USGS. Landsat2	Photo interpretation	view of urban landforms
P185R027_5X19920925 (satellite image)	1992	Earth Explorer. USGS. Landsat5	Photo interpretation	Visualization of landforms
LE71850272005280AS N01 (satellite image)	2005	Earth Explorer. USGS. Landsat7	Photo interpretation	Visualization of landforms
LT51850272011241MO R02 (satellite image)	2011	Earth Explorer. USGS. Landsat5	Photo interpretation	Visualization of landforms
1:25,000 military topographic map	1975-1987	Defense Geospatial Intelligence Agency	Geomorpho-logical mapping of river terraces	Map of the river terraces of Someşul Mic
Historical photographs	End of the 19th century Early 20th century Mid-20th century Late 20th century	Collection "History of Photography in Cluj"	Interpretation	Determination of changes undergone: the bed of the Morii Canal, the bed of the Someşul Mic River, the Cetăţuii Hill

Source: the authors

3.2.1. Geological data

The territory of Cluj-Napoca municipality contains Paleogene (Upper Eocene, Oligocene), Neogene (Lower-Middle Miocene), Pleistocene, and Holocene deposits structured into several formations with local names.

The geology of the study area is represented by processing the geological map at a scale of 1:200,000 and 1:50,000 produced by the Geological Institute of Romania (IGR) (fig. 2).

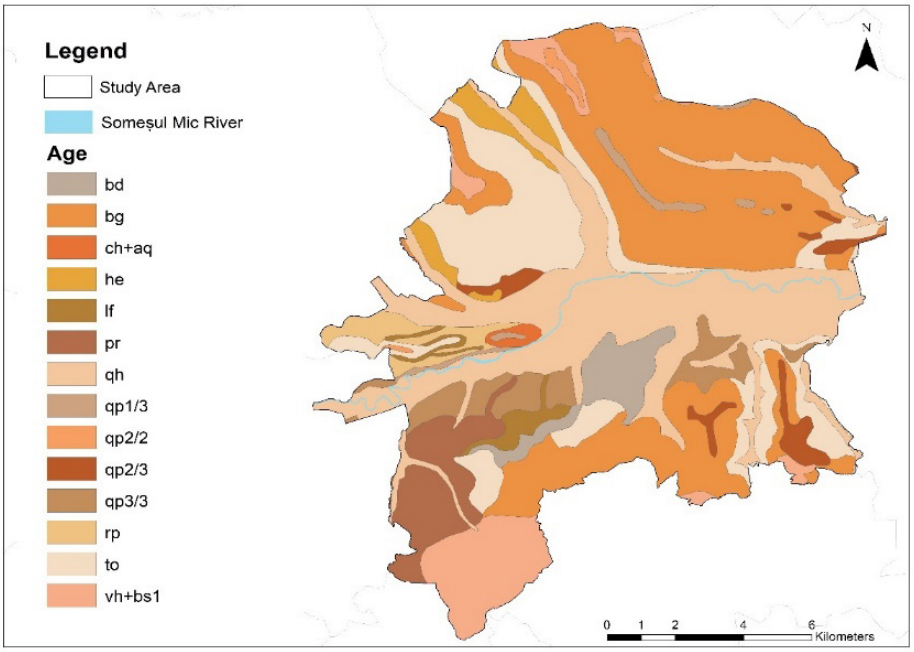

Fig. 2. Map of geological deposits in the city of Cluj-Napoca. The symbols indicate the age of the sediments: bd (Miocene-Eggenburgian -greenish sandy clays); bg (Miocene-Sarmatian-marls, sandstones, clays, tuffs); ch+ aq (Pliocene-Rupelian-sandstones); he (Miocene-Helvetian-conglomerates, sandstones, marly clays); if (Oligocene-Rupelian-sandstones, limestones); pr (Eocene-Priabonian-sands, red variegated clays); qh (Holocene-sands, silts, gravels); qp 1/3 (Upper Pleistocene basal-gravels, sands); qp 2/2 (Upper Pleistocene middle-sands, gravels); qh 2/3 (Upper Middle Pleistocene: sands, gravels); qh 3/3 (Upper Terminal Pleistocene – sands, gravels); rp (Oligocene-Rupelian-red streaked clays, gravels, limestones); to (Tortonian – marly clays, salt, gypsum, tuffs); vh+bs1 (Miocene-Volhynian-Bessarabian – sands, gravels with concretions).

Source: Geological Map 1: 200,000 (1968), Geological Institute of Romania

The Eocene-Priabonian deposits form a sedimentary series, the lower level of which consists of sands and the upper level of red clays. The sandy layer has aquifer potential, while the clays at the top are impermeable. As a foundation soil, it is stable only on flat surfaces, behaving unsteadily on slopes and in conditions of variable humidity (A. Vîjdea *et al.*, 2013).

Cluj limestones, also known as "upper coarse limestones", were formed in a carbonate platform environment with rich marine fauna. Although limestone is a soluble rock, it performs well as foundation soil, provided there is no acidic groundwater. It can also function as an aquifer, but the humidification of slopes favors their instability (A. Vîjdea *et al.*, 2013).

The Oligocene-Rupelian deposits consist of sandstones, sands, clays, and limestones with marine fauna. In the Cluj area, its base is represented by the Hoia Limestones. This formation behaves well as foundation soil and does not favor significant accumulations of groundwater. In the Tăietura Turcului and Cetățuie area, the Oligocene-Rupelian deposits are formed of red continental clays with layers of sand, sandstone, and conglomerates (A.R. Marat *et al.*, 2022).

The Oligocene-Rupelian sandstone geological deposits, called the Gruia Sandstone Formation, consist of a succession of more or less calcareous sands and sandstones, clays, and microconglomerates.

The Miocene-Eggenburgian geological deposits are composed of sand, sandstone, and microconglomerates with marine fauna. It has a transgressive character and represents good foundation soil, with the possibility of functioning as an aquifer reservoir. The Câmpie Group is developed over extensive areas in the northern, eastern, and southeastern parts of the Cluj area. At its base there are tuffs interbedded with marls, followed by gypsum deposits and, in some areas, salt.

The Feleac Formation, consisting of sands, sandstones, and conglomerates, has favorable characteristics for foundations. However, it can accumulate water, negatively affecting unstable underlying formations. Clay intercalations can also promote landslides (A. Vîjdea *et al.*, 2013).

On Cluj sheet map at the 1:50,000 scale, only Quaternary formations are newer than the above-mentioned ones. They are present both as terrace deposits and as floodplain deposits along all the valleys in the studied area and are represented by sands and gravels.

3.2.2. Land use data

For a better understanding of the reasoning behind the current urban expansion, it is necessary to analyze land use at two distinct points in time. To this end, open-source datasets were downloaded from the Copernicus platform, namely the CORINE Land Cover (CLC) datasets for 1990 and 2018 (table 2).

The CORINE Land Cover product, in its current form, is a pan-European inventory of land cover and land use, comprising 44 thematic classes ranging from extensive forest areas to individual vineyards.

This inventory is updated every six years, with the inclusion of new layers of status and changes, the last update having been carried out in 2018. CLC has multiple practical applications, such as environmental monitoring, land use planning, climate change impact assessment, and emergency management. In this study, the CLC dataset was used to determine changes in built-up area relative to natural area.

Table 2. Characteristics of CLC 1990 and CLC 2018

Characteristics	**CLC 1990**	**CLC 2018**
Satellite data	Landsat-5 MSS/TM, single date	Sentinel-2 and Landsat-8 (to fill gaps)
Time interval	1986–1998	2017–2018
Geometric accuracy	≤ 50 m	≤ 10 m (Sentinel-2)

Source: Copernicus Land Monitoring website

Based on the vector datasets, two maps representing land use patterns for 1990 and 2018 were created using ArcMap 10.8 software.

Subsequently, based on the attribute tables of the downloaded data (table 3), information on the area corresponding to each type of land use was extracted.

Table 3. Land use data for 1990 and 2018

Label CLC	Cod CLC	1990	2018	Modificare (+-%)
Continuous urban fabric	111	387,52	0,00	100
Discontinuous urban fabric	112	2905,83	4593,60	58,08
Industrial or commercial units	121	1264,52	1611,04	27,40
Airports	124	0,00	127,68	100
Mineral extraction sites	131	0,00	35,46	100
Dump sites	132	0,00	45,05	100
Construction sites	133	25,96	717,62	2664,25
Green urban areas	141	255,68	198,89	-22,21
Non-irrigated arable land	211	18121,01	10501,00	-42,05
Vineyards	221	59,47	0,00	-100
Fruit trees and berry plantations	222	1673,84	1496,67	-10,58
Pastures	231	4400,00	8065,81	83,31
Complex cultivation patterns	242	1235,00	986,43	-20,13
Land principally occupied by agric	243	1097,37	1393,45	26,98
Broad-leaved forest	311	6694,55	6598,29	-1,44
Coniferous forest	312	28,65	26,50	-7,50
Transitional woodland-shrub	324	193,42	71,00	-63,29
Inland marshes	411	54,74	0,00	-100
Water courses	511	107,10	107,10	0

Source: Copernicus Land Monitoring website

This data was organized into a new table in Microsoft Excel, based on the two years selected for analysis. Then, the percentage changes in area were calculated by applying the following formula:

$$(Ln-Kn)*100/Kn,\ n\in[4,22]$$

L and K are the names of the columns in Excel; n is the row number

In the final stage, the areas were grouped into two categories: built-up areas and natural areas. For each type of area, the corresponding percentages for the years studied were determined, and the results were represented graphically in the form of pie charts to facilitate data interpretation. By extracting the built-up areas between 1990 and 2018 and superimposing them on the slope map and digital elevation model, the current trend in the urban expansion of Cluj-Napoca was analyzed.

4. RESULTS AND DISCUSSIONS

4.1. Trends in land use

To determine the dynamics of geomorphology and urban expansion, it is not enough to assess the evolution of the official built-up area. Even if it coincides to some extent with the real built-up area, in this case it is only a convention. This was found following an analysis of the General Urban Plan published in 2018, in which the proposed built-up area boundary far exceeded the current built-up area boundary. We therefore resorted to using the CLC datasets from 1990 and 2018 to determine the changes undergone by the natural space in favor of the built-up space.

Based on the data, land use maps were created (fig. 3 and 4) to visualize the changes in the terrain.

Firstly, only by analyzing the maps can we observe the disappearance or appearance of certain land use patterns. More specifically, in 1990 there were continuous urban areas and vineyards, but these disappeared by 2018 due to urban or agricultural conversion. Furthermore, built-up areas are diversifying, and new types of land use are emerging: mineral extraction sites, waste disposal sites, and construction sites.

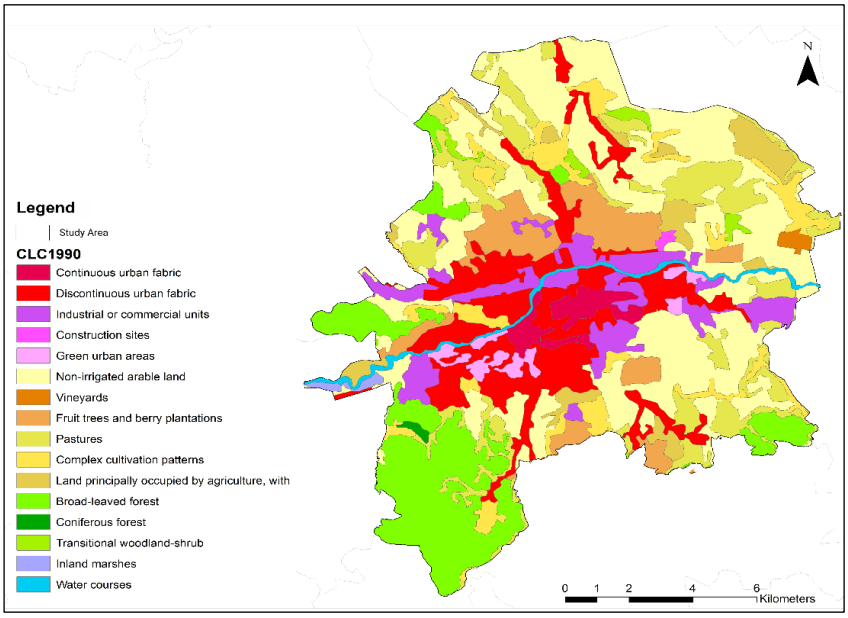

Fig. 3. Land use map of Cluj-Napoca (1990).
Source: 1990 CLC

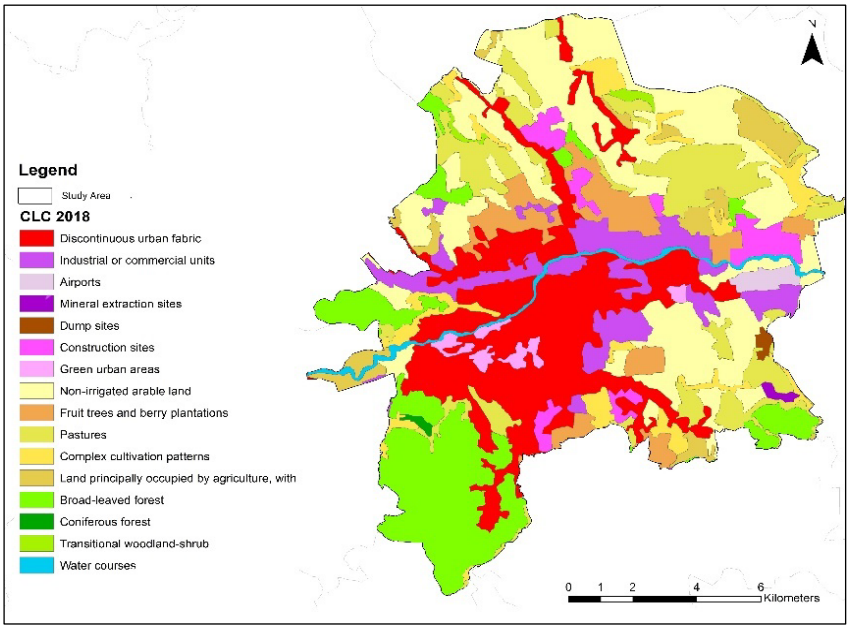

Fig. 4. Map of land use in the Cluj-Napoca UAT (2018).
Source: 2018 CLC

Therefore, following the analysis of the table of changes in land use (table 3), we find that the artificial area is expanding, while agricultural and vegetative areas are shrinking or disappearing altogether. By adding up the areas of all artificial land use types, we obtained the value of the built-up area; and by adding up the areas of all agricultural and vegetated land use types, we obtained the value of the natural area.

Thus, after examining the table, we can see the dynamics of built-up areas in relation to natural areas over the reference period (fig. 5 a, b).

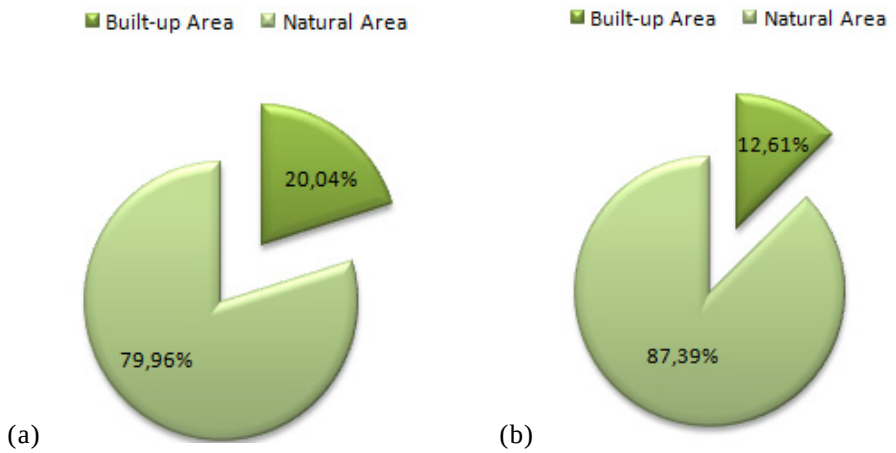

Fig. 5. Percentage representation of built-up areas in relation to natural areas: (a) 1990; (b) 2018.
Source: the authors, based on CLC datasets

The built-up area expanded by 7.43%, or 2489.84 ha. Urban development is therefore evidenced by the multiplication and diversification of artificial land uses, and urban expansion is supported by the increase in built-up area.

Following the intersection of the two cartographic materials presented above, the areas of expansion of the built-up area from 1990 to 2018 were rendered. The resulting data layer was superimposed on the slope data to facilitate data querying and interpretation (fig. 6).

The analysis of cartographic materials highlights a marked trend towards urban expansion into areas considered less favorable for construction, mainly due to slopes with values above 15°, but also due to unfavorable geology. This direction of urban development is driven by the significant increase in demand for land in the context of the real estate boom that began in 2009 in the municipality of Cluj-Napoca.

The expansion of built-up areas is evident in several sectors of the city, especially in sloping areas, such as the Europa, Mănăştur, Făget, Becaş, Zorilor, Bună Ziua, Borhanci, and Sopor neighborhoods, located on the northern slopes of Feleac Hill and along the right slope of the Someşul Mic Valley. In the northern part of the city, new developments are spreading on the slopes of Chintău Valley towards Ropos Hill, with similar slope values. There is also an expansion of the Dâmbul Rotund neighborhood to the North, towards Lomb Hill, and the Iris neighborhood is advancing northwards towards Fânaţele Clujului area.

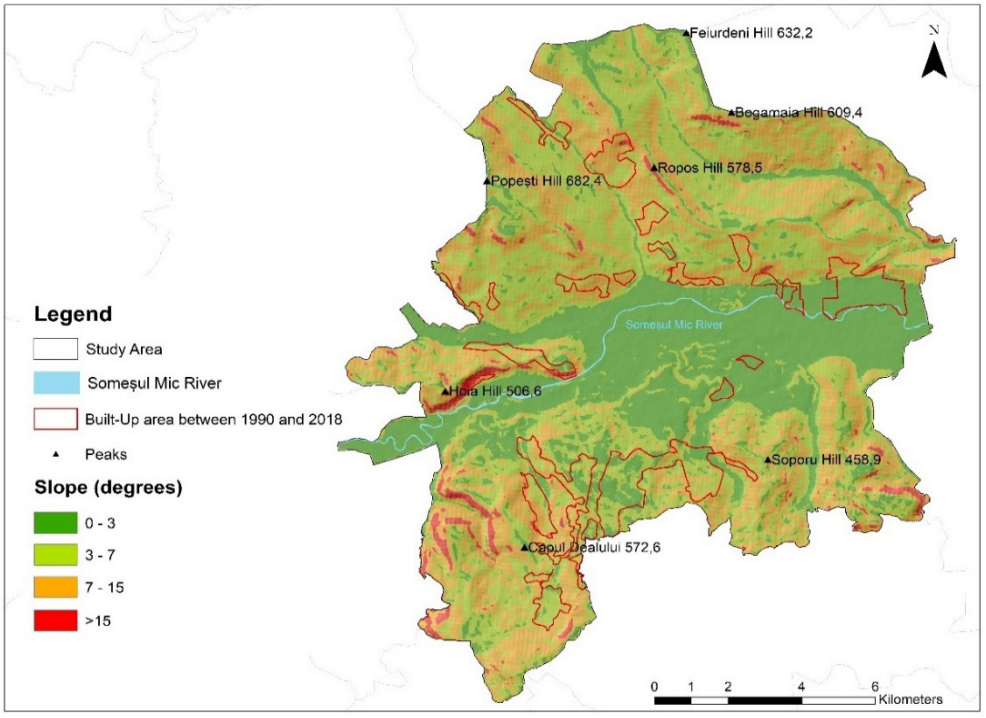

Fig. 6. Expansion of the built-up area within the Cluj-Napoca UAT between 1990 and 2018, overlaid on slope classes.
Source: the authors, based on CLC datasets

In addition, new industrial units are appearing on the southern slopes of Hoia Hill, within the perimeter of Grigorescu neighborhood, as well as on the slopes of Cetăţuii Hill. This general trend confirms that urban development pressure is driving the expansion of construction into geomorphologically vulnerable areas, despite the associated natural risks, such as slope instability, erosion, or infrastructure difficulties.

4.2. The impact of urban expansion on the dynamics and functions of the landscape

This dynamics involves a reconfiguration of the functions assigned to land: areas that were previously classified as unsuitable for construction and delineated as extra-urban, used mainly for agriculture, are now revalued as buildable land as a result of the pressure exerted by urban expansion. In other words, land is undergoing a process of functional reevaluation, in which the values and role of landforms are reinterpreted according to the development needs of the urban territory.

In the case of Cluj-Napoca, the local morphology has always been a determining factor in shaping the city's expansion, influencing not only the directions of development but also the architectural and functional characteristics of the new neighborhoods. Thus, by superimposing three sets of data: (1) maps of urban expansion; (2) map of river terraces; (3) digital terrain model, it is possible to analyze the supporting function of the relief in the urbanization process (fig. 7).

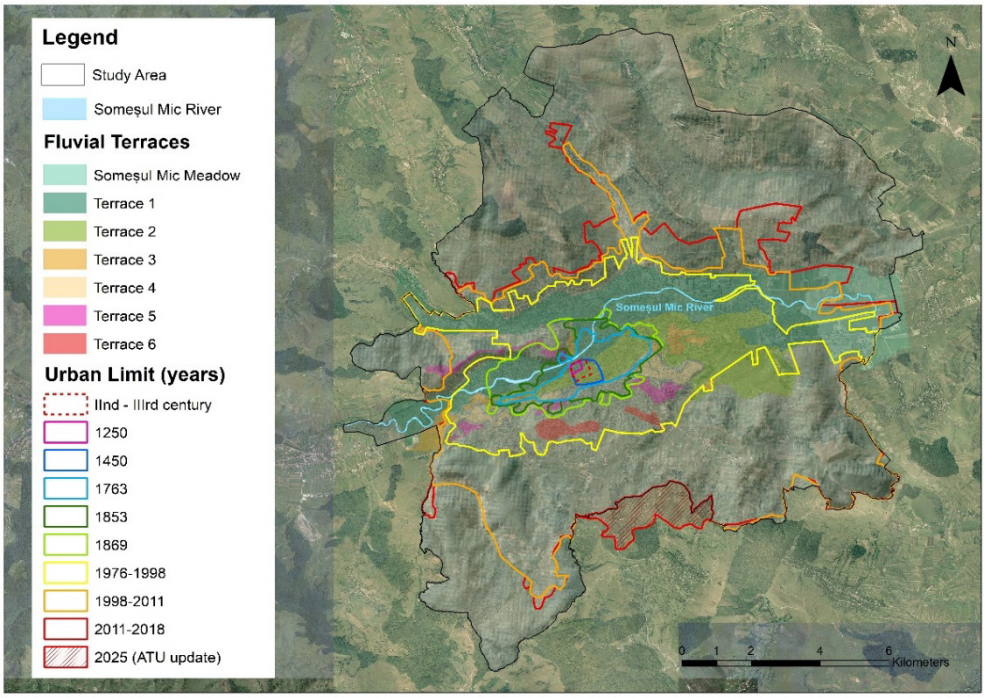

Fig. 7. The relations between fluvial terraces and urbanization process within Cluj-Napoca City.
Source: the authors

This spatial analysis, supplemented by the analysis of historical studies, urban planning reports, and period photographs, allows for the reconstruction of the evolution of the functions attributed to these landforms over time, as well as the identification of the physical and spatial transformations that have occurred as a result of urbanization. This outlines a model of interaction between the natural dynamics of the relief and the socio-economic needs of the urban population, a model that underpins decisions on territorial planning and sustainable development of the city. Therefore, depending on each period of urban development, the landforms that transform into geomorphological supports in the dynamics of urbanization were analyzed.

The first medieval enclosure (circa 1250) took advantage of the Someşul Mic Valley, more precisely the first river terrace. The gentle slopes and relatively flat surface allowed for construction. The proximity to the watercourse can be explained both by the need for water supply and by a possible defensive function, as mentioned by T. Morariu (1957) in his study on the urban evolution of the Municipality of Cluj.

Calvaria Church in Cluj-Mănăştur (first mentioned in documents in 1222) also dates from the same period and functioned as a fortified abbey, surrounded by walls and defensive moats (T. Morariu, 1957). Thus, the hill of the same name acquired a defensive function. Although this area was not part of the built-up area of Cluj-Napoca at that time, it is essential to analyze it, as it reflects an important landform in the current landscape of the city.

In 1558, the Morii Channel was dug to supply water to the mills and later to irrigate the gardens (L. Barbu, 2009).

The fortified medieval city developed on terrace 1 (t1) and terrace 2 (t2) of Someşul Mic River, benefiting from the stability offered by the flat relief. The territory occupied by the medieval city coincides with that of the old Roman city, suggesting that the same geomorphological factors (flat terrain, stability) favored their location. The adjacent hills and slopes were not exploited during this period, as the flat terrain was sufficient for the development of the town, according to the requirements of that stage of development.

In 1763, construction continued to develop around the old fortifications, extending along the t1 and t2 of Someşul Mic River. Development can be observed along the river axis, with a clear preference for land with gentle slopes. Also noteworthy is the crossing of the Someşul Mic River and the expansion of construction to the North. An interesting element during this period is the expansion of the built-up area on the slope of Cetăţuia Hill (J. Lukács, 2005). At its top, Cetăţuia (1715–1735) was built, a fortification erected during the Habsburg domination. Thus, a previously unutilized relief feature took on a strategic role in the defense and control of the city under Austrian authority, given its position on terrace 5 (t5), above the low terraces. The role of the Someşul Mic River remained

dual—water supply and natural defense. Urban expansion to the west took place in parallel with the route of Morii Channel.

In 1853, the urban expansion continued on terraces t1 and t2, but buildings also appeared on terraces t3 and t4, which were mainly used for agricultural purposes. Orchards, agricultural crops, and housing for the urban population were developed (V. Pop, 2010). After the 1848 Revolution, Cetăţuia was turned into a prison, and the hill lost its strategic function, acquiring a negative reputation. Poor people, marginalized by the city itself, began to take shelter on its slopes. Thus, its defensive function was replaced by a social one—that of providing housing in precarious conditions.

In 1869, there was a significant expansion of the built-up area, especially to the west and northwest, on the current territory of the Grigorescu and Gruia neighborhoods. Terrace t1 was used for both construction and agricultural activities. During this period, Someşul Mic River also had an industrial function, supplying the mill located on its left bank. The slopes of Cetăţuia Hill were covered with makeshift, unstable dwellings, sometimes even in caves dug into the hill, emphasizing their informal nature. Until 1900, the southern slope of the hill was entirely occupied by such dwellings, their instability being accentuated by the steep slope and the geological characteristics of the substrate (T. Morariu, 1957).

The expansion of the built-up area to the south and west occurred at a much slower pace, with the river terraces being used, at this stage, mainly for agricultural purposes, as this was the basic economic need of the population at that time.

During the communist period, the expansion of the built-up area accelerated, especially towards the East. Nădaş Valley was used for the development of industrial areas and residential neighborhoods. The river terraces in Mărăşti and Gheorgheni areas were significantly modified—leveled for the construction of apartment buildings (T. Morariu *et al*., 1967). Thus, the landforms previously used for agriculture were transformed for housing and urban infrastructure. At the same time, the floodplain of Someşul Mic River, previously an agricultural area, was reconfigured to support industrial platforms. It is also important to mention the construction of Între Lacuri neighborhood, together with Lake 1, which is man-made. Other neighborhoods that appeared during this period are Grigorescu, Plopilor, Zorilor, and Iris. The Mănăştur district of Cluj underwent a significant urban transformation, during which residential houses were demolished to make way for a large-scale apartment housing development.

After 1960, Cetăţuia Hill changed its function once again: the precarious dwellings were demolished and the area was turned into a park, thus acquiring a recreational role. The Belvedere Hotel was built at the top of the hill, giving terrace 5 (t5) a tourist role, and the slopes were landscaped to reduce the risk

of landslides. Also during this period, the village of Someşeni was integrated into the built-up area.

Furthermore, work was carried out on the bed of Someşul Mic River as a protective measure against flooding. Concurrently with the industrialization of Mărăşti and Bulgaria areas, the Morii Channel was given a utilitarian function by collecting wastewater from factories.

After 1998, the built-up areas advanced southwards towards Feleacu Hill and northwards towards Chintău Valley, Lomb Hill, and Fânaţele Clujului. The slopes of these areas changed their function from agricultural to urban – areas for construction. Calvaria Hill took on a historical and tourist function. Between 2011 and 2018, there was an expansion of the built-up area, especially to the north, with pressure on buildable land exceeding the constraints related to slope instability. A relevant example is the northern slope of Hoia Hill, which changed its agricultural function to an industrial one with the construction of the TETAROM I technology park.

As a result of the multitemporal analysis of the role of landforms in the urbanization process, we will present the summarized information in table form (table 4).

Table 4. The role of landforms in the urbanization process

Landform	13th–18th centuries	18th century–19th century 1853→1949	1853→ 1949	1948→ 1989	1989→ 2011	2011→ 2025
Cetăţuia Hill, Terrace 5	Unexploited → Defense, control	Defense → informal housing	Precarious housing	Green space, park	Recreation, tourism	Recreation, tourism, history
Calvaria Hill, Terrace 3	Unexploited →Defense, control	Defense, control	Defense, control	Defense, control	Historical, tourist	Historical, tourist
The terraces of the Someşul Mic River	Housing (Terrace 1)→ Medieval constructions (first 2 terraces)	Agricultural (upper terraces) Residential	Agricultural, residential	Residential	Mixed urban functions	Mixed urban functions
Someşul Mic River	Water supply, natural protection	Water supply, nascent industry	Industry (paper mill)	Industrial platforms	Reconfiguration for housing	Environmental, ecological, recreational
Hoia Hill	-	-	-	-	Industrial and residential	Industrial and residential

Landform	13th–18th centuries	18th century–19th century 1853→1949	1853→1949	1948→1989	1989→2011	2011→2025
Nadăş Valley	-	-	-	Industrial, residential	Industrial, residential	Industrial, residential
Morii Channel	Water supply (medieval mills), irrigation	Continuous supply, irrigation	Utility	Industrial	Partially covered for construction expansion	Environmental, recreational

Source: the authors

5. CONCLUSIONS

A multitemporal and multidisciplinary methodological approach highlighted the complex relationship between the urban evolution of Cluj-Napoca and the geomorphological characteristics of the territory. The multitemporal and multidisciplinary analysis of cartographic documents, corroborated with satellite data and interpretation using GIS (Geographic Information System), allowed for a closer reconstruction of how the expansion of the built-up area and the transformation of land use took place in relation to the local landforms.

It was found that the urbanization process of Cluj-Napoca evolved in distinct stages, influenced by historical, political, economic, and social factors. In particular, the city's development in the post-1989 period saw accelerated expansion towards geomorphological structures less suitable for construction, indicating a trend towards occupying land previously considered unsuitable for construction. This expansion was driven by demographic pressures and real estate market dynamics, culminating in significant transformations in the functional and landscape structure of the city.

The results of the quantitative analysis of land use between 1990 and 2018, based on CORINE Land Cover data, showed a 7.43% increase in built-up area and a decrease in natural and agricultural areas. Thematic maps illustrated that areas such as Hoia Hill, Cetăţuia Hill, and Nadăş Valley underwent a process of functional reconfiguration.

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ASSESSMENT OF WIND CLIMATE RESOURCES ON THE TERRITORY OF THE REPUBLIC OF MOLDOVA FROM THE PERSPECTIVE OF CLIMATE CHANGE

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ABSTRACT. – Assessment of Wind Climate Resources on the Territory of the Republic of Moldova from the Perspective of Climate Change. This paper investigates the changes in wind climate resources in the Republic of Moldova in the context of climate change. The study analyses wind speed and direction data from meteorological stations over the periods 1961-1990 and 1991-2020. Results show a decreasing trend in average wind speed, particularly in the southern and central parts of the country. Additionally, there is a slight shift in dominant wind directions. The study discusses the potential impact of these changes on wind energy utilization and emphasizes the need for updated wind resource assessments to support renewable energy planning.

Keywords: *wind speed, wind direction, climate change, wind energy, Moldova.*

INTRODUCTION

Renewable energy sources (wind, solar, hydro, ocean, geothermal, biomass and biofuels) are alternatives to fossil fuels that help reduce greenhouse gas emissions, diversify energy supply and reduce dependence on volatile and uncertain fossil fuel markets, especially oil and gas (European Parliament, 2025).

The wind climate resources of the Republic of Moldova have been studied and described in fundamental scientific publications, realized in the last decades in terms of their potential energy (T. Ambros *et al.*, 1999; P. Todos *et al.*, 2002;

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V. Rachier, 2016) or spatio-temporal characteristics (G. Mleavaia, 2016). In this paper we aimed to evaluate the changes in wind climate resources in the light of climate change, an analysis of the evolution over time of the main indicators - wind direction, wind speed and calm.

MATERIALS AND METHODS

Wind observations are performed at all meteorological stations in the country (table 1). According to the recommendations of WMO (World Meteorological Organization), the data analysis and summarization was carried out for 30-year time intervals starting from 1961 (WMO, 2017). In case of missing data for some years or some months of a year, the method of data restoration was applied by using the arithmetic mean for the analysed period of the string.

Table 1. Meteorological stations whose data were used in the study

Station	Observation period, years	Station	Observation period, years
Briceni	1961-2020	Codrii	1996-2020
Soroca	1961-1983, 1985, 1988-1993, 2007-2020	Bălţata	1961-2020
Camenca	1961-2020	Chişinău	1961-2020
Râbniţa	1963-2020	Tiraspol	1961-2020
Bălţi	1961-2020	Leova	1961-2020
Făleşti	1961-2020	Ştefan Vodă	1981-2020
Bravicea	1961-2020	Comrat	1961-2020
Cornești	1961-2020	Ceadâr-Lunga	1961-1964, 1975-2020
Dubăsari	1961-2020	Cahul	1961-2020

Source: the authors

Analysis and understanding of the basic wind characteristics are based on measurement data. The quality of measurement data is a difficult subject, which depends, on one hand, on the equipment and terms of observations, and on the other hand, on the landscape specificity of the meteorological platform location and its changes over time (V. Rachier, 2016; G. Mleavaia, 2016).

For example, until 1966 wind speed was measured 4 times daily - every 6 hours, from 1966 until today - 8 times daily, every 3 hours. Until the ′60s or ′70s, the instrument used to measure wind direction and wind speed was the wind vane fixed at 10 m above the ground, then measurements were made with an anemometer, and nowadays with specialized sensors. These issues are of importance because the probability of recording extreme wind gusts is a function of the terms of the measurements, and the values of the wind speeds measured with the gyro are overestimated compared to those measured with the anemometer.

The statistical processing and string homogeneity checks, and the calculation of basic statistical parameters was performed using the Excel mathematical package.

Spatial modeling of the parameters describing the wind regime in the country did not provide satisfactory results, mainly due to the insufficient number of stations with qualitative data. Some stations were moved during the study period (Chișinău, Ceadâr-Lunga, Tiraspol), others have large gaps in the period of operation (Soroca), some do not have long enough string with years of observations (Codrii, Ștefan-Vodă), but the biggest problem in data homogenization lies in the modification of the station terrain - vegetation cover and construction. These statements are also confirmed in recent specialized publications (V. Rachier, 2016, p. 33).

For these reasons, for the evaluation of the wind regime change trends in the Republic of Moldova, we selected only the stations where the data maximally satisfy the natural conditions or where the structure of the corresponding land has not changed substantially - Briceni, Camenca, Râbnița, Fălești, Bravicea, Cornești, Dubăsari, Bălțata, Leova, Comrat, and Cahul.

RESULTS AND DISCUSSIONS

On the territory of the Republic of Moldova, the wind regime, which is characterized by two highly variable parameters in time and space - wind direction and wind speed (G.F. Lasse, 1978; Administrația Națională de Meteorologie, 2008), is determined both by the general circulation of the atmosphere and by the underlying surface.

Wind direction. The atmospheric circulation on the territory of the Republic of Moldova during the analysed period did not undergo major changes. Meteoclimatic research indicates the major influence of the seasonal baric centres described sufficiently well in the literature (G.F. Lasse, 1978; V.M. Lipinskyi *et al.*, 2003; G. Mleavaia, 2016): the winter Mediterranean cyclone, the winter Black Sea depression and the summer South-Asian cyclone. The results of the statistical analysis indicate that these trends during the analysed period changed little. Winds prevail from two opposite directions - north-westerly and south-easterly. However, the comparative analysis of the changes in wind direction presented in table 2 shows small changes, which occur in the north, north-westerly and, at some stations, southerly directions.

Table 2. Changes in the frequency of annual mean wind direction in numbers, 1991-2020 compared to 1961-1990 (%)

Station	N	NE	E	SE	S	SV	V	NV
Briceni	*5.0*	-0.2	0.3	-0.9	4.1	-1.2	-2.8	*-7.3*
Camenca	2.0	0.8	0.2	-2.4	0.2	0.2	*2.9*	*-4.0*
Râbnița	*-3.7*	2.3	-0.7	1.8	*-4.3*	0.0	2.0	2.9
Fălești	*-1.0*	-0.9	0.3	0.1	-0.2	*1.4*	0.0	0.4
Bravicea	-1.0	-0.2	0.0	-0.3	*-1.8*	*2.0*	0.9	0.4
Cornești	*-1.8*	0.9	-1.5	*2.2*	-0.8	1.0	-0.6	0.6
Dubăsari	1.9	*2.7*	0.2	-0.1	*-3.3*	-0.3	0.0	-0.9
Bălțata	*-1.9*	1.8	-0.6	-0.7	-0.5	0.9	-2.3	*3.4*
Leova	*4.4*	0.2	-0.6	-2.1	-0.5	0.4	0.2	*-1.9*
Comrat	*-2.2*	-0.9	1.0	-0.7	-0.7	0.1	2.7	*0.8*
Cahul	*-1.6*	0.8	0.2	*-1.8*	0.0	1.1	1.1	0.1

Source: data from meteorological stations

Thus, the largest changes in wind frequency (years 1991-2020 compared to 1961-1990) are observed at the meteorological station Briceni, where the frequency of northerly winds increased by 5.0%, southerly - by 4.1% and those from the northwest decreased by 7.3%. At the Râbnița meteorological station the frequency of northerly winds decreased by 3.7% and northerly by 4.3%. In the central part of the country, at the Bălțata meteorological station the frequency of northerly winds decreased by 1.9% and northwesterly winds increased by 3.4%. In the southern part of the country, the greatest changes in wind frequency were observed at the Leova meteorological station, where the frequency of northerly winds increased by 4.4%, while southerly winds decreased by 1.9% (fig. 1 and 2).

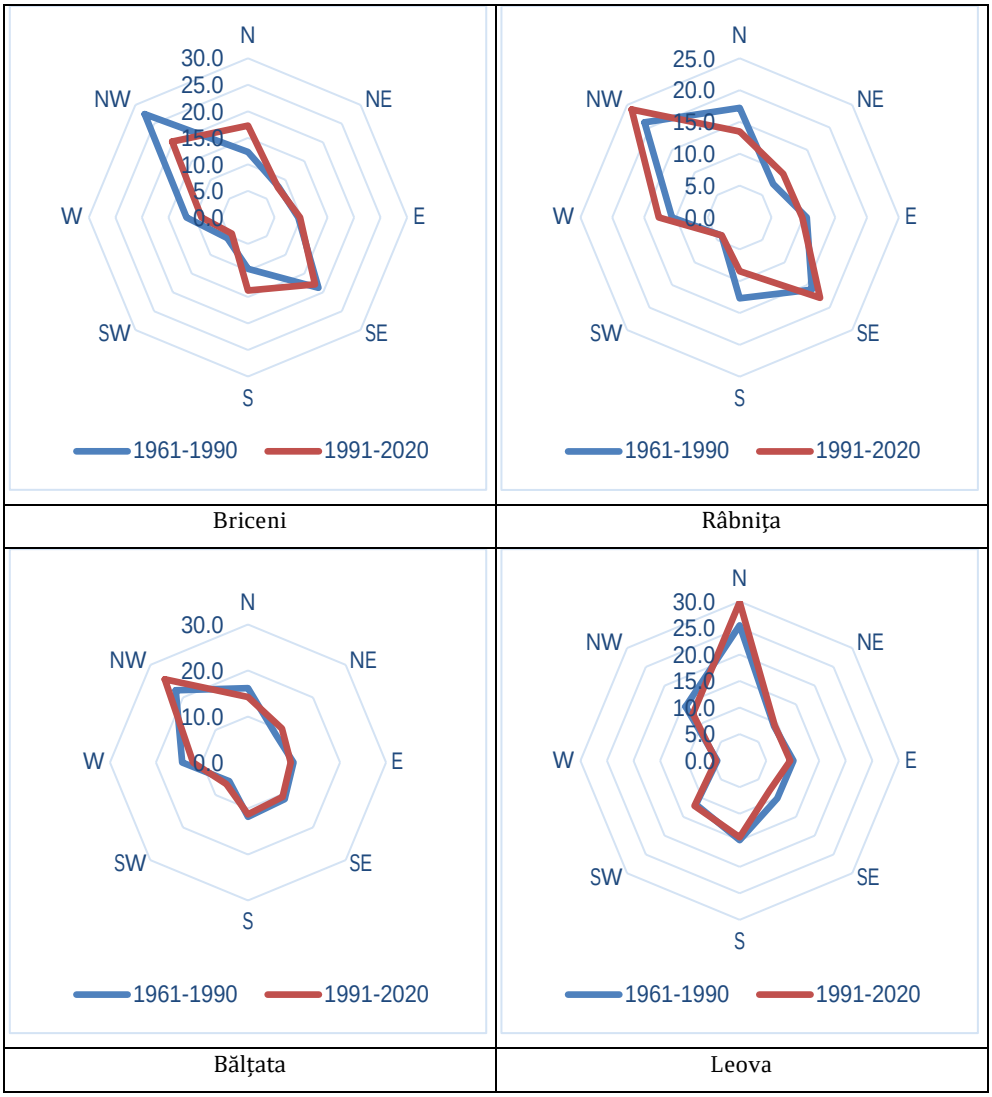

Fig. 1. Wind speed changes, 1991-2020 compared to 1961-1990.
Source: data from meteorological stations

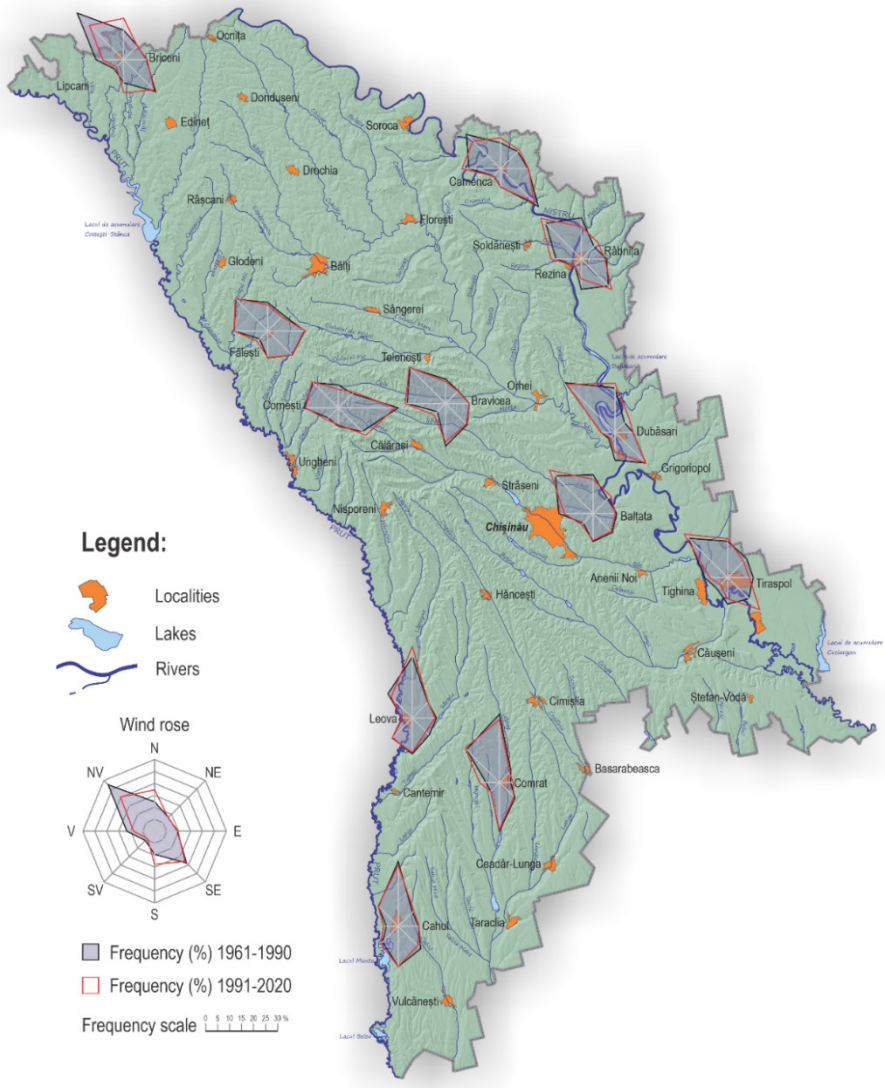

Fig. 2. Wind speed changes over the analysis periods 1961-1990 and 1991-2020.
Source: data from meteorological stations

These changes can be explained by a shift in the movement of air masses from latitudinal to meridional orientation (T. Constantinov *et al.*, 2006). This phenomenon is also confirmed in earlier scientific investigations, which find the

permutation of eastward North Atlantic fluctuations originating from the normal pressure difference between the Azorean maximum and the Icelandic minimum (U. Ulbrich and M.M. Christoph, 1999).

We consider that the atmospheric circulation is an extremely dynamic process, but it is premature only on the basis of the analysis of 60 years of observations to deduce the causes of its modification, even if some trends are noticeable.

Wind speed. It is considered (G.F. Lasse, 1978) that the mean wind speed is a stable value, varying little from year to year. However, recent research results in the literature indicate that decreasing trends in the mean wind speed in south-eastern Europe in particular and in the northern hemisphere in general are evident (A. Busuioc *et al*., 2013; J. Weber, F. Gotzens and D. Witthaut, 2019; S.B. Krasheninnikova and M.A. Krasheninnikova, 2019; R.J. Bartelmie and S.C. Pryor, 2021).

In this context, particular attention should be paid to the results of research obtained in Romania (A. Busuioc *et al*., 2013): "The linear trend of the evolution of the annual mean speed indicates mean decreases over the period 1961-2007 greater than 1 m/s for the north of the Eastern Carpathians, the Moldavian Plateau and the north of the Bărăgan Plain and the Dobrogea Plateau. The same regions have the most relevant values in terms of decrease in wind speed also on a seasonal scale, with values reaching -2...-3 m/s at several meteorological stations in the eastern half of the country".

The average annual wind speed in the country varies, predominantly, depending on the variety of landscape regions of the Republic of Moldova and due to the specific location of the meteorological station. At present, the mean annual wind speed ranges from 1.4 m/s at the Bravicea meteorological station to 3.5 m/s at the Cahul meteorological station (table 3). The highest mean wind speeds are found in the south of the country (Cahul, Comrat). The role of altitude is evident - the average annual wind speed is higher on higher landforms (Cornești, Bălțata), and lower in depressions (Bravicea).

In the cold period of the year, wind speeds are higher (from 1.5 m/s at Bravicea to 3.8 m/s at Cahul) than in the warm period (1.2 m/s and 3.2 m/s respectively). In percentage ratio, the average wind speeds in the cold period of the year for the country as a whole are 22% higher than in the warm period (10.9% at Comrat and 29.7% at Camenca). It should be noted that the gap between average winter and summer wind speeds increases latitudinally from north to south. Thus, average wind speeds in the south of the country are more stable throughout the year.

Seasonally, summer is the season with the lowest average wind speeds, ranging from 1.1 m/s (Bravicea) to 3.1 m/s (Cahul). In percentage ratio the average summer wind speeds are 14.2% lower than the annual average (7.0% in Comrat and 19.6% in Camenca).

In spring the average wind speeds are the highest: 1.7 m/s at Bravicea and 3.9 m/s at Cahul. In percentage ratio, the average spring wind speeds are higher than the annual average by 13.5% on average over the country (9.9% in Cahul and 22.3% in Bravicea).

Table 3. Average wind speed, m/s, 1991-2020

Station	Annual	Warm time of year, (V-IX)	Cold time of year, (X-IV)	Winter	Spring	Summer	Autumn
Briceni	2.2	1.9	2.4	2.4	2.5	1.8	2.1
Camenca	2.5	2.1	2.7	2.7	2.8	2.0	2.4
Râbnița	1.9	1.7	2.1	2.1	2.2	1.7	1.8
Fălești	2.2	1.9	2.3	2.3	2.4	1.8	2.1
Bravicea	*1.4*	*1.2*	*1.5*	*1.5*	*1.7*	*1.1*	*1.2*
Cornești	2.4	2.1	2.6	2.5	2.7	2.0	2.4
Dubăsari	1.9	1.7	2.1	2.1	2.2	1.7	1.8
Bălțata	2.4	2.2	2.6	2.5	2.8	2.2	2.3
Leova	2.5	2.2	2.7	2.7	2.9	2.2	2.4
Comrat	2.5	2.4	2.6	2.6	2.8	2.4	2.4
Cahul	*3.5*	*3.2*	*3.8*	*3.8*	*3.9*	*3.1*	*3.4*

Source: data from meteorological stations

The regional trend of decreasing average wind speeds was mentioned earlier. The analysis of the dynamics of these values over time confirms this statement also for the territory of the Republic of Moldova where the average wind speeds have decreasing trends (tab. 4 and 5, fig. 2). Comparing the average annual wind speeds from 1961-1990 with those from 1991-2020, we find that the average annual wind speed decreased by 0.6 m/s on average over the country or 21.6% (tab. 4, 5). Particularly dramatic is the decrease in mean annual wind speeds at the meteorological station Leova by 1.5 m/s (37,9%). Along with Leova, considerable decreases in mean annual wind speeds are recorded at Râbnița, Camenca and Cornești (0.7, 0.8 m/s or 26.9%, 34.8% and 24.2% respectively). The smallest change in average wind speed was in the south of the country: Comrat (0.2 m/s or 8.8%) and Cahul (0.4 m/s or 8.8%).

Comparison of the change in mean speeds in the warm and cold period of the year (1961-1990 vs. 1991-2020) does not show large differences - mean speeds decreased by 0.6 m/s and 0.7 m/s respectively (21.7% and 21.6%).

The speeds during the cold period of the year have decreased significantly compared to the annual averages - on average by 0.8 m/s per country (1991-2020 compared to 1961-1990) or by 24.3%. In summer the average wind speeds per country decreased by 0.6 m/s or 19.4%.

Table 4. Changes in mean wind speed, m/s, 1991-2020 compared to 1961-1990 (decreasing direction)

Station	Annual	Warm time of year, (V-IX)	Cold time of year, (X-IV)	Winter	Spring	Summer	Autumn
Briceni	0.5	0.5	0.5	0.6	0.4	0.6	0.3
Camenca	0.6	0.5	0.6	0.7	0.6	0.5	0.4
Râbnița	*0.7*	*0.6*	*0.8*	*0.9*	*0.7*	*0.6*	*0.6*
Fălești	0.6	0.5	0.6	0.7	0.6	0.5	0.4
Bravicea	*0.7*	*0.7*	*0.7*	*0.8*	*0.7*	*0.7*	*0.6*
Cornești	*0.8*	*0.7*	*0.8*	*1.0*	*0.8*	*0.6*	*0.6*
Dubăsari	0.4	0.4	0.5	0.5	0.3	0.4	0.4
Bălțata	0.6	0.5	0.6	0.7	0.6	0.5	0.4
Leova	*1.5*	*1.3*	*1.7*	*1.9*	*1.6*	*1.3*	*1.2*
Comrat	0.2	0.2	0.3	0.4	0.3	0.2	0.1
Cahul	0.4	0.2	0.5	0.6	0.4	0.2	0.2

Source: data from meteorological stations

Table 5. Changes in mean wind speed, %, 1991-2020 compared to 1961-1990 (decreasing direction)

Station	Annual	Warm time of year, (V-IX)	Cold time of year, (X-IV)	Winter	Spring	Summer	Autumn
Briceni	18.9	22.6	16.6	19.7	13.6	25.1	13.4
Camenca	18.7	18.1	19.1	21.8	18.1	19.2	13.2
Râbnița	*26.9*	*26.3*	*27.2*	*30.5*	*24.9*	*26.8*	*23.2*
Fălești	21.6	22.1	21.3	23.2	20.1	22.6	17.4
Bravicea	*34.8*	*37.4*	*33.3*	*35.0*	*29.9*	*37.7*	*34.1*
Cornești	*24.2*	*24.5*	*24.0*	*28.1*	*21.9*	*23.8*	*19.7*
Dubăsari	18.0	18.1	18.0	19.9	13.0	18.2	17.6
Bălțata	18.7	17.7	19.3	21.5	18.1	17.2	14.9
Leova	*37.9*	*37.0*	*38.4*	*41.8*	*35.2*	*36.8*	*33.8*
Comrat	8.8	8.6	8.9	12.1	9.9	9.4	3.3
Cahul	9.4	6.6	11.1	13.7	8.5	7.3	6.8

Source: data from meteorological stations

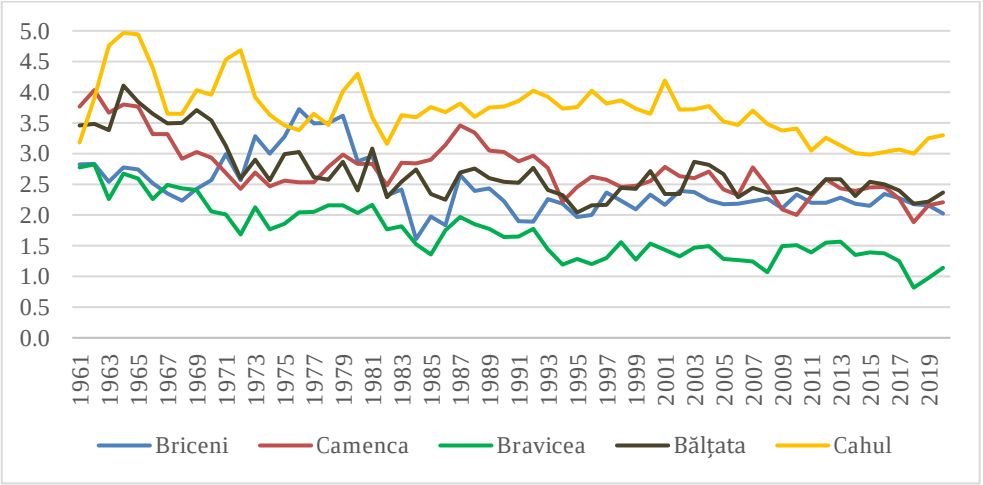

Fig. 3. Dynamics of the change in mean annual wind speeds (m/s) at some representative stations (1961-2020).
Source: data from meteorological stations

In the frequency distribution of wind speeds by gradations (table 6, Fig. 3), we note that in the Republic of Moldova, at present (period 1991-2020), on average, winds with speeds of 2-3 m/s predominate - 42.1%, followed by those with lower speeds - below 1 m/s - 35.8%. Obviously, as the speeds increase, the frequency is decreasing (table 6).

Table 6. Wind speed frequency by gradation, %, 1991-2020

Station	Wind speed, m/s											
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-20	21-24	25-28
Briceni	37.8	44.4	13.4	3.3	0.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Camenca	32.1	42.2	18.2	5.5	1.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0
Râbnița	37.6	46.2	12.7	2.7	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Fălești	30.6	54.9	12.2	1.8	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bravicea	58.1	32.9	7.3	1.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Cornești	29.4	49.7	16.7	3.4	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Dubăsari	45.0	40.4	11.6	2.3	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Bălțata	39.6	31.3	20.1	6.9	1.6	0.4	0.1	0.0	0.0	0.0	0.0	0.0
Leova	36.1	39.5	16.4	5.6	1.7	0.4	0.3	0.1	0.0	0.0	0.0	0.0
Comrat	32.3	41.2	19.4	5.8	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Cahul	15.3	40.3	28.4	11.1	3.6	0.8	0.3	0.1	0.0	0.0	0.0	0.0

Source: data from meteorological stations
Note: If '0.0' is entered, the value indicated is very small, in the order of hundredths, thousandths, etc., and is not shown in the table.

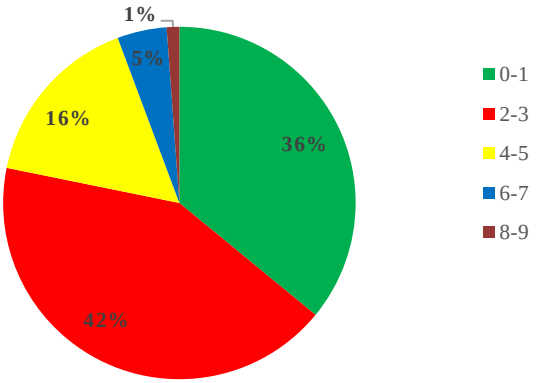

Fig. 4. Wind frequency distribution by speed gradations, %. Period 1991-2020.
Source: data from meteorological stations

The general decrease in wind speed in the Republic of Moldova can be broken down in detail over the analysed period and in terms of frequency according to the speed gradations (tables 7 and 8). It should be noted that against the background of decreasing mean wind speed, the frequency of low wind speeds is increasing. Thus, comparing the frequency of wind speeds in the period 1961-1990 with 1991-2020, it can be seen that the frequency of wind speeds below 1.0 m/s is increasing by 3.5% and the frequency in the 2-3 m/s range - by 7.4%. In percentage ratio this increase constitutes 14.6% and 21,4% respectively.

Table 7. Changes in wind speed frequency by gradation, %,
1991-2020 compared to 1961-1990

Station	Wind speed, m/s											
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-20	21-24	25-28
Briceni	4.0	9.0	-6.2	-4.2	-1.4	-0.7	-0.3	-0.1	0.0	0.0	0.0	0.0
Camenca	1.2	8.2	-4.1	-3.3	-1.3	-0.6	-0.1	0.0	0.0	0.0	0.0	0.0
Râbnița	0.6	14.2	-6.9	-4.9	-2.0	-0.7	-0.2	-0.1	0.0	0.0	0.0	0.0
Fălești	-2.9	13.0	-4.6	-3.4	-1.1	-0.5	-0.3	-0.1	-0.1	0.0	0.0	0.0
Bravicea	7.7	4.0	-5.7	-3.8	-1.4	-0.3	-0.5	0.0	-0.1	0.0	0.0	0.0
Cornești	6.3	6.7	-6.1	-3.8	-1.8	-0.8	-0.3	-0.1	-0.1	0.0	0.0	0.0
Dubăsari	3.2	2.4	-1.8	-1.9	-0.9	-0.5	-0.2	-0.1	0.0	0.0	0.0	0.0
Bălțata	2.1	3.8	0.6	-2.6	-2.2	-0.9	-0.5	-0.1	-0.2	0.0	0.0	0.0
Leova	19.0	6.8	-7.6	-8.7	-5.0	-2.9	-0.9	-0.4	-0.2	-0.1	0.0	0.0
Comrat	-0.1	7.0	-2.1	-2.7	-1.5	-0.3	-0.2	-0.1	0.0	0.0	0.0	0.0
Cahul	-2.4	6.4	2.9	-3.2	-2.1	-1.2	-0.3	-0.1	0.0	0.0	0.0	0.0

Source: data from meteorological stations
Note: If '0,0' is entered, the value indicated is very small, in the order of hundredths, thousandths, etc., and is not shown in the table.

Starting with the range of velocities above 4 m/s the difference between the frequency of velocities in the compared periods is decreasing dramatically. The larger the velocity range, the larger the difference in their frequencies becomes compared to the period 1961-1991. Thus, in percentage ratio the frequency of velocities 4-5 m/s decreased by 20.3% on the country average, 6-7 m/s - by 48.8%, 8-9 m/s - by 65.2%, 10-11 m/s - by 75.9%, and from 21 m/s - by more than 100% (table 8).

Table 8. Percent changes in wind speed frequency by gradations, 1991-2020 compared to 1961-1990

Station	Wind speed, m/s											
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-20	21-24	25-28
Briceni	11.7	25.5	-31.5	-56.0	-67.4	-73.6	-80.1	-63.2	-70.8	-44.3	-100	-100
Camenca	3.9	24.2	-18.3	-37.7	-44.0	-67.2	-58.4	-77.0	-73.8	-100	-100	-100
Râbnița	1.6	44.4	-35.0	-64.4	-77.5	-81.0	-93.4	-94.9	-94.7	-95.0	-100	-100
Fălești	-8.7	31.1	-27.5	-65.0	-75.3	-83.1	-98.4	-94.3	-100	-96.3	-100	-100
Bravicea	15.3	13.9	-43.9	-74.4	-84.9	-82.3	-95.6	-56.9	-100	-100	-100	-100
Cornești	27.3	15.6	-26.9	-52.8	-73.9	-88.6	-91.7	-91.4	-97.9	-100	-100	-100
Dubăsari	7.7	6.3	-13.6	-45.0	-65.7	-77.7	-84.3	-94.1	-96.5	-100	-100	-100
Bălțata	5.5	13.8	3.0	-27.0	-57.4	-66.8	-85.7	-84.2	-96.4	-91.1	-100	-100
Leova	111	20.6	-31.7	-61.0	-74.8	-88.2	-75.4	-82.8	-92.9	-97.2	-100	-100
Comrat	-0.3	20.5	-9.6	-31.6	-59.3	-66.4	-78.9	-72.4	-96.2	-100	-100	-100
Cahul	-13.7	19.0	11.2	-22.3	-36.7	-60.2	-50.0	-36.3	-52.2	-78.6	-100	-100

Source: data from meteorological stations

Spatially, the south of the country stands out because wind speeds above 4 m/s decrease less than the rest of the stations, thus confirming a relative stability in the change of wind speeds in this region. Here the meteorological station Leova again represents an exception conditioned by the specific landscape of the region.

Calms. The mean annual frequency of calms varies spatially depending on the specific physical-geographical and regional features of atmospheric circulation (G.F. Lasse, 1978; Administrația Națională de Meteorologie, 2008). The highest frequency of calms is observed in the northeastern part of the country and in depressions (Râbnița - 25.8%, Bravicea - 39.6%, table 9). The lowest frequency of calms is specific to the south of the country and high, open places (Cahul - 5.1%, Cornești - 9.7%, table 9). In the warm period of the year, the frequency of calms is slightly higher than in the cold period (4.3% on average over the country), keeping the same spatial distribution properties as in the annual average (table 9).

Table 9. Changes in calm frequency, %, 1991-2020 compared to 1961-1990

Station	Calm (an, 1991-2020)	The difference	Calm (V-IX, 1991-2020)	The difference	Calm (X-IV, 1991-2020)	The difference
Briceni	**14.3**	-5.5	**17.9**	-7.4	**14.1**	-5.8
Camenca	**18.8**	-1.8	**22.6**	-2.9	**16.0**	-1.1
Râbniţa	**25.8**	0.3	**30.9**	0.7	**22.1**	-0.2
Făleşti	**9.1**	-5.3	**10.8**	-5.7	**7.9**	-5.0
Bravicea	**39.6**	2.4	**44.4**	3.8	**36.2**	1.4
Cornești	**9.7**	2.7	**10.7**	3.1	**9.0**	2.4
Dubăsari	**18.77**	-3.5	**22.7**	-3.0	**15.9**	-4.2
Bălţata	**24.1**	0.1	**27.3**	1.2	**21.9**	-0.6
Leova	**13.1**	6.7	**13.8**	6.0	**12.6**	7.2
Comrat	**12.51**	-9.8	**12.9**	-11.1	**12.2**	-9.2
Cahul	**5.1**	-2.7	**5.4**	-4.1	**5.0**	-1.7

Source: data from meteorological stations

Compared to the period 1961-1990, the frequency of calmness undergoes visible changes in the direction of decreasing. These changes are particularly noticeable in percentage terms (table 10). Even if at some stations these changes are very small (Râbniţa – 1.1%, Balţata – 0.6%, Bravicea – 6.1% compared to the average for 1961-1990) and have an increasing character, at many stations in the country a considerable decrease in the frequency of calm is observed.

Table 10. Percentage changes in calm frequency, %, 1991-2020 compared to 1961-1990

Station	Calm (an, 1991-2020)	The difference	Calm (V-IX, 1991-2020)	The difference	Calm (X-IV, 1991-2020)	The difference
Briceni	14.3	-38.5	17.9	-41.3	14.1	-41.2
Camenca	18.8	-9.8	22.6	-12.7	16.0	-6.8
Râbniţa	25.8	1.1	30.9	2.3	22.1	-1.0
Făleşti	9.1	-58.2	10.8	-52.4	7.9	-63.8
Bravicea	39.6	6.1	44.4	8.5	36.2	3.8
Cornești	9.7	27.5	10.7	28.8	9.0	26.4
Dubăsari	18.77	-18.9	22.7	-13.3	15.9	-26.4
Bălţata	24.1	0.6	27.3	4.5	21.9	-2.9
Leova	13.1	51.1	13.8	43.4	12.6	57.2
Comrat	12.51	-78.5	12.9	-85.5	12.2	-75.5
Cahul	5.1	-53.6	5.4	-75.5	5.0	-33.3

Source: data from meteorological stations

These trends are particularly strong in the south of the country, where in Comrat the average annual frequency of calms decreased by 78.5% compared to 1961-1990, in Cahul - by 53.6%. In the north of the country these trends are also visible but less expressed - in Briceni the average frequency of calms decreased by 38.5% compared to 1961-1990. Analysis for the hot and cold periods of the year shows the same trends.

On average over the country, the average annual frequency of calm has decreased by 15.5% compared to 1961-1990, in the warm period of the year by 17.6%, and in the cold period by 14,9%.

We find that the overall decrease in calm frequency is accompanied by a decrease in mean annual wind speeds, which is confirmed by the correlation of these parameters (fig. 5). The degree of correlation, R2, ranges from 0.6-0.7, which is within the acceptable range.

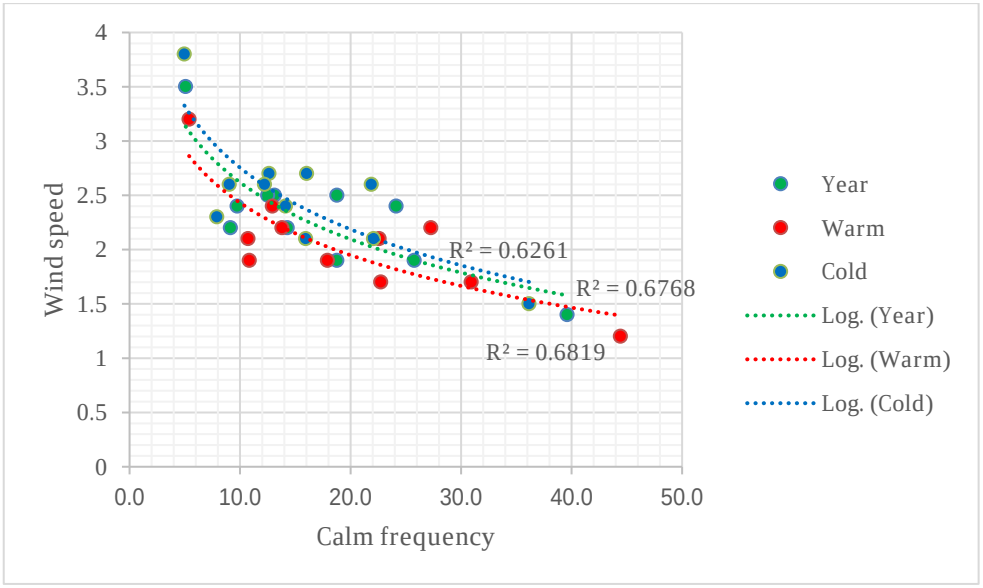

Fig. 5. Function of mean annual mean calm wind speeds, 1991-2020.
Source: the authors, based on data from meteorological stations

This is also confirmed by the frequency distribution of low wind speeds in relation to calm frequency: the higher the calm frequency, the higher the frequency of low wind speeds (below 1 m/s, fig. 4).

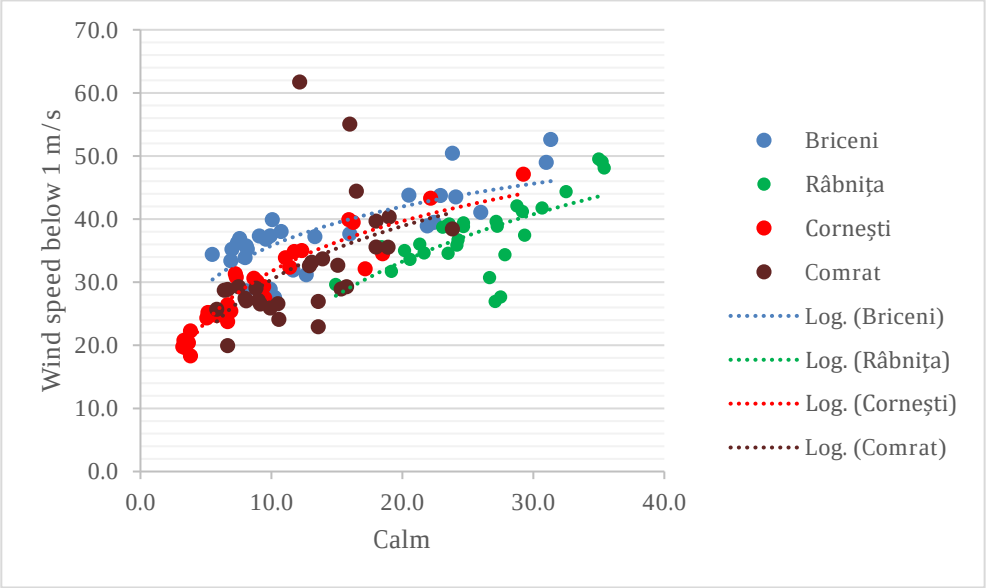

Fig. 6. Frequency function of low wind speeds (below 1 m/s) versus calm frequency, period 1991-2020

Source: the authors, based on data from meteorological stations

In general, the analysis of calm frequency, in particular its correlation with other characteristic wind indicators, requires dedicated studies.

CONCLUSIONS

1. Comparative analysis of the changes in wind direction shows small changes, which occur in the north, northwest and, at some stations, south directions. These changes can be explained by the change in the movement of air masses from latitudinal to meridional orientation. We consider that the atmospheric circulation is an extremely dynamic process, but it is premature only on the basis of 60 years of analysed observations to deduce the causes of its modification, even if some trends are noticeable.

2. For the territory of the Republic of Moldova trends of decreasing average annual wind speeds are characteristic. Comparing the average annual wind speeds of 1961-1990 with those of 1991-2020 we find that the average annual wind speed decreased by 0.6 m/s on average over the country or 21.6%.

The wind speeds in the cold period of the year also decreased compared to the annual average - on average by 0.8 m/s over the country (1991-2020 compared to 1961-1990) or by 24.3%.

3. Against the background of decreasing average wind speed, the frequency of low wind speeds is increasing. Thus, comparing the frequency of wind speeds in the period 1961-1990 with 1991-2020, the frequency of wind speeds below 1.0 m/s is increasing by 3.5% and the frequency in the 2-3 m/s range by 7.4%. In percentage ratio, this increase constitutes 14,6% and 21,4% respectively.

4. Starting with the range of velocities above 4 m/s, the difference between the frequency of velocities in the compared periods is decreasing dramatically. The larger the velocity range, the larger the difference in their frequencies becomes compared to the period 1961-1991. Thus, in percentage ratio the frequency of velocities 4-5 m/s decreased by 20.3% on average over the country, 6-7 m/s - by 48.8%, 8-9 m/s - by 65.2%, 10-11 m/s - by 75.9%, and from 21 m/s - by more than 100%. In the southern part of the country the speeds above 4 m/s decrease less, compared to the rest of the stations, thus confirming a relative stability in the change of wind speeds in this region.

5. Compared with the period 1961-1990, the frequency of calms is visibly decreasing. On average for the country, the annual average frequency of calms decreased by 15.5% compared to 1961-1990, in the warm period of the year - by 17.6%, in the cold period - by 14.9%.

6. Against the background of decreasing average wind speeds, particularly those above 4 m/s, we consider that there is an obvious trend of decreasing wind potential in the average wind on the country, because the more lulls there are, the more frequent are low wind speeds, with small exceptions in the southern part of Moldova.

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ASSESSMENT OF HEAVY METAL CONCENTRATIONS IN IARA RIVER BASIN, CLUJ COUNTY, ROMANIA

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ABSTRACT. – Assessment of Heavy Metal Concentrations in Iara River Basin, Cluj County. This study focuses on the results of analyses carried out on water samples collected in December 2024 and analyzed at the Research Institute for Analytical Instrumentation in Cluj-Napoca. The samples in question were taken within the perimeter of the Iara River basin, which was an important hub for the extractive industry during the communist regime in Romania. With the halting of many industrial and mining activities, mining infrastructure elements were abandoned, posing a significant pollution risk. In the case of the study area, these infrastructure elements are represented by residual waste dumps. However, the results of the water samples reflect not only a very low concentration of heavy metals, but also a very good example of water quality administration and management.

***Keywords**: heavy metals, water quality, mining area, Iara River basin, Cluj County.*

1. INTRODUCTION

Water, through its multitude of uses, is a vital component in the proper functioning of the entire environment; water supports the development of both aquatic and terrestrial biodiversity. Water resources also prevent soil degradation and ensure the sustainability of ecosystems. This means that contamination of this fundamental element generally results in negative effects on the environment.

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Water and river systems play a critical role in the redistribution and transformation of mineral deposits through natural geochemical and hydrological processes. Precipitation acts as a primary driving force by mobilizing water that infiltrates the soil and rock layers, initiating the weathering of old mineral deposits. As river water flows across and through mineralized terrains, it enhances the washing and transport of weathered materials, progressively removing fine particles and dissolved ions. This process leads to the dilution and dispersion of heavy metals, such as iron, manganese, copper, lead, and zinc, from their original deposits into surrounding surface and groundwater systems. While dilution can reduce metal concentrations locally, continuous leaching may also expand the spatial extent of contamination downstream.

The ways in which water is used in raw industrial processes have evolved from one historical period to another, as during the industrial boom, water resources were used to cool machinery or in settling ponds to separate useful ores from the sterile material. Thus, in mining and mineral processing operations, water is essential for gravity separation, flotation, and leaching processes commonly applied to metal related ores. Water suspends finely ground ore particles, allowing minerals to be recovered through gravity or magnetic separation, while copper sulfide minerals are concentrated using flotation methods that rely on water–air–reagent interactions. Additionally, water facilitates the removal of impurities through washing and dilution, improving metal recovery efficiency. However, the extensive use of water in ore separation also has environmental implications. The interaction between water and sulfide-bearing iron and copper ores can promote oxidation reactions that generate acidic conditions and mobilize heavy metals.

The main characteristic of these harmful substances is their ability to bioaccumulate. Through this process, heavy metals can persist to the last link in the food chain by polluting the soil, water, and consequently plants and terrestrial and aquatic life. The use of polluted river water for domestic, agricultural, and industrial purposes further amplifies the environmental health implications of heavy metal contamination (Morais *et al*, 2012). Additionally, elevated metal concentrations can disrupt aquatic ecosystems by impairing reproduction, growth, and metabolic functions of aquatic organisms, ultimately reducing biodiversity and ecosystem resilience.

The Apuseni Mountains represent the highest and most expansive sector of the Western Carpathians, defined by the Mureș Valley corridor to the south and the Barcău and Someș valleys to the north, with a significant "mining foot-print" developed across millennia, starting from the Roman Empire till present time (Șerban *et al,* 2004). Besides the well-known mining deposits from the so-called "Golden Rectangle", the area is known also for the significant iron deposits in Iara Depression (Bătinaș, 2012).

The temporal analysis of scientific research over the past 30 years on mining pollution in the Arieș River catchment area (collector of Iara River) has revealed a certain heterogeneity of the studied topics. Thus, in the late 1990s till 2001, the first studies were focused on tracing different pollutants and their impact regarding environmental contamination. These efforts helped establish analytical methods later applied to river pollution research. One of the earliest quantitative analyses of heavy metals in the Arieș River using a pollution index based on dissolved metal concentrations along a major river transect was published in Studia UBB Geologia (Forray, 2001). In the next decade, until 2010, a series of papers have been related to geochemistry focusing on heavy metal concentrations in surface waters and sediments in relation to local mining (Șenilă *et al,* 2007), (Ozunu *et al*, 2009) and on the mineralogy of the ore deposits and their alteration process that can trigger environmental pollution (Ghergari *et al*, 2004) or on the chemistry analysis of surface waters and hyporheic zone (Marin, 2010). Besides the scientific papers published in various journals, some PhD thesis related to the subject have been defended in that time (Bătinaș, 2010), (Costan, 2010), (Ștefănescu, 2010).

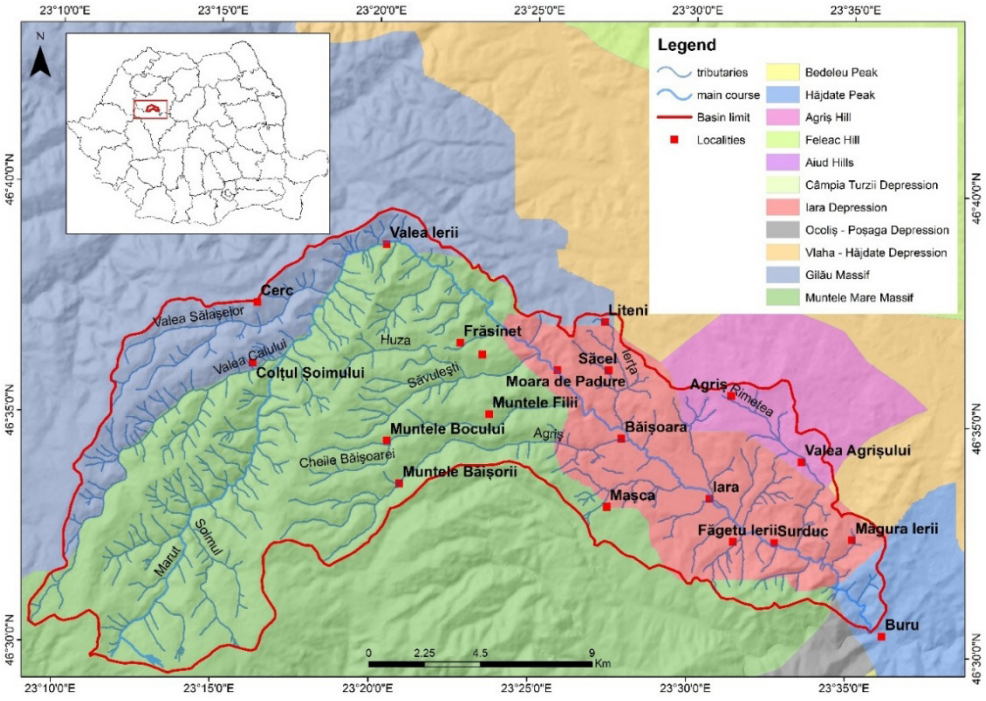

Fig. 1. Location of the Iara River basin
Source: the authors

The decade 2011-2020 was also focused on emphasizing anthropic pollution due to mining operation with focus mainly on heavy metals (Corcheș, 2011), (Levei *et al,* 2014) and radionuclides (Ioniță *et al,* 2017).

The last period (2021-present) has seen studies on water chemistry spatial variation (Moldovan *et al*, 2021) remediation of acid mine drainage methods (Glevitzky *et al*, 2025), evaluation of pollution levels using bio-indicators (Glevitzky *et al*, 2025), sustainable development issues in post-industrial present time (Botezan *et al*, 2020) and proposed remediation methods and techniques in order to mitigate historical pollution impact (Bănăduc *et al*, 2021).

The Iara River Basin, located in the south-west part of the Cluj County (western Romania), overlaps with the Băișoara – Iara mining area, which represents one of the eleven major mining zones identified within the Apuseni Mountains (Constantin, 2011). The largest left-side tributary of Arieș River, Iara basin is defined mostly by mountainous terrain, accounting for 60% (Muntele Mare and Gilău Massif), while 40% overlaps with depression terrain (Iara Depression). Location of Iara catchment and its relation with geographical units are presented in figure 1.

Historically, this region played a significant role in the local mining industry due to its rich underground resources. The industrial scale activity has begun in 1955-1957 with first complex geological explorations. The main activity has begun within Iara and later in Cacova Ierii localities in 1981 within the administration of so-called "*Mining Sector Băișoara – Mining Exploitation Iara*". The primary exploitable resource for much of the 20th century was iron ore, which supported both regional and national metallurgical activities until mining operations halted in 2006. In more recent years, attention has shifted towards the extraction of industrial dacite, a valuable volcanic rock used in construction and various industrial applications (ANRMPSG, 2021). These dacite deposits are primarily located to the northern part of Băișoara settlement, where they continue to sustain limited but ongoing quarrying activity in the Iara basin.

The Iara Basin represents a sensitive hydrographic system influenced by both natural and anthropogenic pollution sources. Scientific investigations identified a slight but persistent tendency toward water pollution, primarily associated with human activities superimposed on natural background processes. Natural pollution sources include the dissolution of water-soluble rocks (large area with limestone), soil erosion processes, and organic inputs from riparian and aquatic vegetation, which contribute suspended solids and nutrients to surface waters (Luca *et al*, 2007).

Anthropogenic pollution sources are more significant and continuous, dominated by domestic wastewater discharges from rural settlements, untreated sewage, and effluents from small agro-zootechnical farms rich in organic matter.

Additional pressures arise from tourism-related activities, including camping and leisure facilities that generate wastewater similar to urban effluents. A critical pollution source is represented by uncontrolled solid waste dumps, particularly sawdust and industrial residues deposited near riverbeds, which facilitate direct runoff and soil infiltration. Historical and ongoing mining and quarrying activities, especially iron exploitation in Maşca and Cacova Ierii and associated mineral processing, further increase the risk of metal mobilization.

2. METHODOLOGY

The scientific approach of this paper is based on several stages, each of which played an important role in the completion of the study. The first stage consists of a thorough review of the literature on the chosen topic, as well as similar studies. Through the method of synthesis, a bibliography was created which, together with the existing level of knowledge on the subject, will serve as the scientific foundation for consolidating the paper output. This stage allowed both a deep understanding of the theoretical context and existing approaches, as well as the identification of gaps in knowledge and research that justify the need for the research in question. Thus, the theoretical foundation represented a solid starting point, capable of properly guiding the methodological course of the study.

The second stage constitutes the cartographic part of the study, as the working area was studied in detail by analyzing a large variety of maps from different sources in order to generate the included maps. Thus, we have combined raw data from different national available servers or databases (catchment area, river network, settlement's location, geographical units, hill shade and terrain slope) to elaborate a general map of the studied area.

The third stage constitutes the first direct contact with the study area, namely going out into the field and collecting samples for analysis; this stage took place on December 14th, 2024. For this stage, four points for sampling were selected, namely: near Dobrin Peak – at an altitude of approximately 1500 m and at a significant distance from any village in that area; in the center of the village of Băişoara – a polarizing center during the heyday of the extractive industry in Romania; in the village of Surduc – on the outskirts of the former mining area, before reaching the Surduc gorge; and at the confluence of Iara and Arieş rivers. The coordinates of the points were recorded using Google Maps, then transferred to ArcMap 10.8 to create a map of their locations (fig. 2).

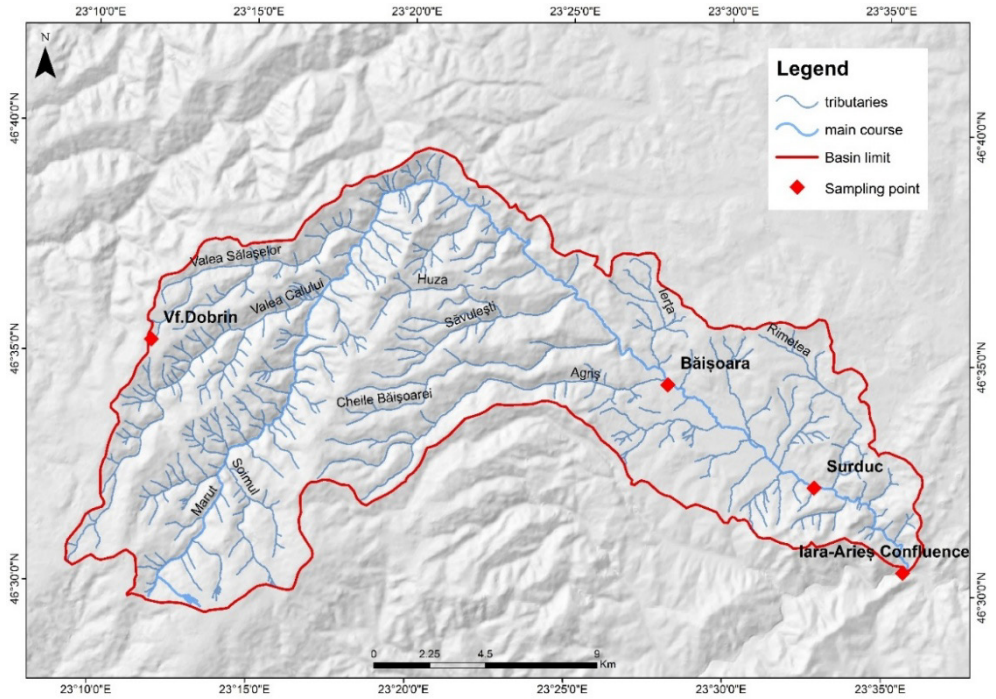

Fig. 2. Location of sampling points in Iara River basin
Source: the authors

Water samples were collected in 50 ml glass containers, stored at temperatures between 0-4°C, and then further analyzed in the laboratory of the Research Institute for Analytical Instrumentation from Cluj-Napoca (ICIA) to determine the concentration of heavy metals in the water. The following parameters were taken into account: Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd, and Pb.

3. RESULTS AND DISCUSSIONS

As a result of the sampling analysis presented in the table below, we can now say that at least in the measured points location' the actual concentrations of heavy metals are complying with the maximum acceptable concentration (MAC). Current legislation act that regulates the maximum concentrations allowed in rivers is the *Regulation on the classification of surface water quality in order to establish the ecological status of water bodies – No. 161 from February 2006*.

According to this regulation, water quality is classified on five quality classes, first one been considered the best, while the fifth the worst in respect with its quality and its possible use.

Table 1. Results of water samples analysis and compliance with standards regulation

No.	Metals	Heavy metal concentrations (µg/l)						
		Dobrin peak	**Băişoara**	**Surduc**	**Confluence**	**Moldovan, 2021***	**MAC** 1st class**	**MAC** 5th class**
1.	Al	1.4	1.0	1.8	4.5	79	-	-
2.	As	<1	1.1	1.5	1.5	2	<10	>100
3.	Cu	<1	2.0	1.3	2.4	94	<20	>100
4.	Cd	<1	<1	<1	<1	28	<0.5	>5
5.	Cr	<1	<1	<1	<1	23	<25	>250
6.	Fe	1.1	1.2	<1	1.4	37	<300	>2000
7.	Mn	<1	7.8	<1	<1	34	<50	>1000
8.	Ni	<1	2.8	<1	1.6	59	<10	>100
9.	Pb	<1	<1	<1	<1	69	<5	>50
10.	Zn	31.2	37.4	4.7	19.8	23	<100	>1000

**Moldovan, 2021*
***Regulation on the classification of surface water quality in order to establish the ecological status of water bodies – No. 161 from February 2006*
Source: the authors

The results do not reflect any exceedance of the legislation standards, but fluctuations in the maximum concentrations recorded at the sampling points in the lower basin, corresponding to the former mining area, can be observed. These variations may be associated with both natural processes of dilution and transport of substances in the riverbed and the possible remobilization of residual contaminants from sediments deposited during periods of mining activity. In addition, hydrological factors, such as seasonal flows or episodes of torrential rain, can temporarily influence the measured values, causing a redistribution of chemical elements from the soil and alluvial material to the water column. Therefore, although the levels do not exceed the permissible limits, the presence of these fluctuations indicates the persistence of a historical anthropogenic influence within the analyzed ecosystem.

Latest research deployed in the same area has been validating that the concentration of heavy metals tends to decrease in Iara catchment. A recent study (Moldovan *et al*, 2021), about water chemistry variables within Arieş catchment has found significant greater values for heavy metals concentration at the confluence of Iara River with its collector Arieş river. Thus, all ten indicators

have shown values with two digits, except *Arsenic* which was in the same level with the values recorded in mid-December 2024. Comparing the values from that study with the regulation act, we notice in several cases the limits of first water quality class have been exceeded.

4. CONCLUSIONS

The Iara River basin is located at the intersection of mining, agricultural, and tourism activities. With a small population but a rich history, this unique area is characterized by a series of diverse occupational and ecological transformations; these transformations reflect the stages of Romania's political and economic evolution. During the communist regime, rapid industrialization meant that the study area underwent partial reconstruction in order to generate capital, resulting in a series of constructions such as quarries, tailings ponds and waste dumps, designed to maximize the efficiency of these activities to the detriment of natural environmental factors. Once these activities ceased, a difficult process of restoring the area began, marked by sustained efforts to rehabilitate the environment and restore the natural balance. This process is highlighted, for example, by the greening of the former tailings pond in Surduc, where recultivation and slope consolidation works have helped reduce the risk of erosion and heavy metal remobilization.

Although there are still vulnerable areas, especially where waste deposits have not been completely stabilized or vegetation is still in its early stages, analyses of heavy metal concentrations in the river show a decreasing trend. This reflects the effectiveness of the measures implemented by the authorities responsible for monitoring, managing, and rehabilitating the river basin, suggesting a trend towards improving environmental quality and a gradual reduction in historical anthropogenic influences. Although measured water quality parameters remained within legal limits during the study period, the coexistence of multiple pollution sources highlights the basin's vulnerability and the necessity for continuous monitoring and preventive environmental management.

Understanding the behavior of heavy metals in river systems, particularly their accumulation in sediments and biota, is essential for effective water resource management and environmental protection. Monitoring metal concentrations, controlling mining discharges, and implementing remediation strategies are critical steps to minimize bio-accumulation risks and safeguard both ecosystem health and the sustainable use of river water resources.

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MULTI-CROP LAND SUITABILITY ASSESSMENT USING GIS–AHP IN OSUN STATE, NIGERIA

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ABSTRACT. – **Multi-Crop Land Suitability Assessment Using GIS–AHP in Osun State, Nigeria**. The sustainable cultivation of arable crops in Nigeria is increasingly challenged by climate variability, land degradation, and inefficient land use practices. This study evaluates the land suitability of Osun State for multiple crops—cassava, maize, yam, rice, cocoa, plantains, and vegetables—using a GIS-based Analytical Hierarchy Process (AHP) approach. The research has been conducted to produce spatially explicit suitability maps to support climate-resilient agricultural planning and optimization of crop selection in the region. Seventeen environmental, climatic, and edaphic criteria-slope, elevation, rainfall, temperature, soil pH, organic carbon, macro-nutrients, proximity to roads, and rivers-were integrated using AHP, which derives weights from expert judgment. The weights were then used in a weighted overlay analysis to map the area according to the suitability classes: highly suitable, suitable, moderately suitable, marginally suitable, and unsuitable. The results revealed that cassava and maize have the highest proportions of highly suitable land in the state, with yam coming next. Spatial analysis sets out the top Local Government Areas such as Aiyedaade, Ife South, Ife North, Atakumosa West, and Obokun as highly preferable zones for multi-crop cultivation. This study draws attention to the usefulness of the GIS–AHP method for land evaluation at the regional scale and provides critical insight into data-driven agricultural policy, sustainable land use, and food security in sub-Saharan Africa.

Keywords: *land suitability; GIS–AHP; multi-crop assessment; agricultural zoning; sustainable agriculture*

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1. INTRODUCTION

Agriculture acts in Sub-Saharan Africa as the backbone of some socio-economic development, along with food security and livelihood sustainability; it accounts for over 60 percent of the workforce while at the same time contributing to a very significant percentage of the national gross domestic product (Haggblade, 2013; Kray et al., 2018; Searchinger et al., 2023). In Nigeria, crops such as yam, maize, cassava, rice, plantain, cocoa, and vegetables keep the small-scale agriculture going and support household food systems and local markets (Olugbire et al., 2021; Chiaka et al., 2022). While the ecological and economic importance of these crops is well documented, their productivity differs depending on the region because there is a mismatch between their ecological requirements and the predominant land use patterns (Siptits & Evdokimova, 2020; Qiu et al., 2021).

That is a complication that is quite keenly felt in southwestern Nigeria, particularly in Osun State, where land use decisions are, until today, still regularly taken on informal or tradition-based grounds. Consequently, poor site selections become a hindrance to farm productivity as do resource misallocations and environmental degradation on a long-term basis (Oyekale, 2012a; Oyekale, 2012b; Alabi et al., 2024). Population pressure, climate variability, and the depletion of soil nutrients have added another layer of adversity to the problems of agricultural land management and planning, thus invoking the urgent need for data-based tools (Ezekiel et al., 2020; Kehinde et al., 2020).

In an answer to this urgent requirement, Geographic Information Systems (GIS) and Remote Sensing (RS) have been considered dynamic tools in the spatial land suitability evaluation and one that can layer and combine different environmental data sets like soil properties, topographies, rainfall, and infrastructure networks required in spatial decision-making (Partoyo, 2022; Alam et al., 2024; Yuliawan & Pusvita, 2024). To enhance objectivity and reproducibility in land evaluation, GIS is increasingly being paired with Multi-Criteria Decision Analysis (MCDA) methods, particularly the Analytic Hierarchy Process (AHP). AHP offers a robust and transparent framework for assigning weights to multiple biophysical and socioeconomic criteria, allowing for expert-driven prioritization (Rovai & Andreoli, 2018; Wotlolan et al., 2021; Nungula et al., 2024). Its flexibility in handling both qualitative and quantitative data makes it especially suitable for agricultural applications (Jozi & Ebadzadeh, 2014; Wijesinghe, 2024).

Several studies have demonstrated the application of GIS and AHP in agricultural land suitability assessments. In the Amhara Region of Ethiopia, land suitability for rice production was assessed through GIS-AHP, considering soil, climate, and topography. It was also noted that in more than 70% of the areas, either high or moderate suitability for rice production was indicated, presenting a great prospect for agricultural development in the region (Ayehu & Besufekad, 2015). In Ghana, 23.3% of land ranked as highly suitable for cocoa,

whereas from 1.5 to 23% of the territory in Peru was identified by the AHP model as highly suitable, depending on the modeling approach employed (Rojas-Briceño et al., 2022; Bhat, 2023); meanwhile, a study in Egypt observed 36% suitability for maize, stressing the importance of the existing climate and soil conditions (Abuzaid & El-Husseiny, 2022). A few other assessments in Nigeria indicated land suitability for cassava up to the extent of 65.92% existing in the southern part of Adamawa State, thereby recognizing large areas for potential cultivation (Zemba et al., 2018) as well as rice in Oyo State (Ayoade, 2017) and soybean in Kaduna State (Sadiq et al., 2023). However, most of these studies are limited by narrow spatial coverage, focus on a single crop, or use of low-resolution datasets, limiting their relevance for broader agricultural policy and spatial planning.

Notwithstanding the growing corpus of GIS–AHP literature, only a few studies have developed comprehensive, multi-crop, land suitability maps at sub-national scale in Nigeria capturing the seven crops this study is examining. Another major gap in research is the relative inter-crop suitability studies across entire state territories using fine-scale data that have been validated using expert opinions and empirical observations.

The proposed study is set to create a large-area scale (30 m), multi-crop land-suitability model using a GIS–AHP approach for seven major arable crops of Osun State. The thrust will then be to produce spatially explicit suitability maps that can be employed in the pursuit of precision agriculture, sustainable land management, and zoning policy decisions at the local government area (LGA) level. The inclusion of various environmental variables and stakeholder knowledge in the decision-making process aims to support sub-national planning frameworks that might enhance food security and resource optimization in southwestern Nigeria.

2. MATERIALS AND METHODS

Study Area. The study was undertaken in Osun State (Southwestern Nigeria) located between latitudes 7°30′N and 8°10′N and longitudes 4°00′E and 5°05′E. Osun State covers an area estimated at 9,251 km^2 and comprises 30 Local Government Areas. The region has a tropical climate and four distinct seasons of bimodal rainfall, with rainfall ranging from 1,100 mm to 1,400 mm, and temperature ranges between 25°C and 31°C. The topography varies from lowland plains to undulating hills, with the land predominantly used for smallholder rain-fed agriculture. Because of this diversity of ecological features, Osun State supports varied arable crops, making it a fair latitude land suitability analysis location. The study area is shown in figure 1.

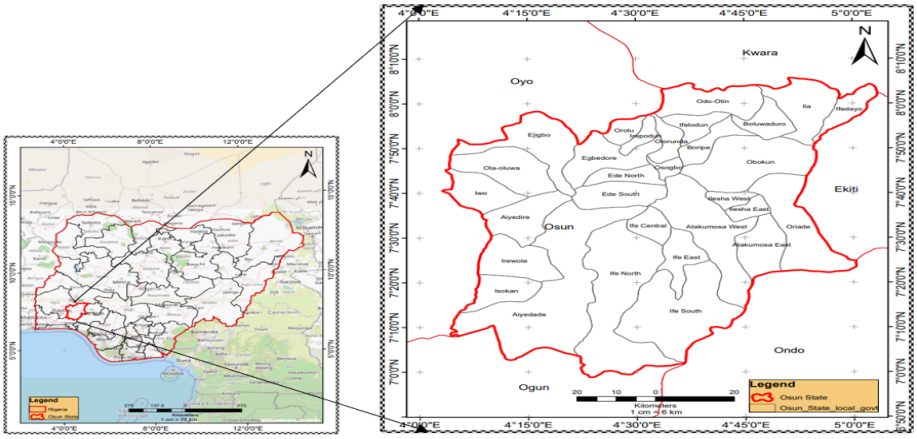

Fig. 1. Map of the study area.
Source: the authors

Data Sources. The land suitability assessment incorporated a range of geospatial datasets relevant to crop growth, including climatic, topographic, edaphic, and infrastructural variables**.** The data sources are listed in table 1.

Table 1. Spatial datasets and metadata used to derive suitability layers in the multi-criteria evaluation model

S/N	Data	Name	Resolution	Sources
1	Land use and land cover	Landsat 8 & 9	30m	*https://earthexplorer.usgs.gov/*
2	Elevation & slope	SRTM	30m	*https://earthexplorer.usgs.gov/*
3	Climate (Precipitation)	CHRS	4km	*https://chrsdata.eng.uci.edu/*
4	Climate (Temperature)	MODIS Global LST	1km	*https://earthexplorer.usgs.gov/ (Google Earth engine)*
5	Climate (Humidity)	NASA	2m	*https://power.larc.nasa.gov/data-access-viewer/*
6	Soil	ISRIC	250m	*https://data.isric.org/geonetwork/srv/eng/catalog.search#/home*
7	Rivers / surface water	OSM	250m	*https://download.geofabrik.de/africa.html*
8	Roads	OSM	250m	*https://download.geofabrik.de/africa.html*

Source: the authors

Data Acquisition and Processing. Environmental and spatial datasets were integrated to analyze land suitability for seven major arable crops throughout Osun State. Land use/land cover data were procured from Landsat

8/9 (30 m), while terrain data such as elevation and slope were extracted from SRTM. Climate variables of precipitation, temperature, and relative humidity were derived from CHRS, MODIS, and NASA POWER, respectively. Soil characteristics of pH, organic carbon, texture, and water holding capacity were collected from ISRIC SoilGrids. Distances to infrastructure were calculated using road and river vector datasets from OpenStreetMap and HydroSHEDS.

All the layers were reprojected to WGS 84 / UTM Zone 31N and resampled to a common 30-m resolution. Geospatial preprocessing steps were rasterization, Euclidean distance analyses (for proximity variables), image classification (for LULC), and interpolation (for climate and soil surfaces). Elevation and slope layers were derived from the DEM using standard geoprocessing tools. Each layer was reclassified into five suitability classes based on crop-specific ecological requirements and standardized for integration into a weighted overlay analysis using AHP-derived weights.

Normalization and reclassification based on crop requirements. Using ArcGIS Pro 3.2 for heavy assessment and for determining land suitability for arable crops, an integrated approach has been undertaken, starting with the accumulation of all the necessary data mentioned in objective one. These datasets include soil texture, temperature, relative humidity, rainfall, pH, slope, soil nutrient, proximity to roads and rivers, and land use/land cover data. The datasets are normalized and reclassified depending on each crop's special requirements.

Minimum and Maximum Criteria Values in Osun state Nigeria. The criteria required for crops in study farming in Osun state Nigeria are represented (table 2). Additional suitability tables are provided in the Supplementary list.

Table 2. Suitability criteria ranges (S1–N) for major crops in Osun State, Nigeria

Criterion	Yam	Maize	Cassava	Rice	Plantain	Cocoa	Vegetables
LULC (S1)	Agricultural land	Agricultural land	Agricultural land	Agricultural land	Agricultural land	Forest	Agricultural land
Elevation (m, S1)	68–155	68–155	68–155	68–155	68–155	68–155	68–155
Slope (S1)	0–5	0–5	0–5	0–5	0–5	0–5	0–5
Precipitation (mm, S1)	2600–2800	2801–3100	2600–2800	2517–2599	3401–3697	3401–3697	2801–3100
Temperature (°C, S1)	28–30	26–28	28–30	28–30	28–30	26–28	24.6–26
Relative Humidity (% S1)	70–75	70–75	70–75	70–75	65–70	80–82	65–70
Soil pH (S1)	6.13–6.17	6.13–6.17	6.13–6.17	6.13–6.17	6.13–6.17	6.13–6.17	6.13–6.17
Soil Texture (S1)	Loam	Loam	Loam	Clay	Loam	Loam	Loam
Soil N (mg/kg, S1)	450–599	450–599	450–599	450–599	450–599	450–599	450–599

Criterion	Yam	Maize	Cassava	Rice	Plantain	Cocoa	Vegetables
Soil P (mg/kg, S1)	500–676	500–676	500–676	500–676	500–676	500–676	500–676
Soil K (mg/kg, S1)	200–260	200–260	200–260	200–260	200–260	200–260	200–260
Soil Ca (mg/kg, S1)	1100–1493	1100–1493	1100–1493	1100–1493	1100–1493	1100–1493	1100–1493
Soil Depth (cm, S1)	40–58	36–46	40–58	23–36	40–58	40–58	0–23
Soil Organic Carbon (g/kg, S1)	428–698	428–698	428–698	428–698	428–698	428–698	428–698
Soil Water Capacity (kPa, S1)	263–336	263–336	263–336	263–336	263–336	263–336	263–336
Distance to Rivers (m, S1)	5000–9999	2000–4999	5000–9999	2000–4999	2000–4999	2000–4999	2000–4999
Distance to Roads (m, S1)	0–500	0–500	0–500	0–500	0–500	0–500	0–500

Source: the authors

Analytical Hierarchy Process (AHP). Analytic Hierarchy Process (AHP) is a method or a tool that aids in sorting and assessing complex decisions. Thomas L. Saaty was the developer of this tool in the 1970s and it has been used to establish a hierarchy of criteria and factors influencing land suitability. AHP techniques assign appropriate weights to each criterion based on its relative importance, so that crucial factors such as soil types, soil pH, climatic data, soil nutrients, land use, and soil depth are emphasized in the analysis, while other factors such as road and river proximity are given less importance. Because the AHP Excel file supports only 10 criteria, the free web-based decision-making tool AHP Online System (AHP-OS) from https://bpmsg.com/ahp/ahp.php was preferred. This is because 17 criteria were needed to be considered for the analysis.

If one clicks on AHP Priority Calculator and chooses the number of criteria (17), a new window opens where one can enter the criteria that were used in the analysis. Pairwise comparisons are then carried out to ascertain how important each criterion is relative to every other one. The AHP scale includes: 1- Equal Importance, 3- Moderate importance, 5- Strong importance, 7- Very strong importance, 9- Extreme importance (2,4,6,8 values in-between).

The resulting weights for the criteria based on the pairwise comparisons. The multi-criteria evaluation and expert judgment with the Analytic Hierarchy Process (AHP) guided the decision-making process. The derived priorities highlight the relative importance of each criterion in determining land suitability for crop cultivation in Osun State. A total of 136 pairwise comparisons were conducted to establish the weights, with a Consistency Ratio (CR) of 6.5%,

which is below the 10% threshold, confirming that the expert judgments were consistent. The principal eigenvalue was 18.678, converging in six iterations with high precision (delta = 4.3×10^{-8}).

The results show that rainfall, soil characteristics, slope, and land use/land cover had the highest influence on suitability outcomes, while lineament density and NDVI contributed less significantly. These priorities were computed from the decision matrix through eigenvector calculations and were applied in the weighted overlay analysis to produce the final suitability maps. The Pairwise Comparison matrix of land suitability for farming in Osun state, Nigeria is presented in fig. 2.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	2.00	5.00
2	1.00	1	1.00	1.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	1.00	3.00	3.00	2.00	4.00
3	0.50	1.00	1	1.00	1.00	1.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	3.00	4.00	4.00	4.00
4	1.00	1.00	1.00	1	3.00	4.00	5.00	4.00	4.00	4.00	4.00	4.00	5.00	4.00	5.00	5.00	5.00
5	1.00	0.50	1.00	0.33	1	1.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	3.00	4.00	5.00
6	1.00	0.50	1.00	0.25	1.00	1	1.00	1.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	3.00
7	1.00	1.00	0.33	0.20	0.33	1.00	1	1.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00	4.00	4.00
8	1.00	0.50	0.33	0.25	0.33	1.00	1.00	1	3.00	3.00	3.00	3.00	3.00	4.00	4.00	3.00	4.00
9	1.00	0.50	0.33	0.25	0.33	0.50	0.50	0.33	1	1.00	1.00	1.00	2.00	3.00	4.00	4.00	2.00
10	1.00	0.50	0.33	0.25	0.33	0.50	0.50	0.33	1.00	1	1.00	1.00	2.00	3.00	4.00	4.00	2.00
11	1.00	0.50	0.33	0.25	0.33	0.50	0.50	0.33	1.00	1.00	1	1.00	2.00	3.00	3.00	3.00	3.00
12	1.00	0.50	0.33	0.25	0.33	0.50	0.50	0.33	1.00	1.00	1.00	1	2.00	3.00	4.00	4.00	3.00
13	1.00	1.00	0.50	0.20	0.25	0.50	0.33	0.33	0.50	0.50	0.50	0.50	1	3.00	3.00	4.00	5.00
14	0.33	0.33	0.33	0.25	0.25	0.33	0.33	0.25	0.33	0.33	0.33	0.33	0.33	1	1.00	3.00	3.00
15	1.00	0.33	0.25	0.20	0.33	0.33	0.50	0.25	0.25	0.25	0.33	0.25	0.33	1.00	1	1.00	3.00
16	0.50	0.50	0.25	0.20	0.25	0.33	0.25	0.33	0.25	0.25	0.33	0.25	0.25	0.33	1.00	1	3.00
17	0.20	0.25	0.25	0.20	0.20	0.33	0.25	0.25	0.50	0.50	0.33	0.33	0.20	0.33	0.33	0.33	1

Fig. 2. Pairwise Comparison matrix of land suitability for farming in Osun State, Nigeria.
Source: the authors

The Weighted Sum Analysis (WSA) procedure found within ArcGIS was used for integrating together the reclassified raster datasets, with some weights obtained through the AHP method. Using the slope as an example, general land parameters like slope, soil pH, and rainfall affecting crop growth were multiplied by their respective weights and accumulated to derive the composite land suitability index. The output raster was then converted into integers and classified into five suitability ranges: Highly suitable- S1, Suitable-S2, Moderately suitable- S3, Marginally suitable- S4, and Unsuitable-N. These maps serve as a guideline in selecting prime areas for growing cassava, maize, yam, rice, cocoa, plantains, and vegetables in Osun State. Criteria rank and weighted values are presented in table 3.

Table 3. Criteria rank and weighted value of land suitability for farming in Osun state, Nigeria

Criteria	Priority (%)	Rank	(+)	(-)
LULC	6.6	6	4.0	4.0
Elevation	8.4	4	3.8	3.8
Slope	9.9	2	4.4	4.4
Precipitation	15.3	1	7.5	7.5
Temperature	9.8	3	4.5	4.5
Relative Humidity	6.5	7	1.7	1.7
Soil pH	6.3	8	2.2	2.2
Soil Texture	7.3	5	3.4	3.4
Soil Nitrogen	4.4	10	1.9	1.9
Soil Phosphorus	4.4	10	1.9	1.9
Soil Potassium	4.3	12	1.5	1.5
Soil Calcium	4.5	9	1.8	1.8
Soil Depth	4.0	13	2.2	2.2
Soil Organic Carbon	2.3	14	1.1	1.1
Soil Water Capacity	2.3	15	1.3	1.3
Distance to Rivers	2.0	16	1.0	1.0
Distance to Roads	1.5	17	0.6	0.6

Source: the authors

3. RESULTS AND DISCUSSION

Land use and land cover dynamics in Osun State. The land use/land cover (LULC) analysis studied the agricultural landscape of Osun State. Forest areas, as of 2023, are the dominant landscape, covering 37.53% (fig. 3), a proof of the region's ecological richness. Agricultural lands cover 15.23% while shrublands and bare lands take 19.81% and 22.69%, respectively. Built-up areas considered less for development cover 4.53%, and water bodies cover 0.20%. These spatial patterns point towards the land being a bit of everything: conservation and agricultural land.

Elevation and slope as determinants of suitability. Elevation analysis (fig. 3) indicates that Osun State's terrain spans from 68 to 773 meters. Most agricultural activities occur in areas with low to moderate elevation (Low: 26.25%, Moderate: 29.45%). High and very high elevation zones (26.75% and 12.05%, respectively) are limited in agricultural viability. Slope, a critical determinant of runoff and erosion, shows that 71.7% of the state has very low slope (fig. 3), ideal for crop farming, while only 0.10% is categorized as high slope terrain.

Climatic patterns: precipitation, temperature, and humidity. Rainfall patterns range from 2,516.73 mm to 3,697.17 mm (fig. 3), supporting diverse crop types. The northwestern regions exhibit high rainfall suitable for plantain and cocoa, while areas with lower rainfall (southwest) suit yam and maize. Temperature ranges from 24.61℃ to 35.14℃ (fig. 3), with central zones experiencing optimal crop temperatures (28-30℃). Relative humidity varies between 60.49% and 82.14%, contributing to moisture availability for crops like vegetables and rice.

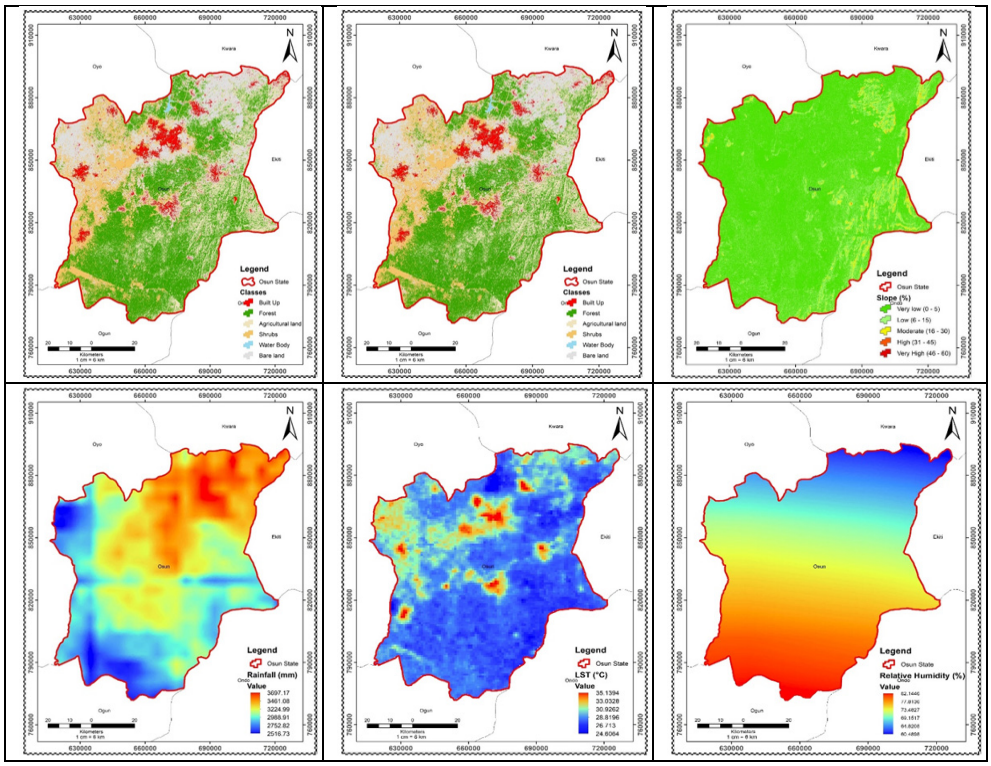

Fig. 3. Land use and land cover map, elevation map, slope map of Osun state, rainfall map, temperature map and relative humidity of Osun State, Nigeria (2022).
Source: the authors

Soil suitability indicators. Soil pH in Osun State varies slightly from 5.87 to 6.17, suitable for most crops (fig, 4). Nutrient content such as nitrogen (0-599 mg/kg), phosphorus (75.71-675.60 mg/kg), and potassium (76.92-260.43 mg/kg) shows a moderately rich nutrient profile (fig. 4). Organic carbon (0-698 g/kg) and calcium (488.01-1,493.08 mg/kg) indicate fertility variation (fig. 4). Soil texture includes loam, sandy loam, and clay, influencing crop-specific performance (fig. 4).

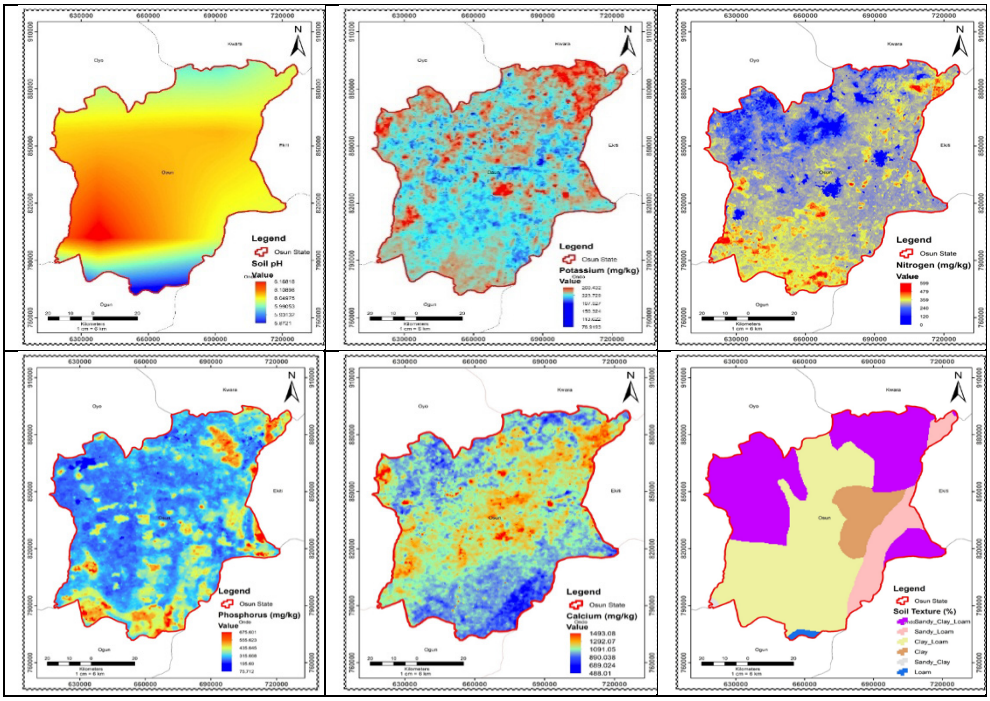

Fig. 4. Soil pH map, soil potassium map, soil nitrogen map, soil phosphorus map, soil calcium map, and soil texture map of Osun State, Nigeria. *Source: the authors*

River and road accessibility. Euclidean analysis of road and river networks (fig. 5) shows that most areas lie within 0 to 5,000 meters from water sources and roads. This proximity enhances irrigation potential and market access, especially vital for perishable crops like vegetables.

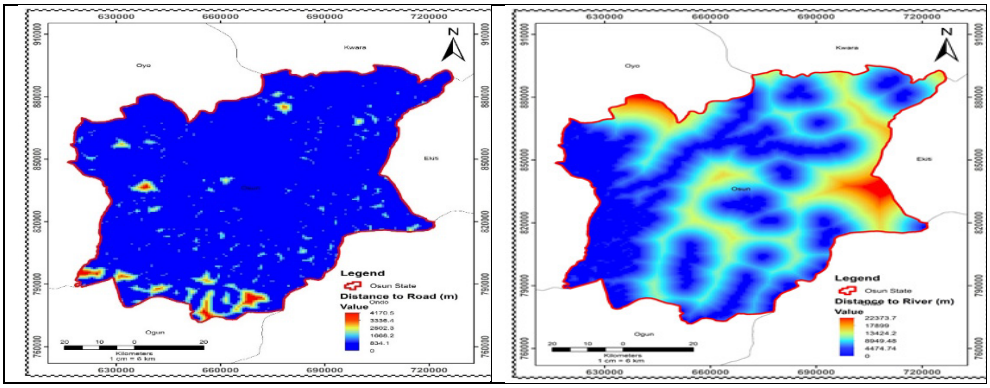

Fig. 5. Euclidean distance to road map and Euclidean distance to river map of Osun State, Nigeria. *Source: the authors*

Suitability mapping and validation. The final suitability maps were generated for seven crops: yam, maize, cassava, rice, plantain, cocoa, and vegetables. Each map was classified into S1–N zones using Jenks Natural Breaks to allow for data-driven interval segmentation. Output maps were normalized to a 0–1 scale for cross-crop comparability.

Table 4. Land suitability area covered for arable crops in Osun state, Nigeria

Crop	Highly Suitable (S1)	Suitable (S2)	Moderately Suitable (S3)	Marginaly Suitable (S4)	Unsuitable (N)
Yam	20.16% (1687.678 sq km)	28.93% (2420.86 sq km)	27.19% (2275.9 sq km)	17.60% (1473.015 sq km)	6.12% (511.9051 sq km)
Maize	20.66% (1728.457 sq km)	26.22% (2193.395 sq km)	26.37% (2205.898 sq km)	16.15% (1350.735 sq km)	10.60% (886.8412 sq km)
Cassava	22.41% (1870.042 sq km)	27.98% (2335.098 sq km)	23.61% (1970.261 sq km)	19.68% (1642.066 sq km)	6.33% (528.3051 sq km)
Rice	16.44% (1375.83 sq km)	27.51% (2302.94 sq km)	26.11% (2185.75 sq km)	20.96% (1754.37 sq km)	8.99% (752.38 sq km)
Plantains	12.83% (1071.64 sq km)	28.15% (2350.83 sq km)	26.30% (2196.03 sq km)	24.22% (2022.26 sq km)	8.50% (710.03 sq km)
Cocoa	19.91% (1663.10 sq km)	25.47% (2126.87 sq km)	25.03% (2090.30 sq km)	19.79% (1652.90 sq km)	9.80% (818.58 sq km)
Vegetables	16.43% (1372.38 sq km)	22.90% (1912.27 sq km)	26.80% (2237.69 sq km)	23.97% (2001.22 sq km)	9.90% (826.97 sq km)

Source: the authors

Land suitability for arable crops. The land suitability analysis for various crops (table 4 and fig. 6) of Osun State, covering a total area of 8,549.21 square kilometers, shows varying degrees of suitability for yam, maize, cassava, rice, plantains, cocoa, and vegetables. The highly suitable areas (S1) for these crops range from 12.83% to 22.41% of the land, while the suitable areas (S2) span between 22.90% and 28.93%. Moderately suitable areas (S3) constitute 23.61% to 27.19%, and marginally suitable areas (S4) cover 16.15% to 24.22%. Finally, the unsuitable areas (N) make up 6.12% to 10.60% of the land, depending on the crop.

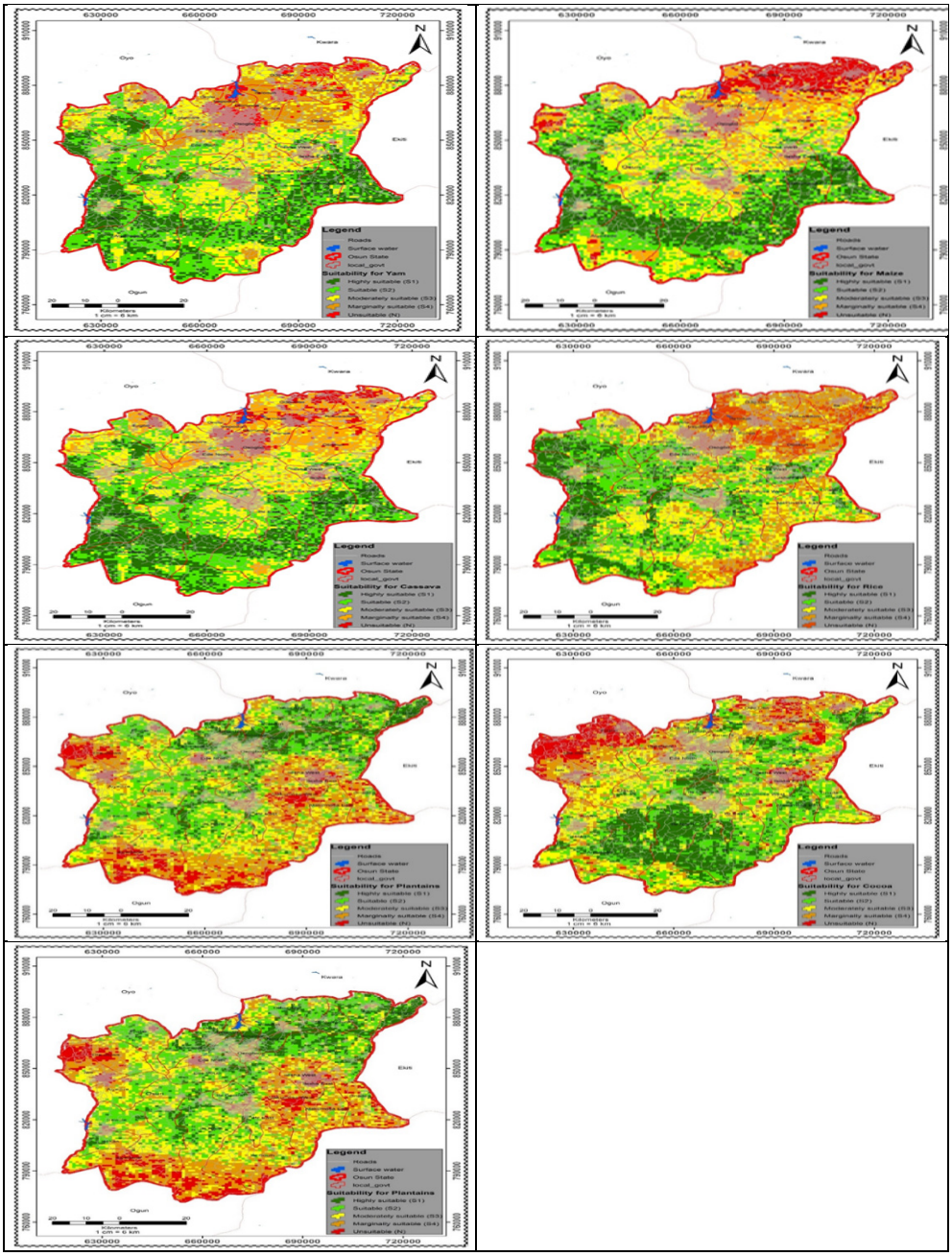

Fig. 6. Composite suitability maps of yam, maize, cassava, rice, plantains, cocoa and vegetables farming in Osun State, Nigeria.
Source: the authors

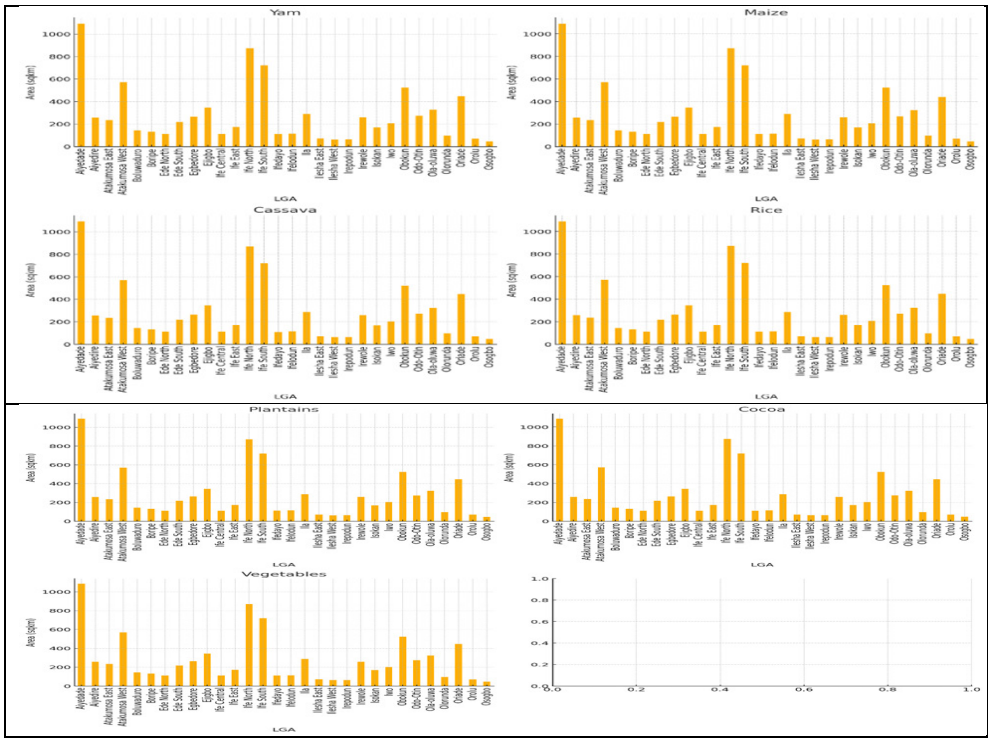

Fig. 7. Land suitability graph for arable crops in Osun State, Nigeria.
Source: the authors

4. CONCLUSIONS

This study performs a full-scale analysis of land suitability for arable crop production in Osun State, Nigeria, through an adapted GIS-based AHP procedural framework. Using spatial datasets for synthesis that include land use/land cover, topographic (slope, elevation), climatic (temperature, precipitation, relative humidity), edaphic (soil nutrients, pH, texture, depth, water-holding capacity), and infrastructural (roads and rivers) variables, it practically models spatial variability in the suitability of seven major crops: cassava, maize, yam, rice, cocoa, plantains, and vegetables.

Major findings show that the production of cassava and maize stands first in agronomic and spatial favorability throughout Osun State, where the highest proportion of land has been classified as highly suitable (S1). Yam also features many lands in the suitable to moderately suitable range, thereby reinforcing the local food economy. On the contrary, rice, cocoa, plantains, and

vegetables show spatial selectivity in suitability, depending on various ecological restrictions, such as sensitivity to pH, elevation, or rainfall limits. These differences testify to the different agroecological requirements of the crop and bring to view the need for site-specific planning.

At the sub-regional level, spatial disaggregation across the thirty local government areas of Osun shows that those with the highest multi-crop suitability potential include Aiyedaade, Atakumosa West, Ife North, Ife South, and Obokun. With favorable terrain, good soils, and moderate climatic conditions, these areas are high priority zones for intensification in agriculture, resource allocation, and investment. This study, by adopting a data-driven, spatially explicit approach, asserts the usefulness of the GIS-AHP in precision agriculture, land-use optimization, and resource management. Thus, the methodology offers a scalable template that can be replicated in other agro-ecological zones within Sub-Saharan Africa, given land pressure, climate change, and suitable resilient food systems. More definitively, the outputs represent crucial inputs to policy formulation, thereby enabling various stakeholders-from government agencies to development partners and local farmers-to make informed decisions about land allocation, crop diversification, and agricultural zoning. Therefore, the study thereby adds to the discourse on sustainable agriculture, food security, and environmental stewardship across the region at large.

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THE SETTLEMENTS AND THE IMPACT OF SUBURBANIZATION ON THE DEMOGRAPHIC AGE STRUCTURE IN SIBIU COUNTY, ROMANIA

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ABSTRACT. – The Settlements and the Impact of Suburbanization on the Demographic Age Structure in Sibiu County, Romania. The process of suburbanization has had an impact on the settlement system in Sibiu County. Demographic data collected from the last two censuses (2011 and 2021) as well as from the National Institute of Statistics show that the cities of Sibiu and Mediaș experienced a demographic decline in the last decades, while their suburban areas increased demographically. The highest growth has been recorded in the commune of Șelimbăr and in the town of Cisnădie, as well as in other communes around the city of Sibiu (Șura Mare, Șura Mică, Cristian, Roșia). While there is no data regarding the age of the migrants from the core cities to their respective suburban areas, the analysis shows that most of them are young adults and their (future) children. This has led to a sharp change in the age structure of the population both in the core cities and in the suburban settlements. On the one hand, the cities of Sibiu and Mediaș experienced a decline in young and adult population, and an increase of the weight of the elderly population. On the other hand, suburban settlements have registered not just an increase in terms of population, but also in the weight of the young and adult population. Therefore, we witness a process of sharp rejuvenation in the suburban settlements (mostly in Șelimbăr and Cisnădie), at the same time with the intensification of demographic ageing in many parts of Sibiu County, including the two cities, Sibiu and Mediaș. At the same time, suburbanization brought along a number of issues, such as the insufficient number of educational institutions in the suburban areas and increased traffic due to the large number of commuters.

Keywords: *suburbanization, settlements, cities, age structure, Sibiu County, Romania.*

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1. INTRODUCTION

Suburbanization has been an important process in post-socialist Romania, especially after 2000 (Voiculescu *et* al, 2010; Grigorescu *et al*, 2012; Suditu, 2012; Cocheci, 2014; Grigorescu, Mitrică, and Mocanu, 2015; Bodocan, Benedek, and Rusu, 2018; Rusu, Bodocan, and Man, 2020; Rusu, 2022), the same as in other parts of Central and Eastern Europe (Hamilton, Dimitrovska Andrews and Pichler-Milanović, 2005; Enyedi and Kovács, 2006; Young and Kaczmarek, 2008; Sýkora and Bouzarovski, 2012; Sýkora and Stanilov, 2014). Many urban residents, who grew tired of the compact cities filled with communist-style blocks of flats, have preferred to move to the neighbouring villages, adopting a more rural lifestyle, without giving up the urban commodities and amenities or their jobs in the city, commuting daily between their new homes and the core city.

This process has had a strong impact on the development of settlements around larger cities, as well as on the cities themselves. While Romania has been characterized by a general demographic decline (Benedek and Török, 2014; Vasile and Dobre, 2015; Dumitrașcu, Trică, and Caragea, 2018; Hărăguș and Földes, 2020; Patița, 2024), suburban settlements were among the very few ones which experienced a constant and sometimes explosive growth in terms of population, while the core cities declined due to emigration (Rusu, Bodocan, and Man, 2020). This process is also seen as a sort of re-migration, because some of migrants returned to their original villages, which they left for the cities during the socialist period. However, in most cases the migrants are young adults who were not even born in the socialist period. From a historical perspective, this process is nevertheless the reverse of what happened during the socialist period (and before), when people from rural areas flocked to the cities.

Given the young age of the migrants, suburbanization has left a mark on the demographic age structure. Therefore, suburban settlements have a much younger population on the whole, with a significant proportion of young adults and children, leading to high birth rates, while the core cities are affected by demographic ageing and high mortality rates. The positive natural balance in the suburban settlements doubles the effect of immigration, generating explosive population growth, while the negative natural balance in the core cities creates a downward spiral in demographic terms, leading to an even more striking decline.

2. DATA AND MATERIALS

Historical data regarding settlements have been retrieved from a number of studies. For instance, the first documentary attestation of each settlements has been taken from the works of Suciu (1968), but other sources have been checked as well, especially for newer settlements.

Population data has been retrieved from the 2011 and 2021 censuses, available online, as well as from the National Institute of Statistics (INS), which publishes annual statistical data on the online platform TEMPO. Data has been assessed and then used to create maps using Arc-GIS 10. Unfortunately, only the censuses provide the total population at settlement (village) level, and there are no other sets of data at this level, except for the demographic structure according to gender, also provided by the censuses every 10 years. Annual relevant data provided by the INS are available at the level of municipalities (cities, towns, and communes), and therefore most of the maps have been created using the administrative map of the county, and demographic processes are mainly assessed at this level.

This paper follows a previous study (R. Rusu *et al*, 2024) which analysed the natural and the migration balance rate of the population in Sibiu County at various levels. The findings of that study are used in this paper to explain certain features of the settlements in Sibiu County as a whole, and especially of those located in the suburban areas.

3. RESULTS AND DISCUSSION

Sibiu County is located in the central part of Romania, in southern Transylvania. It has been always been an important hub for trade and transport, because it provides one of the few ways of crossing the Southern Carpathians, along Olt River. Most of the current settlements date from the Middle Ages, when Germans (mainly Saxons) were settled in southern Transylvania, and the city of Sibiu has become the main seat of the Saxon community, which had certain facilities granted by the Hungarian kings. Nowadays the number of Saxons is very low, because most of them emigrated to Germany (and other German-speaking countries) in several waves during the 20th century: one at the end of World War II, one during the socialist period, and the last one at the beginning of the 1990s.

While German settlements date mainly from the 12th to 14th century, some of the Romanian settlements may be even older than that, although they appeared in the documents roughly during the same period. It is worth mentioning that almost 75% of the current settlements (140 out of 188) have been attested for the first time during the 13th and 14th centuries (fig. 1).

Administratively, the 188 settlements of Sibiu County are grouped into 2 cities (Sibiu and Mediaș), 9 towns, and 53 communes. There are 11 urban settlements (the core settlements of the 2 cities and 9 towns) and 177 rural settlements (villages), out of which 25 rural settlements belong to either cities or towns, and the other 152 rural settlements make up the 53 communes,

meaning that there is an average of almost 3 rural settlements in each commune. 53 rural settlements are commune seats, while the other 99 rural settlements are smaller villages belonging to the communes.

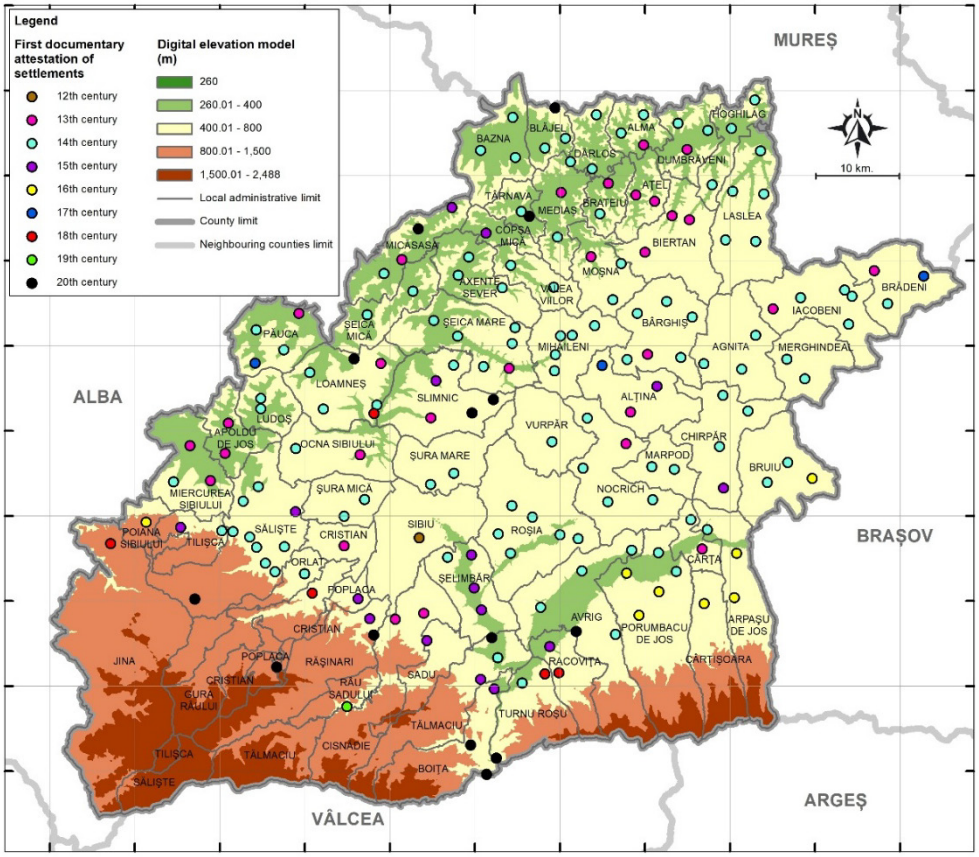

Fig. 1. The first documentary attestation of settlements in Sibiu County, Romania.
Source: the authors, according to data from Suciu (1968)

In terms of size, according to data from the last census (in 2021), the only available data at the level of each settlement, there is one large city, above 100,000 inhabitants (Sibiu), two middle-sized urban settlements, between 20,000 and 100,000 inhabitants (Mediaș and Cisnădie) and 8 small towns (Avrig, Agnita, Dumbrăveni, Copșa Mică, Ocna Sibiului, Sălișteː, Miercurea Sibiului, and Tălmaciu), which all have less than 20,000 inhabitants, and most of them even less than 10,000 inhabitants.

Rural settlements have been classified into very large villages (more than 4,000 inhabitants), large villages (1501 – 4000 inhabitants), middle-large villages (1001 – 1500 inhabitants), middle-small villages (501 – 1000 inhabitants), small villages (101 – 500 inhabitants), very small villages (6 – 100 inhabitants), and depopulated villages (less than 6 inhabitants).

There are only two very large villages (Şelimbăr and Răşinari), both located near the city of Sibiu. 15.3% of the villages are large, 13% are middle-large, 26% are middle-small, while the largest category is the one including small villages (36.2% of all the villages in Sibiu County). Very small villages are few (5.1%), while 6 villages (3.4%) may be considered as depopulated, since their number of inhabitants dropped to zero or almost zero (fig. 2).

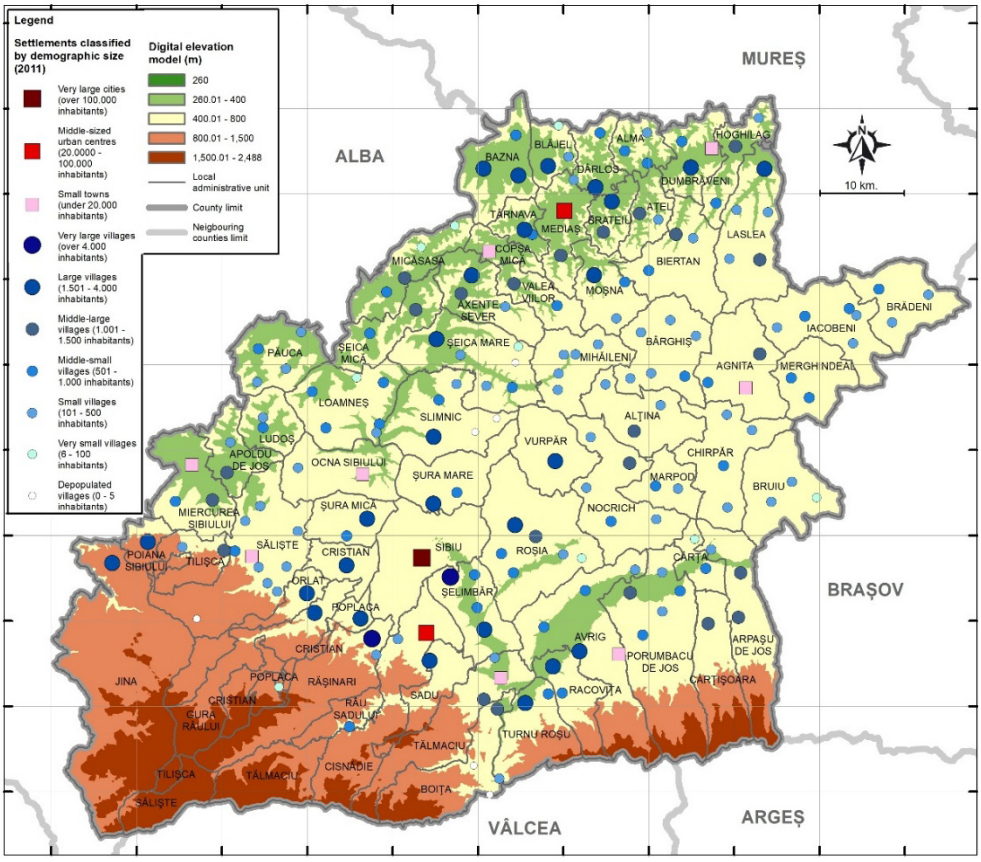

Fig. 2. Classification of settlements in Sibiu County according to their demographic size.
Source: the authors, according to data of the 2011 and 2021 censuses

Moving up to the administrative level of cities, towns, and communes, a classification based on demographic size (based on the 2021 census data) would include similarly a large city (Sibiu), two middle-sized urban centres (one city, Mediaș, and one town, Cisnădie), and eight small towns (Avrig, Agnita, Dumbrăveni, Copșa Mică, Ocna Sibiului, Sălișteː, Miercurea Sibiului, and Tălmaciu). It should be noted that among the small towns only Avrig is larger than 10,000 inhabitants, while all the others have less than 10,000 inhabitants, and three towns (Miercurea Sibiului, Ocna Sibiului, and Copșa Mică) have even less than 5,000 inhabitants, which makes them smaller than very large communes.

Communes have been classified according to their demographic size in very large communes (more than 5,000 inhabitants), large communes (3001 – 5000 inhabitants), middle-sized communes (1500 – 3000 inhabitants), small communes (1000 – 1499 inhabitants), and very small communes (less than 1000 inhabitants).

Currently, there are three very large communes – Șelimbăr, Rășinari, and Roșia, all located near the city of Sibiu. This suburban location allowed to them to grow demographically even in recent years, with Șelimbăr reaching to more than 17,000 inhabitants, which is more than most towns in Sibiu County. The large communes are located also in the suburban areas of the cities of Sibiu (Cristian, Șura Mare, Șura Mică, Gura Râului) or Mediaș (Târnava, Brateiu, Bazna), or along the man transport corridors (Slimnic, Șeica Mare, Axente Sever, Laslea). Almost half (43.5%) of the communes in Sibiu County are middle-sized, and almost a quarter (24.5%) of them are small and very small communes. There are five very small communes: Râu Sadului, Ludoș, Bruiu, Mihăileni, and Marpod, which are located far from the towns and the main transport axes (fig. 3).

Comparing the census population data of 2011 and 2021 respectively, it comes out that the population of Sibiu County has registered a small decline, from 397,322 inhabitants in 2011 to 388,325 inhabitants in 2021. This decline is mainly due to the negative natural balance, partly compensated by a positive migration balance (R. Rusu *et al*, 2024).

However, looking at the level of administrative units within Sibiu County, there are important differences (fig. 4). While most of the administrative units within the county, including the two cities (Sibiu and Mediaș) experienced demographic decline, there are several administrative units which grew, some of them even at explosive pace, such as the commune of Șelimbăr, which experienced a demographic increase by 148.9%, meaning it more than doubled its size in ten years, from 7,028 inhabitants in 2011 to 17,492 inhabitants in 2021. The annual data from the INS, while slightly different than the numbers provided by the censuses, shows the same growth, and one should point out that this has continued, as the population of Șelimbăr on 1 July 2025 (the latest available figure) was 20,096 inhabitants (INS, 2025).

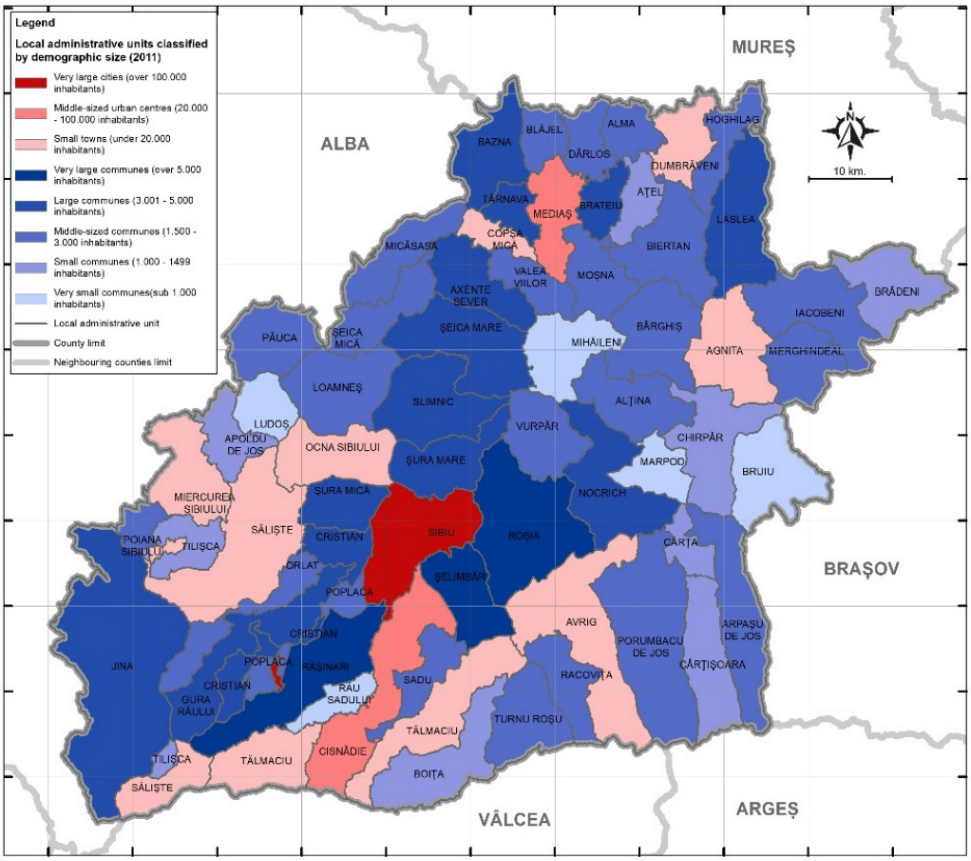

Fig. 3. The classification of administrative units according to their status and demographic size.
Source: the authors, according to data of the 2021 census

An important demographic increase, by 56%, is also remarkable in the case of the town of Cisnădie, also located in the suburban area of Sibiu. This has led to Cisnădie rising from the status of small town to that of a middle-sized town, as it surpassed 20,000 inhabitants in 2021, reaching 27,221 inhabitants on 1 July 2025 according to INS (2025). Demographic growth is noticeable in other communes around Sibiu, such as Şura Mare, Şura Mică, Roşia, Cristian, and Sadu. It is obvious that the decline of the city of Sibiu is at least partly due to migration towards its suburban area, and that the process of suburbanization has intensified after 2010, as demographic data shows. The same is true, though in lesser numbers, for the city of Mediaş and its surroundings, where only two communes experienced a demographic increase – Târnava and Valea Viilor.

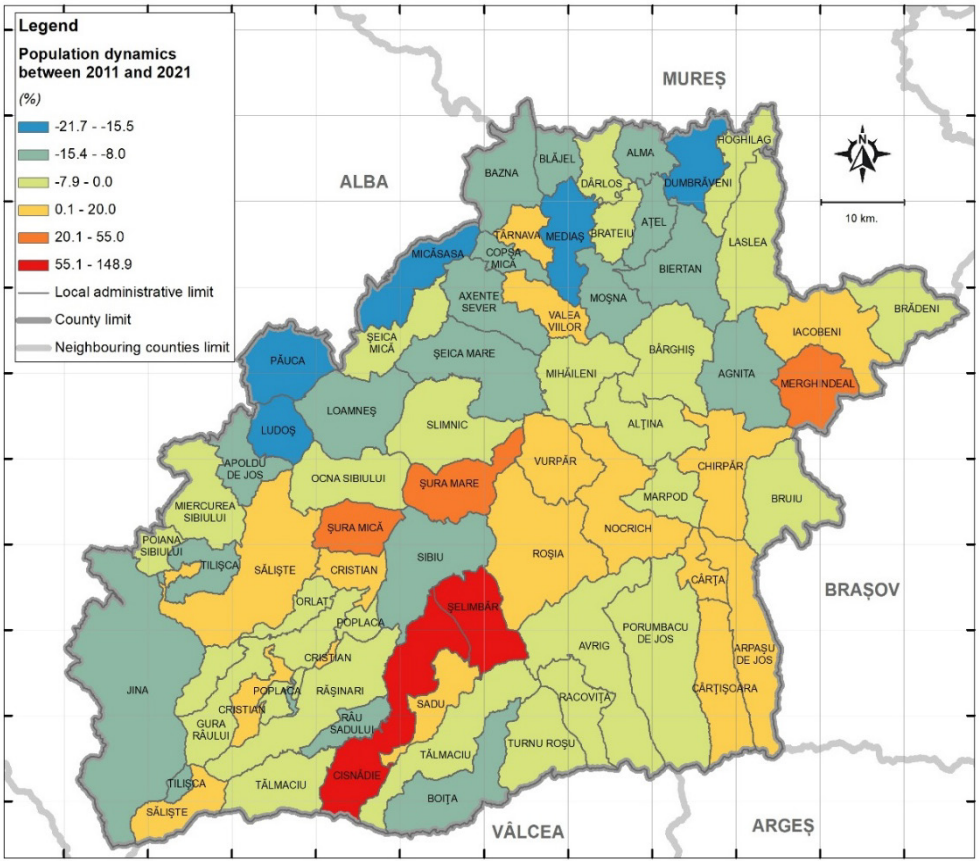

Fig. 4. The population dynamics between 2011 and 2021 at the level of administrative units within Sibiu County.
Source: R. Rusu et al. (2024)

The process of suburbanization brought important changes in the age structure of the population. Those who moved from the core cities to the suburban settlements are usually young adults, which generated a boost in terms of birth rates (R. Rusu *et al*, 2024). Looking closely to the weight and distribution of the young population (0-14 years old) in the administrative units within Sibiu County (fig. 5), it comes out that most of the administrative units with the youngest population are located close to the cities of Sibiu (Roșia, Șelimbăr, Șura Mare, Nocrich) or Mediaș (Brateiu, Târnava), or in between them, in the central part of Hârtibaciu Plateau (Mihăileni, Vurpăr, Marpod), as well as in the easternmost part of the county (Iacobeni, Brădeni).

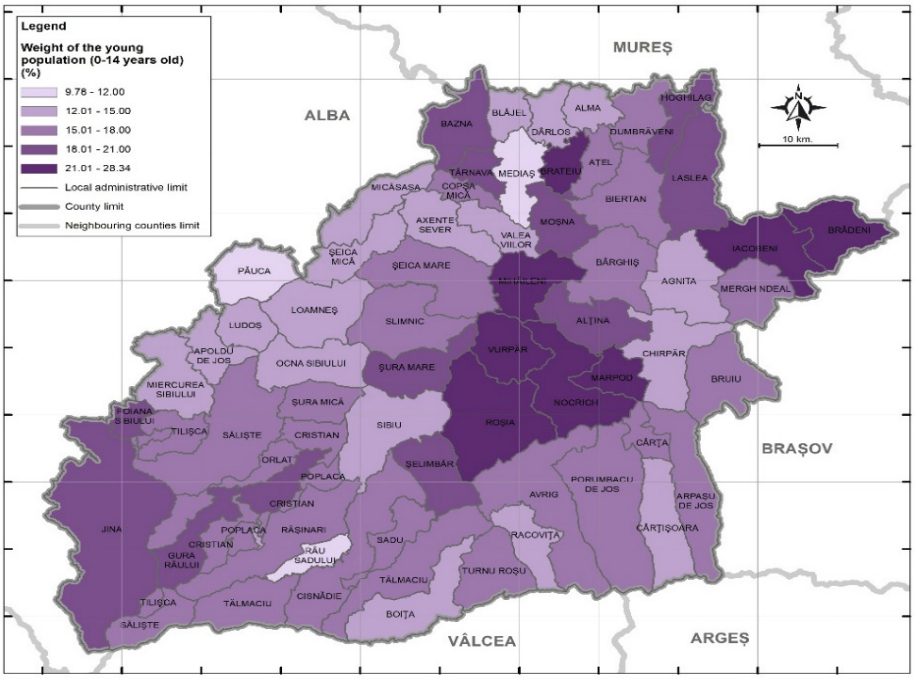

Fig. 5. The weight of the young population (0-14 years old) in the administrative units within Sibiu County in 2022.
Source: the authors according to data from INS (2025)

The administrative units with the youngest population correspond to those which experienced a high birth rate in the last 15 years, and there are certain different reasons for these numbers (R. Rusu *et al*, 2024). One of the reasons is suburbanization, because some of the families that migrated to the suburban areas had already had children, while others planned to have children, and obviously many did, therefore the suburban settlements are now confronted with insufficient kindergartens and schools for all these children. The lack of educational institutions in the suburban areas led to yet another issue – daily commuting became compulsory for families whose children attend kindergartens and schools in the core city. Public transport has not entirely adapted to the needs of these families, who are therefore using the personal cars to commute, generating traffic jams at rush hours.

At the opposite end, the lowest weight of young people is found in communes located far from the cities and towns, especially in Secaşe Plateau, in the West of the county (Păuca, Ludoş, Loamneş), in the mountains (Râu Sadului), but also in the main cities (Sibiu, Mediaş) and some of the towns (Agnita, Miercurea Sibiului, and Ocna Sibiului).

The adult population (15-64 years old) represented more than two thirds (67.83%) of the total population of Sibiu County in 2022 (INS, 2025). At the level of administrative units within Sibiu County (fig. 6), the largest weight of adult population was recorded in the town of Copşa Mică (73%), followed by many administrative units in the suburban areas of the cities of Sibiu (Cisnădie, Tălmaciu, Poplaca, Şelimbăr, Şura Mică, Orlat, Cristian, Avrig) and Mediaş (Moşna, Dârlos, Biertan). Once again, the process of suburbanization had a certain impact on the growing number of adults in these areas, especially in the cases of Cisnădie (71.19%, the second highest weight in the county) and Şelimbăr. While there is no data regarding the age of the migrants to the suburban areas, it comes out that most of the migrants have been and are young adults, who are more willing to change their residence for a number of perceived facilities, including the lower living costs, more space for them and their children, a healthier and more secure environment.

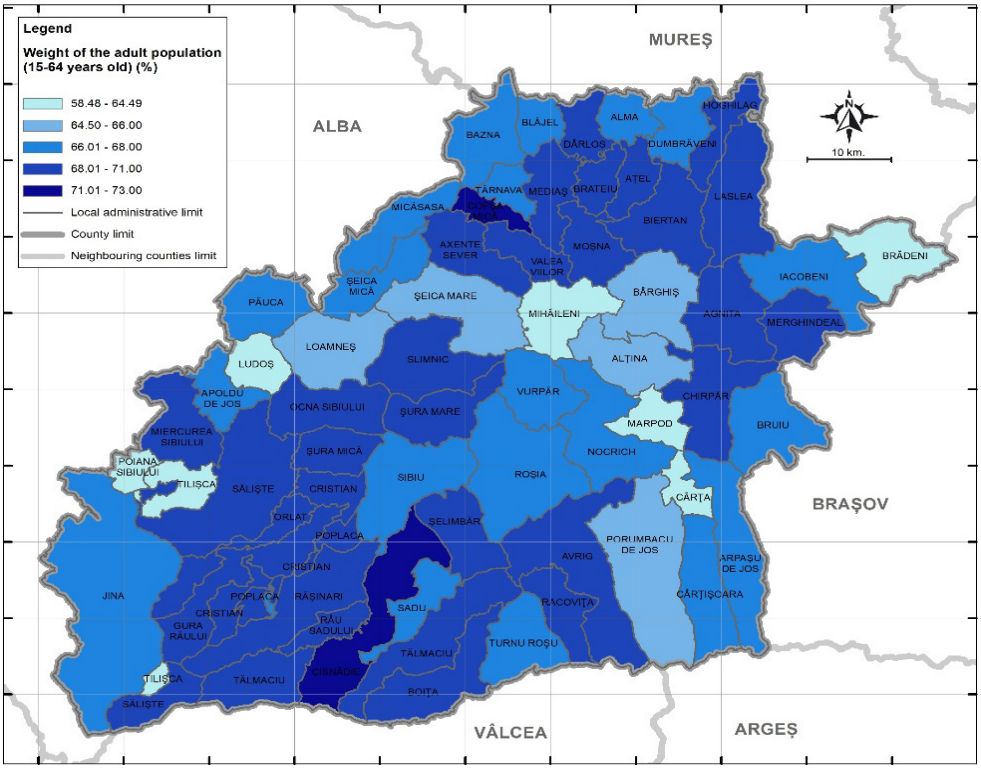

Fig. 6. The weight of the adult population (15-64 years old) in the administrative units within Sibiu County in 2022.
Source: the authors according to data from INS (2025)

The lowest weight of the adult population was recorded in some communes located in the central part of the county, in Hârtibaciu Plateau (Mihăileni, Marpod, Brădeni), in the western part of the county, in Secașe Plateau (Ludoș, Loamneș) or at the feet of the Carpathians (Poiana Sibiului, Tilișca).

The weight of the elderly population (65 years and older) has grown steadily in the last decades, as the birth rate declined, and the average life expectancy increased. In 2022, the weight of the elderly population was 16.89% in Sibiu County as a whole, exceeding the weight of the young population, which was only 15.27%. These numbers indicate that demographic ageing is an important issue in Sibiu County, just like almost everywhere else in Romania (Nancu, Guran-Nica, and Persu, 2020).

The analysis of the weight of the elderly people at the level of administrative units within Sibiu County shows however that there are important differences (fig. 7).

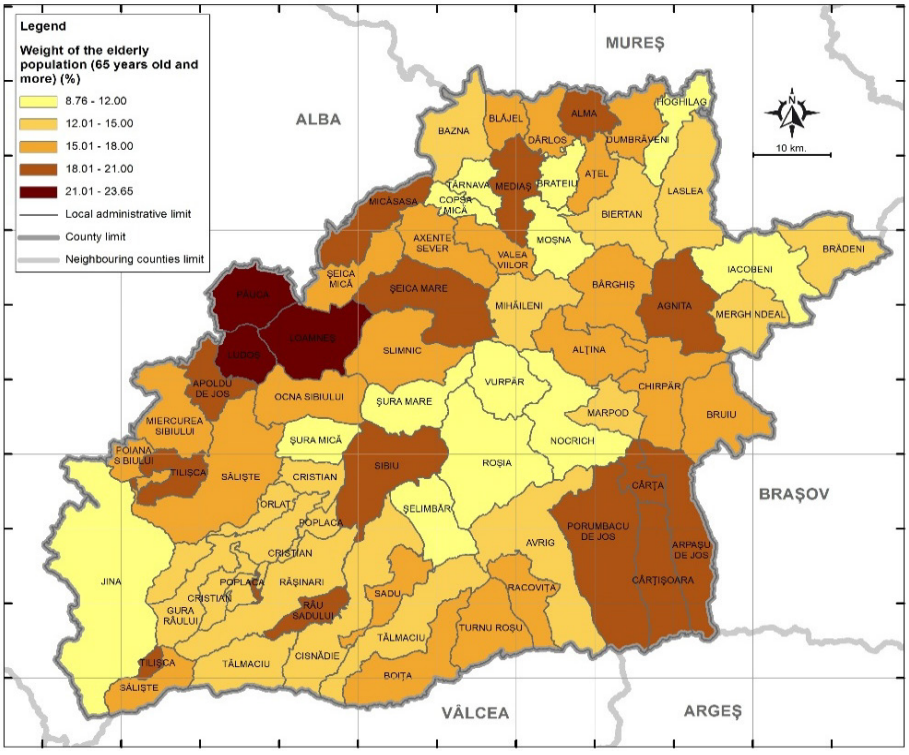

Fig. 7. The weight of the elderly population (65 years old and more) in the administrative units within Sibiu County in 2022.
Source: the authors according to data from INS (2025)

The highest weight of the elderly population was recorded in the western part of the county, especially in Secaşe Plateau, in communes such as Păuca (23.65%, the highest value), Ludoş, Loamneş, and Apoldu de Jos, and in the South-East of the county, in Făgăraş Basin, in communes like Cârţa, Cârţişoara, Arpaşu de Jos, and Porumbacu de Jos. High values of the elderly population were also recorded in the cities of Sibiu (19.95%) and Mediaş (19.93%), as well as in some of the towns (Agnita, for example). At least in the case of the two cities, one of the explanations for the high weight of the elderly population is suburbanization, materialized by the migration of young adults and their (future) children, while the elderly population is not equally mobile. Elderly people are more likely to remain in the core cities, as they are already accomodated with the neighbourhoods and they feel safer in a well-known environment, where everything they need (including medical services) is close and easier to reach.

As opposed to this, the lowest weight of elderly people was registered (not surprisingly) in Şelimbăr (8.76%), the suburban commune with the highest growth in the latest decades. Other communes with low weights of the elderly population are also located near the city of Sibiu: Roşia, Şura Mare, Şura Mică, Vurpăr, Nocrich – all with values less than 10% elderly population, or near the city of Mediaş: Brateiu, Târnava, Moşna, the town of Copşa Mică. These figures show clearly that the process of suburbanization had a strong impact on the age structure of the population, reducing the weight of the elderly population in the suburban settlements, and increasing the weight of the young population and / or the adult population in the same settlements.

4. CONCLUSIONS

The process of suburbanization has had an impact on the settlement system in Sibiu County. Demographic data collected from the last two censuses (2011 and 2021) as well as from the National Institute of Statistics (INS) show that the core cities of Sibiu and Mediaş experienced a demographic decline in the last decades, while their suburban areas increased demographically. The highest growth has been recorded in the commune of Şelimbăr and in the town of Cisnădie, as well as in other communes around the city of Sibiu (Şura Mare, Şura Mică, Cristian, Roşia).

While there is no data regarding the age of the migrants from the core cities to their respective suburban areas, the analysis shows that most of them are young adults and their (future) children. This has led to a sharp change in the age structure of the population both in the core cities and in the suburban settlements. On the one hand, the cities of Sibiu and Mediaş experienced a

decline in young and adult population, and an increase of the weight of the elderly population to such an extent, that they almost have the same values of the weight of the elderly population as some of the most isolated and peripheral rural communes in Sibiu County. On the other hand, suburban settlements, especially those around the city of Sibiu, have registered not just an increase in terms of population, but also in the weight of the young and adult population. Therefore, we witness a process of sharp rejuvenation in the suburban settlements (mostly in Şelimbăr and Cisnădie), at the same time with the intensification of demographic ageing in many parts of Sibiu County, including the two cities, Sibiu and Mediaş, and some of the other towns in the county.

The new demographic realities of the suburban settlements brought along a number of issues which the authorities have to deal with. There are not enough kindergartens and schools in the suburban settlements to accomodate the ever increasing number of students, and the existing schools are not large enough. The authorities need to find solutions, and the building of new kindergartens and schools is an absolute priority. Because of the insufficient number of educational facilities, many families have decided to commute together with their children to the core cities of Sibiu or Mediaş, where there are enough schools, and the parents have jobs. Public transport is not yet adapted to the increasing demand, and not always service the newly-built areas, where newcomers have to rely mainly on their personal car to move around and to commute. Therefore, traffic has increased manyfold, leading to jams at rush hours, given the poorly designed road infrastructure, not prepared to take in so much traffic. Authorities have to adapt quickly the public transport to the new territorial realities, and to find ways to develop new roads and bypasses to allow for a better connectivity and accessibility to the newly-built areas in the suburban areas. Many of these areas also need other facilities as well, such as shops, schools (as pointed above), health-related services, and many others, because their new inhabitants are former urban dwellers who expect to have at least the same living standards as in their former neighbourhoods in the city.

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TYPOLOGICAL ANALYSIS OF THE ROAD TRANSPORT SYSTEM AND URBAN SPATIAL ORGANISATION USING CADMAPPER AND OPENSTREETMAP (OSM). CASE STUDY: BISTRIȚA-BECLEAN-NĂSĂUD-SÂNGEORZ-BĂI URBAN AXIS

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ABSTRACT. – Typological Analysis of the Road Transport System and Urban Spatial Organisation Using Cadmapper and OpenStreetMap (OSM). Case Study: Bistrița-Beclean-Năsăud-Sângeorz-Băi Urban Axis. This research presents an analysis of typological aspects of the road stacking system and their impact on the spatial organisation of urban functions along the Bistrița–Beclean–Năsăud–Sângeorz-Băi urban axis, following the structure and definitions of the analytical study in *The Role of Streetscape* (Tătar, A.M., Pop, C.C., 2025). The study emphasises how types of roads create organisational structures and affect the distribution of commercial, economic, tourist, and cultural locations, as well as the functioning of urban industries in a medium-sized urban area. The study used Cadmapper and OpenStreetMap (OSM), which are freely accessible geospatial datasets, to assign types of roads and map the spatial logic and configuration of urban functions. By employing typological mapping and spatial analysis, this research identified various transport types and functional types, as well as their relationships. In doing so, this enables the role of urban land utilisation. The results revealed how road slab structures and hierarchies affected the location of urban functions differently. While specific types of roads produced the most effective spatial organisation in transport models, certain kinds of roads influenced urban structure and efficiency less than others. The study highlights the significance of transport system typology in urban planning as a crucial element of

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sustainable development and functional zoning. The paper provides the basis for developing better urban diagnostics and urban contrasts, as well as strategies that take into consideration development scenarios specific to Bistriţa-Năsăud area.

Keywords: *road transport system, urban spatial organisation, Bistriţa-Beclean-Năsăud-Sângeorz Băi urban axis, Cadmapper, OpenStreetMap (OSM).*

1. INTRODUCTION

The geographical axis is defined as a "line of spatio-temporal shape, a line that allows, in a temporal-spatial way, the diagnosis and geographical forecasting of a territory. This territory can take different geometric conformations and dimensions according to the capacity of component polarisation" (Pop, C.C., 2003).

The geographical axis operates through the integration of its constituent elements, and every point, place, level, order of organisation, secondary axis, central axis, local mesh, and so on, has its organisational laws (C.C. Pop, 2016, p. 287). A geographical axis comprises elements, and how these elements manifest reflects the status of its functioning (Pop, C.C., 2016, p. 289).

The spatial distribution of urban functions and the structure of road transport systems are universally accepted as related yet distinct elements of sustainable urban development, especially in medium-sized cities (Rodrigue, J.-P., 2023). In this case, a structured road network not only enables mobility but also plays a proactive role in distributing economic, cultural, and tourist functions across space and time. Our analysis will focus on the Bistriţa–Beclean–Năsăud–Sângeorz-Băi axis, where urban form and transport networks co-evolve and spatially influence land use and functional zoning.

Various forms of urban roads (i.e., arterial roads, collector roads, and pedestrian streets) contribute significantly to city orientation and, in practice, shape the placement and manifestation of urban functions. The existence and nature of street types, in essence, dictate the quality and liveability of urban environments (Tătar A.M., Pop, C.C., 2025). For example, arterial roads bring commercial and logistical activity due to their speed and mobility space (Baker Institute, 2023), and cultural and tourism activity, on the other hand, clings to pedestrian streets and historic streetscapes near high-value spaces with aesthetic features and close spatial relationships (Bhalla, K., 2023). The location of cultural institutions and leisure facilities in Bistriţa and Beclean, for example, complements the secondary road networks, where access and environmental benefit provide opportunities for enhancing mobility patterns and behaviours.

The establishment of economic places is directly associated with transport access, as clusters of high accessibility (indicative of geographic analysis of locations such as Eindhoven; Qin, J., et al. 2022) often feel an attraction for retail, services, and mixed-use developments; likewise, cultural and tourist zones are frequently discovered within 'walkable' environments, in spatial proximity to multimodal nodes, adding to their experiential benefit as well as pedestrian flows (Wang M., et al. 2025). The orientation and distance, as measured in walking and cycling time, demonstrate that these zones are 'designed' patterns, indicative of the road networks and where people can navigate, including implications for visibility and their intended use of urban space.

This study employs open geospatial data from Cadmapper and OpenStreetMap (OSM) – viewing & treating the road types as a typological mapping approach – seeking to clarify open road types and the geographic considerations, transport relationships with urban function using an integrated accessibility approach for overlaying land use using metrics, and hierarchical networks for establishing convenience of transport planning within their urban formations. The applied framework enables the identification of spatial mismatches, underutilised spaces of inactivity, and the potential for densifying functional spaces in situ (Lu P., et al. 2025).

Recent work has investigated the new open geospatial technology (UGT) capabilities offered by tools such as Cadmapper and OpenStreetMap (OSM) and how they reinvigorate urban diagnostics and spatial modelling (Ou, J., et al., 2025).

With these tools, we can classify road networks and integrate them with land-use data to map typologies and conduct spatial analyses at scales ranging from local to global (Kuncheria et al., 2025; Gil, 2015). Further, with volunteered geographic information (VGI), spatial data has become more accessible, enabling urban studies that are more inclusive and replicable (Capineri et al., 2024).

The importance of urban traffic network studies to urban economic and social development is self-evident. The most far-reaching impact on the modern urban form has been the development of traffic technologies such as the automobile, highway, metro and subway (Ding R. et al., 2019, p. 3). The expansion of these urban traffic networks has shaped the morphology of modern cities, while changes in urban forms will, in turn, affect urban traffic network structures. Here, we define an "urban traffic network" as an urban land-based traffic network, with emphasis on road and rail networks, and it is both related to the traffic flow and infrastructure (Ding R. et al., 2019, p. 3).

Typological studies of transportation systems have evolved, progressing from typological characterisations based solely on geometry to studies that consider the interplay between transport and land use, encompassing traffic dynamics, trip demand, and multimodal connectivity (Rode, P., et al., 2015; Gao, Y., & Zhu, J., 2022).

Recent literature has moved beyond theoretical models to embrace data-driven, context-sensitive planning strategies.

Street networks may be planned according to clear organising principles, or they may evolve organically through accretion, but their configurations and orientations help define a city's spatial logic and order (Boeing, G., 2019). The street network is considered the skeleton of a town, as it links geographical units in urban space. To some extent, the morphological structure of streets determines the breadth and intensity of interconnections between different functional areas in urban settings. Accordingly, it affects the flows and operational efficiencies of various resource elements within the city and its urban spatial structure (Lobsang, T., Zhen, F., & Zhang, S., 2020).

Debates persist regarding the most effective way to integrate transport planning and land-use planning. Some contend that dense, transit-oriented development is the solution (World Bank, 2023), compared with the provision of zoning flexibility that allows real estate development to be responsive to demands for transport modes that reflect emerging travel patterns and changing socio-economic forces (HelloLandMark, 2025).

In Eastern European contexts, including Romania, the legacy of mono-functional planning and fragmented infrastructure poses challenges to coherent spatial organisation (Chung, Y., et al., 2025). Building on the analytical framework established in "*The Role of Streetscape*" (Tătar, A.M., & Pop, C.C., 2025), this study extends the typological analysis to a regional scale.

The results show that road hierarchy and configuration are essential for the location and accessibility of vital urban functions. Specific typologies—for instance, radial arterial networks and grid-based secondary streets—promote greater spatial coherence and efficiency of development, supporting sustainable urban planning and functional area zoning consistent with the Bistrița-Năsăud area.

2. MATERIALS AND METHODS

This research utilises a mixed-methods geospatial framework to examine the typology of road transport systems and their impact on urban spatial organisation within the Bistrița–Beclean–Năsăud–Sângeorz-Băi geographical axis.

The method uses open-source geospatial tools, typological mapping, and spatial analysis techniques to ensure that the results can be replicated and are transparent.

To facilitate this analysis, a typological classification of the road transport system was employed. It was based on five primary factors: functionality, network structure, accessibility level, infrastructure type, and usage purpose.

We used these categories to break down and make sense of road network data from Cadmapper and OpenStreetMap (OSM). This helped us get a better picture of how people move around in cities and suburbs.

The classification made it easier to find transport corridors, differences in infrastructure, and spatial dynamics that are important for sustainable urban planning and territorial cohesion.

The method includes:

A. Data Sources

The primary datasets were obtained from:

- Ø Cadmapper: Used to extract topographic and infrastructural data, including road networks, building footprints, and elevation models.
- Ø OpenStreetMap (OSM): Provided volunteered geographic information (VGI) on road classifications and land-use types.

These datasets were selected for their accessibility, frequency of updates, and compatibility with GIS platforms. All data used are publicly available and can be accessed via cadmapper.com and openstreetmap.org.

B. Spatial Analysis Techniques

The following spatial analysis methods were applied:

- Ø Network hierarchy analysis: To determine the structural role of each road type in urban connectivity.
- Ø Land-use overlays: Urban functions (commercial, cultural, tourist, and economic) were mapped and overlaid with road typologies to identify spatial correlations.
- Ø Accessibility metrics: Calculated using isochrone maps and proximity buffers to assess how road types influence access to urban functions.
- Ø 15-minute city concept application and ANOVA analysis.

C. Study Area Delimitation and Replicability – Data Availabilitys

The geographical axis was segmented into four urban nodes: Bistrița, Beclean, Năsăud, and Sângeorz-Băi. Each node was analysed individually and comparatively to identify typological patterns and spatial mismatches. (Figure 1)

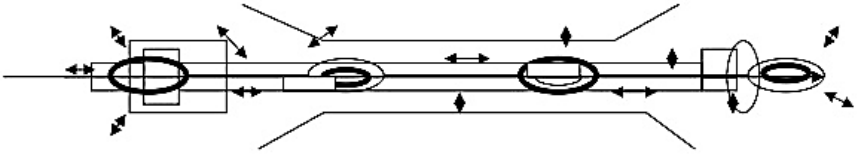

Fig. 1. The composite model for spatial structures in the form of a geographic axis is used in the study.
Source: (Pop, C.C., 2016, pp. 286-287)

All datasets and scripts used in this study are available upon request. The use of open-source tools and public data ensures that the methodology can be replicated and adapted for use in other urban contexts.

3. RESULTS AND DISCUSSIONS

3.1. Geographical Context

The Urban Axis Bistriţa–Beclean–Năsăud–Sângeorz-Băi developed along a natural geographical corridor composed of:

- Ø Bistriţa Basin
- Ø Someşul Mare Corridor
- Ø Sângeorz-Băi Basin

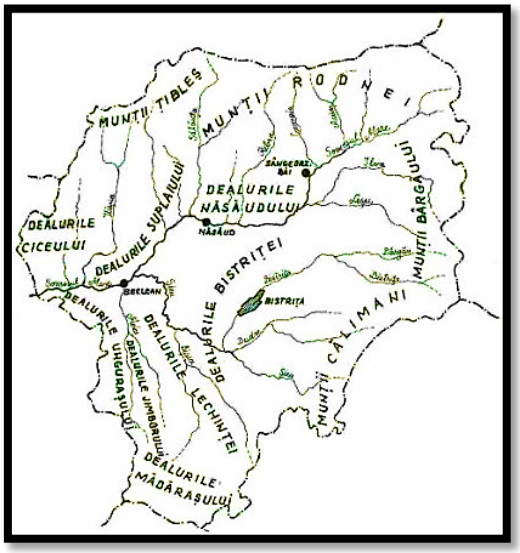

Fig. 2. Location of the Urban Axis Bistriţa–Beclean–Năsăud–Sângeorz-Băi
Source: Bîca, I., Onofreiu, A., 2014, p. 13

This succession of landform units provided favourable conditions for:

- Ø The development of the road transport system, particularly through national roads DN17 and DN17D, follows these natural corridors.
- Ø The organisation of urban space, with towns arranged linearly and efficiently connected, according to the characteristics of the terrain (floodplains, terraces, mountain basins) (fig. 2).

From a geographical point of view, the axis follows an East-West direction, primarily following the route of the national road DN17 and the Someşul Mare River.

Component towns have a linear arrangement, promoting the establishment of a corridor of development with urban-rural linkage possibilities.

Bistriţa-Beclean-Năsăud-Sângeorz-Băi is a polycentric spatial pattern connecting four major urban hubs in the northern region of Bistriţa-Năsăud County. The correlation is characterised by a homogenous territorial area and a varied set of functional characteristics, including those of an administrative, economic, tourist, and regional transportation nature.

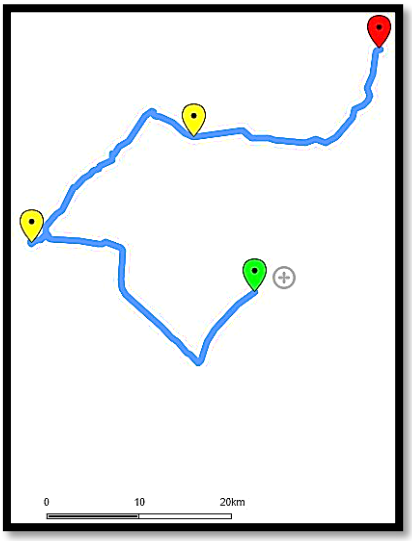

Fig. 3. Geographical axis model: Bistriţa-Beclean-Năsăud-Sângeorz-Băi
Source: https://www.openstreetmap.org/

The colored markers indicate the component cities of the axis, and the blue route represents the geographical connection between them. It is a functional model of a geographical axis (fig. 3).

For better organisation and clarity, the research results are structured into two subchapters:

I. Analysis of Road Transport System

II. Points of interest (POIs) and Urban spatial organisation

3.2. Analysis of the Road Transport System

In the urban municipalities of Bistrița-Năsăud County, such as Bistrița, Beclean, Năsăud, and Sângeorz-Băi, the road transportation system follows a common base construction, which is organised along a road network, which constitutes the fundamental physical infrastructure, including national routes, city streets, and principal boulevards.

The network connects city quarters and settlements in the vicinity, as well as other settlements in Bistrița-Năsăud County.

Public transportation is primarily provided by a network of suburban and urban buses owned and operated by private enterprises, with notable routes established to benefit the central district and nearby suburban regions.

Alternative transportation infrastructure includes cycle-specific routes, pedestrian precincts, upgraded pavement, and electric vehicle charging stations. The city has a program on sustainable transportation, in line with the principles of green urbanism.

The highway system of transportation plays an essential role by connecting urban spaces, rationalising the movement of vehicles, and enhancing the overall quality of urban life in these three aspects.

Despite the general structural similarities, the degree of development, network density, and urban integration level vary significantly due to differences in town size, geographical position, and resource availability. For these reasons, it is fitting to discuss a common typology with local adaptations that are peculiar to each city.

3.2.1. Bistrița

a. Typology of the Road Transport System in the City of Bistrița

Ø Model: Axial and Central

Classification:

Ø Axial – Linear development along Bistrița Valley and DN17, with predominantly East-West urban expansion.

Ø Central – Presence of a well-defined historical core, with a radial street network converging toward the medieval centre.

Ø Justification:

The municipality of Bistriţa has developed along the natural axis formed by the Bistriţa River and the DN17 road layout, giving the town an overall axial structure. The medieval historical centre, with its central square, defined the organisation of streets that connect the present town centre radially with George Coşbuc and Dornei, thereby defining the urban core. The main axial routes, connecting to the human and environmental geography, are Calea Moldovei and Drumul Cetăţii, radially branching off this historic and contemporary urban core, and have a primarily axial urban character.

Example:

- Central core: Central Square, George Coşbuc Street, and Dornei Street.
- Axial expansion: Calea Moldovei (to the East) and Drumul Cetăţii (to the West), running parallel to the Bistriţa River and DN17.

b. Road transport system

National and County roads crossing Bistriţa

These roads ensure the city's connection with surrounding villages and peripheral neighbourhoods:

- DN17 (E58) – crosses the city from East to West. It connects the neighbourhoods of Unirea, Viişoara, Independenţei, and Calea Moldovei. It is the main transit route toward Beclean, Dej, and Vatra Dornei.
- DN17C – route is Bistriţa – Dumitra – Năsăud – Salva – Coşbuc – Moisei. It is essential for connecting with the northern part of the county.
- DN17D starts in Beclean and heads northeast, connecting the town of Năsăud and the communes along the Upper Someş Valley.
- DJ173 connecting the localities of: Bistriţa (DN 17) – Jelna – Orheiu Bistriţei – Budacu de Sus – Şoimuş – Şieu – Posmuş – Teaca – Ocniţa – Milaş – the border with Mureş County.

Typology of neighbourhoods in Bistriţa (table 1)

1. Central neighbourhoods

- Historic Centre – pedestrian area, with streets such as Gheorghe Şincai and Piaţa Centrală (Central Square).
- Andrei Mureşanu – residential and commercial area, connected via Decebal Boulevard and Andrei Mureşanu Street.
- Subcetate – a developing area, accessible via Năsăudului Street.

2. Peripheral and Extended neighbourhoods

- Unirea – connected via Calea Moldovei (DN17), an area with heavy traffic and commercial development.
- DJ172B connects the Unirea district with the component locality of Slătiniţa.

- Viișoara – accessible via Independenței Boulevard and Libertății Street.
- Access route to Sigmir. The main access is from the western part of the city, using the extension of National Road DN17 (Calea Clujului), followed by Sigmirului Street.
- The main access to the component locality of Slătinița is from the north-eastern area of the municipality of Bistrița, using National Road DN17, followed by County Road DJ172B.
- Ghinda – accessible via modernised secondary roads, with proposed links to DN17 and Jelna.
- The road that starts in the municipality of Bistrița on Tărpiului Street and crosses the Industrial Area (passing by facilities such as Leoni) is County Road 173B (DJ 173B).

Table 1. Main Boulevards and Streets in Bistrița
Connected Roads and Served Areas

Boulevard / Street	Served Neighbourhoods / Zones	Connected / Crossed Roads
Independenței Boulevard	Viișoara, industrial area, Petru Rareș Square	DN17
Calea Moldovei	Unirea, Viișoara, commercial area (Selgros, Kaufland)	DN17
Decebal Boulevard	Andrei Mureșanu, central area	DN 17
Andrei Mureșanu Street	Andrei Mureșanu, Năsăudului, train station area	DN17
Năsăudului Street	Subcetate neighbourhood, exit toward Năsăud	DN17C
Gheorghe Șincai Street	Unirii Square, the central area	DN 17, DJ 173C
Gării Street	Bistrița Nord Train Station, industrial area	DN 17, DJ 173 B
Libertății Street	Viișoara, southern area	DN17
Tărpiului Street	Tărpiului neighbourhood, connection to DN17C	DJ 173B, Gării Street

Source: the authors

3. Expanding Neighbourhoods

- ANL Subcetate – new housing developments, accessible via Năsăudului Street.
- Zona Electrica – streets such as Lt. Călin, Minulescu, and Cerbului – are currently under modernisation.

Road Connections Between Neighbourhoods

- Urban streets – Decebal, Andrei Mureșanu, Gheorghe Șincai, Năsăudului.

Proposed or modernised roads: Sigmir – Valea Căstăilor (for traffic decongestion), Ghinda – Jelna / DN17 (for faster access), Slătiniţa – Nepos / Livezile (for network expansion), Tărpiului Road – DN17C (for industrial area access).

The public transportation network in Bistriţa, operated by Transmixt, consists of a total of 221 stations (fig. 4). The local public transport system in Bistriţa follows the spatial organisation of the city, which we have structured into:

Ø Main Routes - Bus routes with a strategic role in urban mobility

1. Routes linking urban centres and peripheral areas

Ø Calea Moldovei – Unirea. Main stops: Calea Moldovei (Selgros, Kaufland), Unirea (Avicola, Lacrima School, Unirea Church, Agronomist's House).

Ø Calea Clujului - Calea Moldovei. Main stations: Independenţei Nord, Decebal, Petre Ispirescu, Ștefan cel Mare, Calea Moldovei (Cibela).

Role: Crosses the city from West to East, connecting two major arteries and natural areas (Codrișor).

Fig. 4. Road infrastructure and Urban landscape on DN 17 Calea Moldovei towards Unirea, Bistriţa.
Source: the authors

2. Routes connecting the civic centre with administrative and educational areas:

Ø Republicii - Calea Moldovei (fig. 5). Main stations: Republicii, Gării, General Grigore Bălan, 1 Decembrie, CNLR, CNAM.

Role: Connects the administrative Centre with the commercial area and DN17.

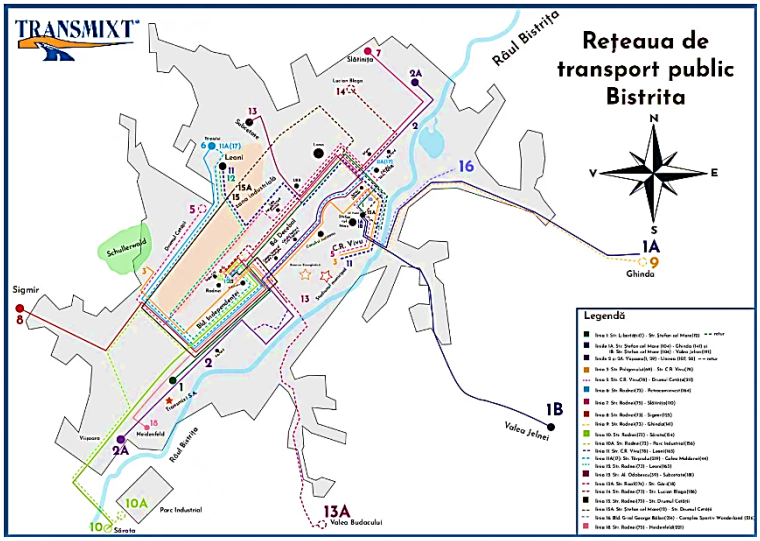

Fig. 5. Bistriţa's public transport network
Source: https://tmxbn.ro/transport-local/

Ø Secondary Routes - Complementary and Local Routes

1. Distribution routes in neighbourhoods and residential areas

Ø Libertăţii – Independenţei. Main stations: Libertăţii, Petru Maior, Eroilor, Independenţei (Kindergarten No. 10, Mat).
Role: Short route between administrative and commercial areas.

Ø Petre Ispirescu - Andrei Mureşanu - Ştefan cel Mare. Main stations: Petre Ispirescu, Andrei Mureşanu, Ştefan cel Mare.
Role: Internal routes in mixed-function neighbourhoods (housing, education, services).

2. Routes with a tourist and ecological role

Ø Calea Moldovei - Capuşele - Cocoşul Forest - MHC Lake. Main stations: Calea Moldovei, Ioan Slavici.

Access to Capuşele and Cocoşul Forest

Ø Role: Trail with ecotouristic potential, linked to bicycle infrastructure and green spaces.

Fig. 6. Public Transport Infrastructure – Bus Stop on Calea Moldovei, Bistriţa
Source: the authors

Infrastructure for Alternative Mobility – Bicycle Lanes

Approximately 30 km of bicycle lanes have already been developed on 29 streets in the city (primary route): 1 Decembrie, Năsăud (Han zone), Avram Iancu, Grănicerilor, Ghinzii, C.R. Vivu, Vasile Lupu, Tudor Vladimirescu, Cimitirului, Crinilor, Ioan Slavici, Subcetate, Drumul Cetății, Drumul Dumitrei Vechi, Dimitrie Cantemir, Eroilor, Împăratul Traian, Valeriu Branişte, Aleea Sălciilor, Petru Maior, Alexandru Odobescu, Ioan Rațiu, Codrişor/Victor Onişor, Alba Iulia, Aleea Şieu, Panait Cerna, Gheorghe Pop de Băseşti, Axente Sever, Garoafei (fig. 7).

Elements highlighted in Fig. 7:

- Road lane marked “BUS” – indicates priority for public transportation.
- Red-coloured bicycle lane – with directional markings.
- Pedestrian sidewalk – paved and clearly delineated.
- Traffic signalling – visible in the pedestrian area, contributing to traffic safety.

Fig. 7. Integration of Road, Bicycle, and Pedestrian Infrastructure on Năsăudului Street, Bistriţa
Source: the authors

Bike-Sharing System (fig. 8)

The bike-sharing system in Bistriţa, operated by means of the GLOBIKES app, includes:

- Ø 165 mechanical bicycles
- Ø 10 electric bicycles
- Ø 7 rental terminals located throughout the city

Fig. 8. Bike Rental Station – Alternative Mobility Infrastructure in Mihai Eminescu Park, Bistriţa
Source: the authors

The image shows a bike rental station located on a paved sidewalk in Mihai Eminescu Park, Bistrița. Five blue and white bicycles are neatly aligned, each equipped with a front basket and a rear locking device.

In the background, trees and parked cars are visible, indicating the facility's integration into the urban landscape.

Bus stops on the route between Libertății Street and Independenței Street in Bistrița:

- Ø Stop 1 – near the starting point (Libertății Street)
- Ø Stop 2 – at the intersection with Petru Maior Street
- Ø Stop 3 – at the intersection with Eroilor Street
- Ø Stop 4 – near the endpoint (Independenței Street)

The bus route encompasses DN17, a national route that connects users with other parts of the county as well as neighbouring villages and the north-eastern part of Romania (fig. 9). The bus route connects two major streets in the city, allowing users to move between residential areas, commercial, and institutional destinations. Libertății Street is associated with the administrative and residential areas of the town, while Independenței Street serves the same commercial and transit purposes.

Bus stops on the route Between Decebal Street and Năsăudului Street (Bistrița):

- Ø Stop 1 – located on Decebal Street, near the intersection with Republicii Street
- Ø Stop 2 – on Crinilor Street
- Ø Stop 3 – on Andrei Mureșanu Street
- Ø Stop 4 – on Năsăudului Street, near the intersection with Gârleanu Street

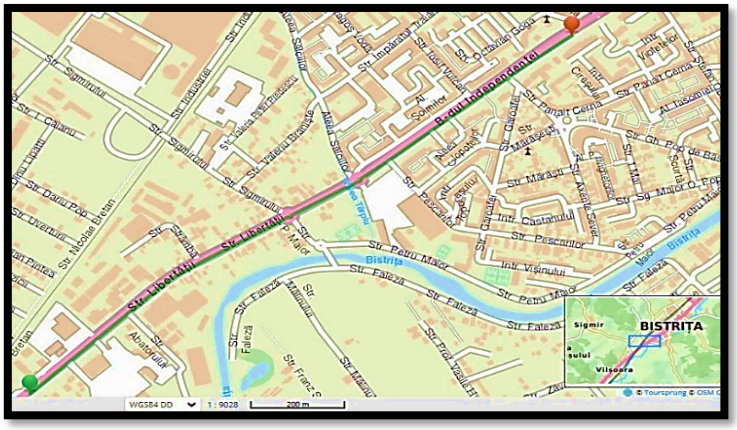

Fig. 9. Route Libertății Street - Independenței Street
Source: https://www.openstreetmap.org/

The bus route is marked on the map with a green line, connecting two key areas of the city: the central zone (Decebal–Republicii) and the northern zone (Năsăudului–Gârleanu). It follows essential urban streets and is part of the public transportation network in Bistriţa. The route also intersects DN17, a major national road that enhances regional connectivity (fig. 10).

Fig. 10. Route: Decebal Boulevard - Năsăudului Street
Source: https://www.openstreetmap.org/

Bus stops on the route between Republicii Boulevard and Calea Moldovei Street (Bistriţa):

- Ø Stop 1 – near Bulevardul Republicii (starting point, marked with green)
- Ø Stop 2 – on Gării Street
- Ø Stop 3 – on General Grigore Bălan Street
- Ø Stop 4 – on 1 December Street
- Ø Stop 5 – near Calea Moldovei (endpoint, marked with red)

This bus route connects Bulevardul Republicii, a central boulevard with administrative and commercial functions, to Calea Moldovei, a major eastern exit of the city aligned with DN17, a national road of strategic importance. The route passes through key urban streets such as Strada Gării, which links to the train station, and Strada General Grigore Bălan, a segment of DN17 that supports regional traffic (fig. 11).

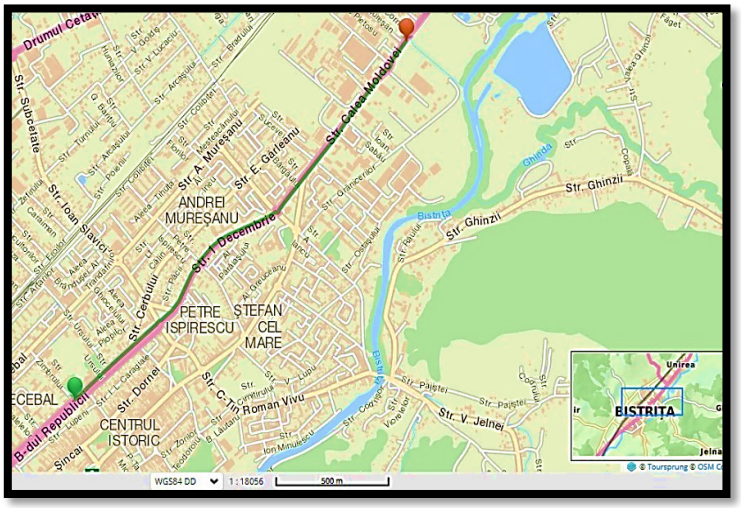

Fig. 11. Route Between Republicii Boulevard and Calea Moldovei Street
Source: https://www.openstreetmap.org/

Neighbourhoods along the route:

- Historical Centre – the cultural and civic core of Bistriţa
- Ştefan cel Mare Street – mixed-use area with residential blocks and public institutions
- Petre Ispirescu – residential neighbourhood with proximity to green areas
- Andrei Mureşanu – dense urban zone with educational and service infrastructure

Bus stops on the route between Calea Clujului and Calea Moldovei (Bistriţa):

- Stop 1 – in the Independenţei Nord area (near Calea Clujului)
- Stop 2 – in Independenţei Sud
- Stop 3 – near Decebal Street
- Stop 4 – on Petre Ispirescu Street
- Stop 5 – in the Andrei Mureşanu neighbourhood
- Stop 6 – near Ştefan cel Mare Street, close to Calea Moldovei

This bus route connects two major entry/exit arteries of Bistriţa: Calea Clujului (western access) and Calea Moldovei (eastern access). It passes through central and residential neighbourhoods, such as Decebal, Andrei Mureşanu, and Ştefan cel Mare, and intersects key urban zones, including the Historic Centre, as well as natural areas like Codrişor Forest.

The route is part of the city's public transport network and follows segments of DN17, enhancing both local and regional mobility (fig. 12).

Fig. 12. Route Calea Clujului - Calea Moldovei
Source: https://www.openstreetmap.org/

The bus route connects Calea Moldovei (a major commercial artery) with Unirea, a rapidly expanding residential area (fig. 13).

Passes through several key streets:

- Ø Calea Moldovei Street – a main road with heavy traffic and access to commercial centres.
- Ø Ioan Slavici Street – a connector between residential neighbourhoods.
- Ø Andrei Mureşanu Street – a mixed-use area with housing and services.
- Ø DN17C – a national road facilitating access to peri-urban and rural areas.

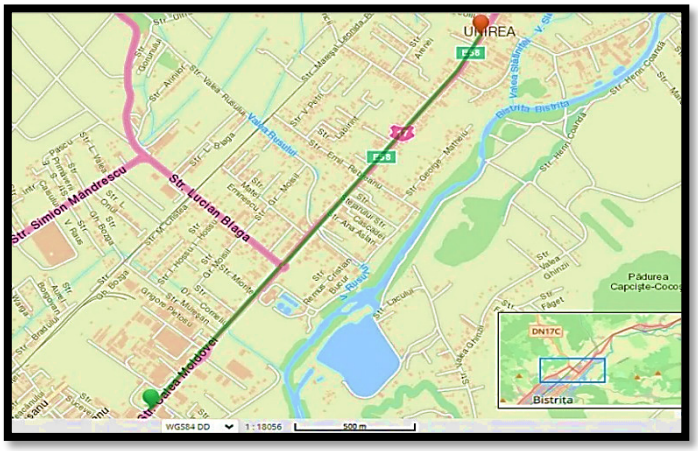

Fig. 13. Bus route Calea Moldovei-Unirea
Source: https://www.openstreetmap.org/

Importance of the Route

Ø Access to commercial centres:

The route serves areas with supermarkets, DIY stores, and other commercial facilities along Calea Moldovei. It facilitates transportation for both employees and customers.

Ø Expanding residential area – Unirea:

Population growth and real estate development in Unirea require efficient connectivity with the city centre. The route supports daily mobility for residents to schools, workplaces, and public institutions.

Ø Links to natural attractions and tourist infrastructure:

Proximity to Capușele-Cocoșul Forest, Bistrița River and the MHC Lake offers opportunities for the development of leisure and ecotourism routes.

Ø Key roads on the route:

Calea Moldovei – a commercial and industrial artery, Ioan Slavici – a transit street between neighbourhoods, and Andrei Mureșanu – a residential and educational area.

DN17C – a strategic road connecting to the northern parts of the county.

3.2.2. Beclean

a. Typology of the Road Transport System in the Town of Beclean

Ø Model: Linear

Classification:

Ø Linear – Urban development along the DN17 road axis, with an elongated structure and urban functions concentrated along this main direction.

Ø Justification:

The town of Beclean has predominantly developed along the national road DN17, which gives the settlement a linear morphology. The urban structure is elongated, with commercial, administrative, and transport functions concentrated along the central axis. Lateral branches are limited, which emphasises the linear character of the road transport network.

Example:

Ø Central axis: 1 Decembrie 1918 Street, which crosses the town from East to West.

Ø Nodal point: Beclean Train Station area, situated on the DN17 axis, serves as a regional mobility hub.

Recent infrastructure projects (road overpasses, connections between DN17 and DJ172) aim to improve traffic flow along the central axis, highlighting the importance and centrality of this linear structure in the town's spatial organisation.

b. Road transport system

Bicycle Route in Beclean:

- Ø Aleea Gării – a central pedestrian area, an important starting point.
- Ø 1 Decembrie 1918 Street – connects the city centre to the Someşul Mare River area.
- Ø Someşul Mare River Promenade – a bike lane separated from the roadway, located on the embankment.
- Ø Codrului Street leads toward the forest and recreational area.
- Ø Băile Figa Area – the route circles the spa complex and the nearby forest.
- Ø Gării Street – part of the "Drumul Gării din Beclean" project.
- Ø Coldău and Podirei neighbourhoods – connected through extended bike lanes.

These bike lanes are part of a 15–17 km infrastructure project that connects the city's neighbourhoods and recreational areas (fig. 14 and 15).

Fig. 14. Integration of bicycle lanes into the urban landscape of Beclean
Source: the authors

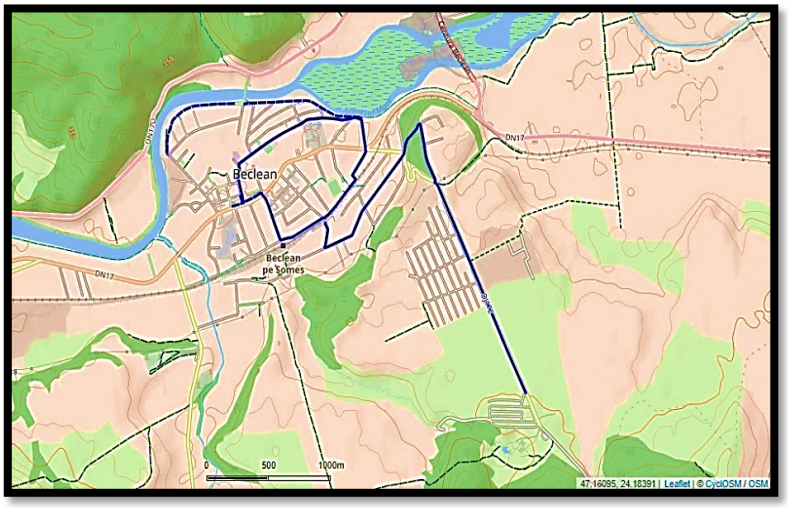

Fig. 15. Spatial Distribution of Bicycle Lanes in Beclean
Source: https://www.openstreetmap.org/

Public transport operator

- Official name: Urban Public Transport Company Beclean SRL
- Fleet type: exclusively electric buses
- Number of bus stops and routes: there is a total number of 55 bus stops in the town of Beclean, 5 routes and itineraries: Băile Figa – Coldău, Băile Figa – Beclenuț, Podirei – Rusu de Jos, Băile Figa – Rusu de Jos, Figa – Town Centre – S-D Figa – Coldău.

Descriptive analysis of two public transport routes in Beclean – "Băile Figa – Coldău" and "Figa – Town Centre – S-D Figa – Coldău" – from an economic, tourist, and social perspective.

Route: Băile Figa – Coldău

- Economic importance: it connects the tourist area of Băile Figa with Coldău, a neighbourhood with residential and commercial functions. It facilitates access for employees and suppliers to the spa complex and commercial units in Coldău (fig. 16). It supports local economic development through connectivity between service and production areas.
- Tourist importance: Băile Figa represents one of the most important tourist attractions in Bistrița-Năsăud County. The route offers easy access for tourists staying in Coldău or neighbouring regions. It promotes ecological mobility in a city that supports sustainable tourism.

Ø Social importance: it provides public transportation for Coldău residents to commute to work or for recreation at Băile Figa. The bus service promotes less dependence on private transport by offering Coldău residents their own accessible and environmentally friendly mode of transportation.

It connects two communities and encourages social inclusivity and municipal response, including all ratepayers' access to a public facility.

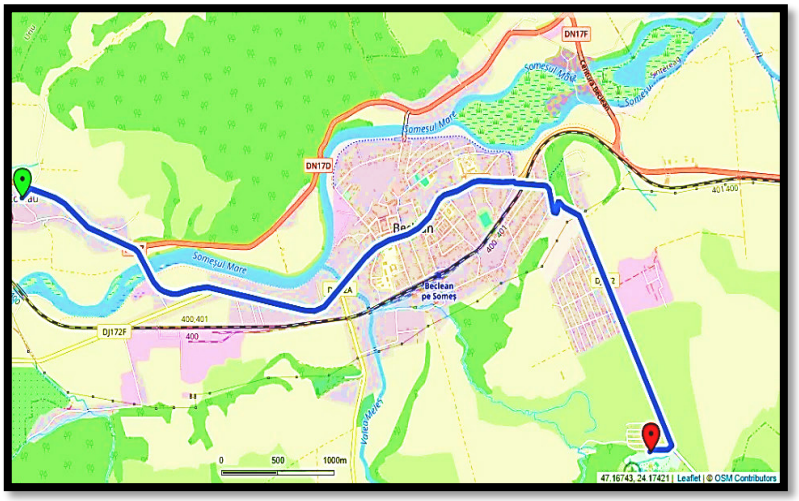

Fig. 16. Route: Băile Figa – Coldău, Beclean
Source: https://www.openstreetmap.org/

Figa – Town Centre – S-D Figa – Coldău

Ø Economic importance: it passes through the town centre of Beclean, a commercial and administrative hub. It links the tourist area with the development zone S-D Figa, where residential and infrastructure projects are located. It supports economic activity by connecting residential areas with service and commercial zones (fig. 17).

Ø Tourist importance: it provides direct access between Băile Figa, the town centre, and Coldău, facilitating tourist movement between key points of interest. It is ideal for tourists who wish to visit both the spa area and the historic or commercial centre of the city.

It can be integrated into "urban ecotourism" routes, considering the bicycle infrastructure and electric buses. Figa Resort is located in Bistrița-Năsăud County, 3 km from Beclean, and was opened in 2010 with the assistance

of PHARE funds, making it one of the most modern locations with thermal baths in Romania. Băile Figa resort is located in a basin between the hills of Beclean, and is famous for its salty waters and mud with properties similar to those of Techirghiol. The recreational area is composed of an outdoor saltwater pool, an indoor heated freshwater pool, a sauna, a jacuzzi, massage, fitness, sports fields with synthetic surfaces.

The resort features an indoor heated freshwater pool, alongside a sauna, a jacuzzi, and a doctor's office. Upstairs, guests can enjoy massage rooms, table tennis, and a fitness room. Terraces also surround an outdoor saltwater pool. Near the saltwater pool is a mini sandy beach with sun loungers.

The mud is similar to the one in Techirghiol and is suitable for the treatment of rheumatic diseases, musculoskeletal disorders, nervous system conditions, and even gynaecological diseases (https://www.hartaturistului.com/).

Ø Social importance: it is a multifunctional route serving residents from multiple neighbourhoods and areas of interest. It connects new residential zones (S-D Figa) with the town centre and educational, cultural, and medical facilities. It contributes to urban cohesion by reducing peripheral isolation and promoting equitable mobility.

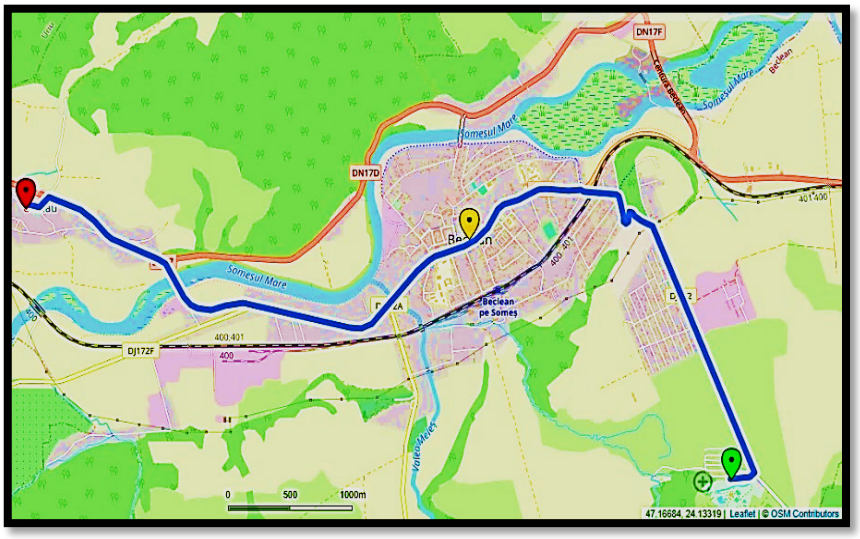

Fig. 17. Route: Figa – Town Centre – S-D Figa – Coldău
Source: https://www.openstreetmap.org/

These two routes are strategic for the town of Beclean. They integrate tourist, economic, and social functions, support sustainable mobility through the use of electric buses, and connect urban development zones with the town centre and existing infrastructure.

3.2.3. Năsăud

a. Typology of the Road Transport System in Năsăud

Central and radial model

- Ø Central model: Năsăud has a well-defined civic centre, located around the Town Hall and the Central Park, which functions as the urban core.
- Ø Radial model: Several major streets radiate from this core and extend towards the outskirts, which is characteristic of a radial layout.
- Ø Spatial justification

A mix of administrative, commercial, and recreational functions characterises the central area. Streets such as Mihai Eminescu, Piața Unirii, and Bulevardul Grănicerilor converge towards this area, supporting the idea of a radial organisation.

- Ø Examples

Bulevardul Grănicerilor is a main artery connecting the central area to the southern part of the town.

Mihai Eminescu Street links the central area to the eastern part. Piața Unirii serves as an intersection node and a point of convergence.

b. Road transport system

DN17C connects Năsăud with Bistrița (to the south) and with Moisei/ Maramureș (to the north).

DN17D connects Năsăud with Sângeorz-Băi (to the northeast) and with Beclean (to the west).

In Năsăud, the local public transportation system is undergoing significant development through the urban mobility project, which is financed with 5 million euros from European funds. The road infrastructure has been modernised, specifically the carriageway used jointly by public passenger transport vehicles, to reduce CO_2 equivalent emissions from transport.

A total of 3.8 km of road has been upgraded, including Crișan, Avram Iancu, Andrei Mureșanu, Vasile Nașcu, Tudor Vladimirescu, Comoarei, and Dumitru Vârtic streets. Additionally, pedestrian routes (sidewalks) have been laid out over a distance of 2.8 km.

Electric buses have been purchased, a depot has been built and charging stations have been installed. Furthermore, a traffic management system will be created, including video monitoring and an intelligent transport system (ITS) (fig. 18).

Description of the local road transport system:

The system comprises five electric buses, of which three are small electric buses with approximately 10–15 seats, and two are large electric buses with approximately 25–30 seats, designed for public road transport.

The project also involves the construction of a depot for local public passenger transport, including the associated technical infrastructure, and the installation of 32 public transport (electric bus) stops. An integrated ticketing system for passengers will be created ("e-tickets" or "e-ticketing").

Fig. 18. Bus Stop "Năsăud 2025" model: urban light – EcoTransit – transparent shelter – SmartStop
Source: the authors

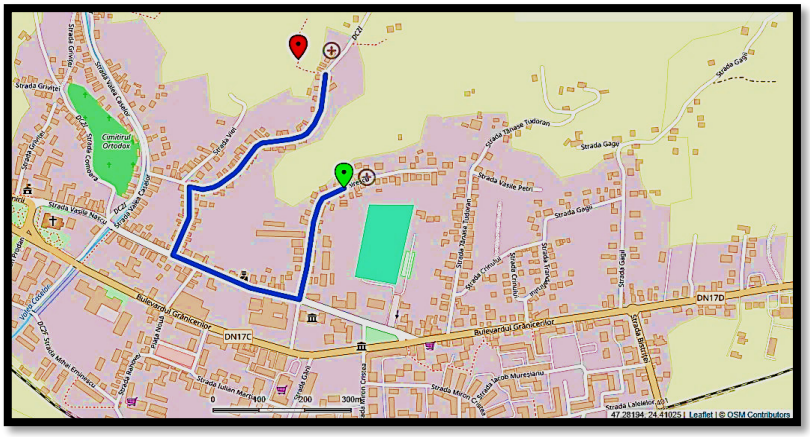

Fig. 19. Route: Tudor Vladimirescu-Avram Iancu
Source: https://www.openstreetmap.org

3.2.4. Sângeorz-Băi

a. Typology of the Road Transport System in Sângeorz-Băi

Grouped and axial model

Ø Justification:

The town of Sângeorz-Băi has a dispersed structure, with residential areas and tourist zones (the spa resort) separated spatially but connected through axial roads. This spatial organisation reflects a functional distribution of the urban space, where areas are grouped according to their purpose (residential, tourism, nature) and linked via an axial transport network.

Example:

Ø DN17D is the main road artery connecting the central area with the spa districts and surrounding natural zones.
Ø Urban areas are grouped based on their functions: administrative centres, residential neighbourhoods, and tourist facilities.

This layout ensures efficient accessibility between the town's key functions without causing excessive congestion in the central core.

b. Road transport system

In the town of Sângeorz-Băi, local public transport is provided by Sângeorz-Băi Town Hall, in collaboration with local operators, through a modern system of electric minibuses.

Operator and infrastructure:

Local authorities manage the transport system, and routes are available in the Moovit app, which provides real-time information.

Number of stops: the public transport network includes 36 bus stops, distributed across two main lines.

Transport lines:

Ø Line 1: Depot – Valea Borcutului; Length: 5 km; Number of stops: 9.
Ø Line 2: Depot – Cormaia School; Length: over 8 km; Number of stops: 18.

These lines cover the central neighbourhoods and points of interest in the town, including the wastewater treatment area, Cormaia, Valea Borcutului, and the town centre (fig. 20).

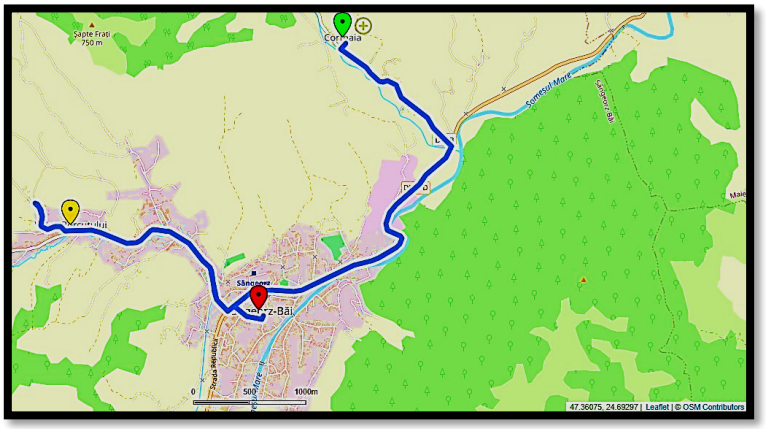

Fig. 20. Transport route: Cormaia-Sângeorz-Băi-Valea Borcutului
Source: https://www.openstreetmap.org

Bicycle lanes and bike-sharing system in Sângeorz-Băi

Length of bicycle lanes

- Ø A total of 6.334 km of bicycle lanes were built as part of the urban mobility project.
- Ø The lanes are equipped with public lighting, pedestrian railings, and waste bins.

The route largely follows the banks of the Someşul Mare River, connecting the central area with the spa districts and promenade zones.

- Ø Additional cycling routes

There are also cycling trails in the Valea Borcutului–Parva area, measuring 3,704 m in length, suitable for cyclists with intermediate experience. These routes offer spectacular views and are integrated into the natural landscape of the Rodna Mountains.

Bike-sharing system

- Ø A total of 60 bicycles were purchased through European funding.
- Ø The bikes are available at four bike-sharing stations located throughout the town.
- Ø Usage is free for the first hour, after which a fee of 10 lei/hour is charged.

Access is granted via a card issued by the Town Hall, with online registration available at sangeorzbike. ro.

3.2.5. Typology of the Road Transport System in Bistriţa–Beclean–Năsăud–Sângeorz-Băi urban axis

Ø Dominant model: axial

Reasoning: The DN17 and DN17D arteries ensure urban connectivity by following the natural axis formed by the Bistriţa and Someşul Mare valleys, being configured in accordance with the specific relief of the depressions they cross.

Key characteristics:

Ø The towns are aligned along a regional transport axis.
Ø The primary road network dictates the direction of urban development.
Ø Connections between cities are direct, with few major branches.

Secondary influences:

Ø Central: it is important in towns such as Bistriţa and Năsăud, where a well-defined urban core exists.
Ø Linear: in Beclean, where development is closely tied to the road axis.
Ø Grouped: in Sângeorz-Băi, where urban functions (residential, tourism) are dispersed but connected axially.

Examples:

Ø DN17 links Bistriţa to Beclean and further towards Cluj-Napoca.
Ø DN17D continues towards Năsăud and Sângeorz-Băi, following the valley of the Someşul Mare River.

Table 2. Total length of bicycle lanes – bike-sharing systems

City	Length of bicycle lanes (km)	Number of bicycles	Number of stations	Notes
Bistriţa	30 km	175 (165 regular + 10 electric)	7 stations	GLOBIKES system, mobile app available
Beclean	17 km	-	-	-
Năsăud	0 km (functional)	-	-	-
Sângeorz-Băi	6.3-6.4 km	60	4 stations	Access via Town Hall-issued card, registration at sangeorzbike. ro

Source: the authors

Analysis of bicycle infrastructure and bike-sharing systems in Bistriţa–Beclean–Năsăud–Sângeorz-Băi urban axis (table 2):

Ø Estimated total length: ~49.3-50 km of bicycle lanes across the urban axis.
Ø Number of bicycles: 235; stations: 11.

The data regarding cycling infrastructure within the urban axis Bistriţa–Beclean–Năsăud–Sângeorz-Băi reflects the situation as of 2025, with prospects for future expansion.

In the studied urban axis, the bus stop models for 2025 include the following functional and stylistic subtypes:

- Urban light – featuring an airy design with a lightweight metal structure, suitable for modern urban spaces.
- EcoTransit – adapted for ecological transport using electric buses.
- Transparent shelter – equipped with transparent panels for enhanced visibility and safety.
- SmartStop – integrated with an e-ticketing system and video monitoring for a digital and secure passenger experience.

3.3. Urban spatial organisation

3.3.1. Analysis of the degree of implementation of the 15-minute city principle

The 15-minute city concept aims to create self-sufficient neighbourhoods with the essential functions of living, working, commerce, healthcare, education, and entertainment by decentralising urban functions and services (Khavarian-Garmsir et al., 2023). Seven dimensions constitute the 15-minute city: (1) proximity, (2) density, (3) diversity, (4) digitalisation, (5) human scale, urban design, (6) flexibility, and (7) connectivity.

These are briefly discussed (Khavarian-Garmsir et al., 2023) (table 3).

Table 3. Percentage of urban residential areas covered by the 15-minute city principle

City	Percentage of Urban Residential Areas
Bistriţa	75%-80%
Beclean	90%
Năsăud	90%
Sângeorz-Băi	70%

Source: the authors

The differences in coverage percentages within the 15-minute city principle for the four cities along the Bistriţa–Beclean–Năsăud–Sângeorz-Băi axis can be explained by urban typology, street network structure, and the distribution of essential functions.

- *Beclean*

A small town with essential functions (schools, markets, parks, public transport) concentrated in the centre. Distances are short, and access is easy from almost any residential point.

Ø *Năsăud*

A transparent and efficient urban structure, with a predominantly orthogonal street network. Urban functions are evenly distributed, and the town's size favours proximity.

Ø *Bistrița*

A larger city with a mixed street network: historical areas with narrow and winding streets, and modern zones that are better organised. Functions are well distributed in the centre, but peripheral regions may have limited access to certain services. Distances increase in new neighbourhoods or industrial zones. Good accessibility is available in the centre, but it decreases towards the periphery.

Ø *Sângeorz-Băi*

A resort town with mountainous terrain, which negatively affects pedestrian accessibility. It has an organic street network, with winding roads and a dispersed distribution of buildings. Urban functions are concentrated in the central tourist area, while peripheral residential zones are less connected.

The more compact a city is, with an orthogonal street network and evenly distributed functions, the more likely it is to align with the 15-minute city principle.

The analysis was conducted using Cadmapper.

Analysis of variance ANOVA is a statistical method developed by Sir Ronald A. Fisher. Anova works by dividing the total variation into two components variation between groups sum of squares between groups, indicated as SS_Between and variation within the group sum of squares within the groups, indicated as SS_Within. Fisher, in the 1920s, used to compare the averages of various groups and determine whether the differences observed between them are statistically significant or attributed to chance variation. Then we calculate the mean squares MS and the statistic F, which is the ratio between MS_Between and MS_Within.

The resulting p-value indicates whether the differences are significant ($p < 0.05$) or not (Cochran, W. G., 1980; Janczyk, M., & Pfister, R., 2023).

In this study, ANOVA analysis was applied to compare the coverage of the 15-minute city principle in four cities in the urban axis Bistrița-Beclean-Năsăud-Sângeorz-Băi. The percentage values examined were Bistrița (75-80%), Beclean (90%), Năsăud (90%), and Sângeorz-Băi (70%).

The result obtained was an F-statistic of 8.20 and a p-value of 0.2500, indicating that there are no statistically significant differences between cities in terms of coverage of the 15-minute city principle.

This finding has important implications for the study of the urban axis. It suggests a functional coherence among the analysed cities, which validates the polycentric model and supports the idea of a balanced territorial organisation. Secondly, it demonstrates that the morphological diversity of cities (axial, central, and clustered) does not hinder the application of sustainable urbanism principles but rather allows for efficient local adaptations.

3.3.2. Spatial Analysis with Cadmapper

3.3.2.1. Bistrița

The axial-central urban layout model relies on the existence of an axis - usually a boulevard or major thoroughfare - that crosses the urban landscape, and on which the complete metropolitan morphogenesis is based.

This axis is a unifying spatial element that links urban morphologies adjoining it, serving to connect areas of civic importance, public utilities, commercial zones, and residential areas within the city (fig. 21, fig. 22).

The balanced or symmetrical disposition of buildings, roads, and green spaces with respect to an axis suggests a systematic effort toward efficient and aesthetic urban planning, as the axis appears to represent the systematic arrangement of spatial objects.

The symmetrical green space along the axis suggests a concern for the quality of the urban environment and the formation of ecological corridors and recreational spaces.

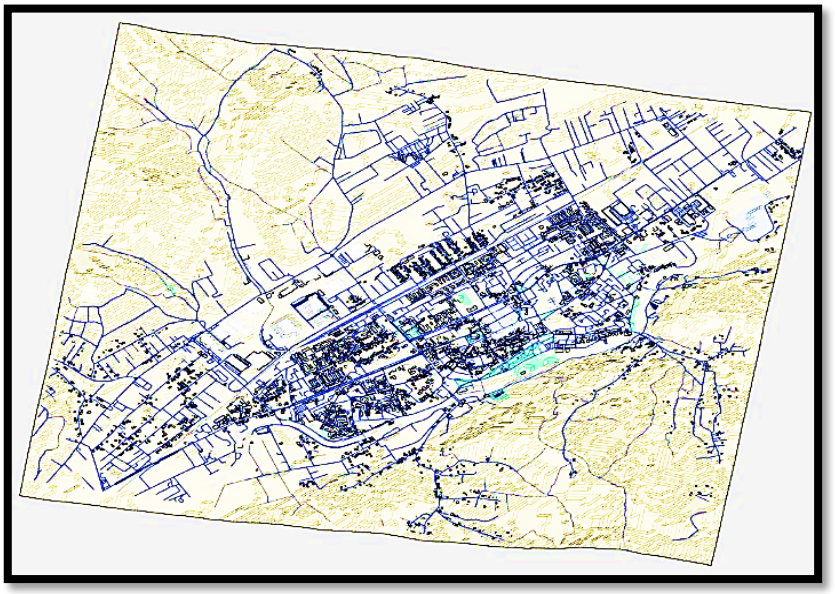

Fig. 21. Spatial structure of Bistrița municipality - cartographic representation
Source: https://cadmapper.com/pro

- File Type: AutoCAD DXF
- Area: 24.429 km^2
- Buildings: 4285 total, 66 with height value (2%)

- Topography: included, 337.00 m above sea level
- Settings: Road meshes (highways 8.0, major 8.0, minor 8.0, paths 5.0), 3D buildings (no value = 3.0 m), 10 m contours
- Spatial Reference System: Meters; UTM Zone: 35, Easting: 306875.44, Northing: 5220790.12. 3D Axonometric View
- 1:20.000

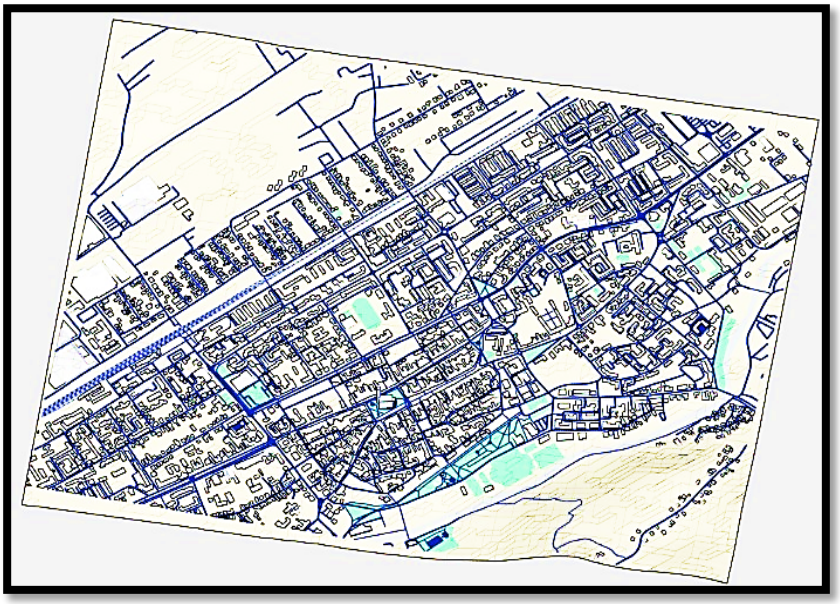

Fig. 22. Bistriţa - spatial organisation and road network
Source: https://cadmapper.com/pro

- File Type: AutoCAD DXF
- Area: 5.149 km^2
- Buildings: 2117 total, 62 with height value (3%)
- Topography: included, 352.00 m above sea level
- Settings: Road meshes (highways 8.0, major 8.0, minor 8.0, paths 5.0), 3D buildings (no value = 3.0 m), 10 m contours
- Spatial Reference System: Meters; UTM zone: 35, easting: 308852.33, northing: 5222285.43.3D Axonometric View
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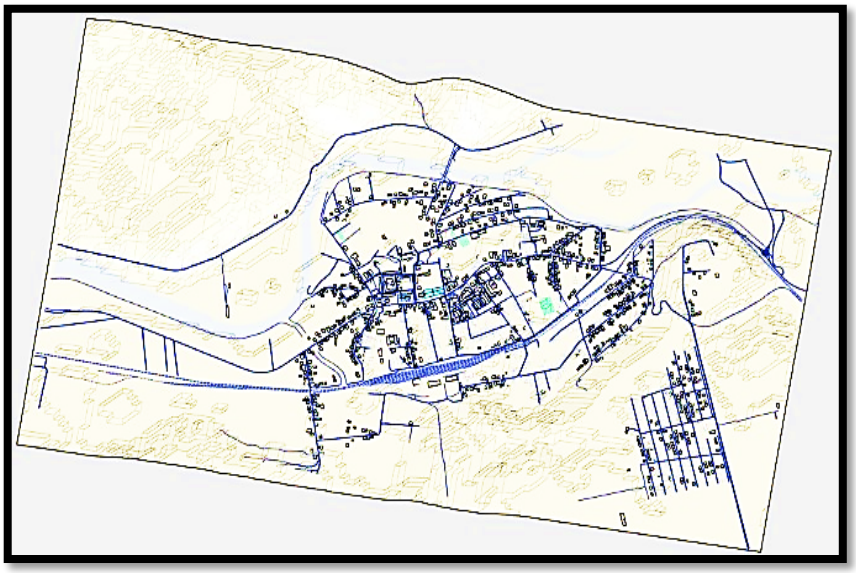

Fig. 23. Urban structure and hydrographic network in Beclean
Source: https://cadmapper.com/pro

- File Type: AutoCAD DXF (fig. 23)
- Area: 9.607 km^2
- Buildings: 1424 total, 0 with height value (0%)
- Topography: Included, 246.00 m above sea level
- Settings: Road meshes (highways 8.0, major 8.0, minor 8.0, paths 5.0), 3D buildings (no value = 3.0 m), 10 m contours
- Spatial Reference System: Meters; UTM Zone: 35, Easting: 284086.25, Northing: 5227786.39. 3D Axonometric View.
- 1:10.000

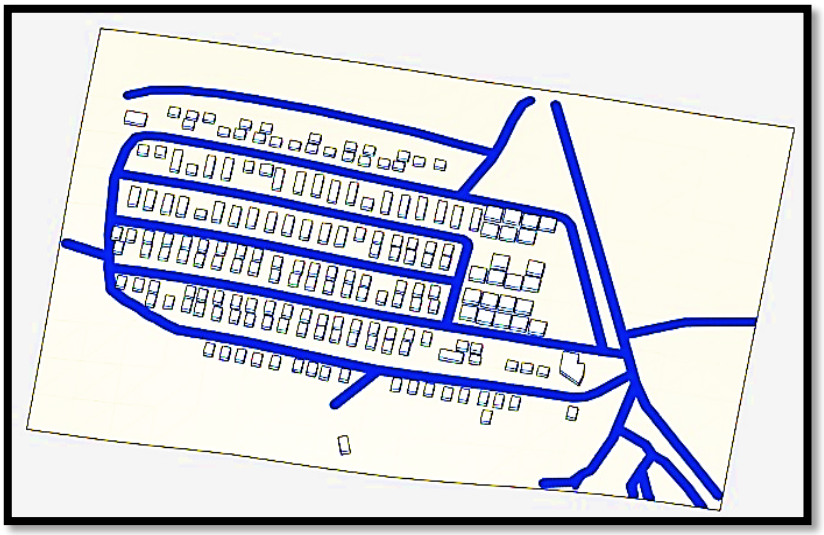

Fig. 24. Organisation model of the Tourist Resort Băile Figa
Source: https://cadmapper.com/pro

- Ø File Type: AutoCAD DXF
- Ø Area: 0.117 km²
- Ø Buildings: 187 total, 0 with height value (0%)
- Ø Topography: Included, 290.00 m above sea level
- Ø Settings: Road meshes (highways 8.0, major 8.0, minor 8.0, paths 5.0), 3D buildings (no value = 3.0 m), 10 m contours
- Ø Spatial Reference System: Meters; UTM Zone: 35, Easting: 288076.23, Northing: 5227208.93. 3D Axonometric View.
- Ø 1:5.000

The tourist resort Băile Figa is organised in a coherent spatial system, with a well-defined road network, characterised by parallel and perpendicular roads that facilitate access to the main areas of interest: accommodation, leisure and tourist infrastructure. The layout of buildings in a rectangular pattern suggests urban planning oriented towards functional efficiency and accessibility to the city, located on County Road DJ 172 (fig. 24).

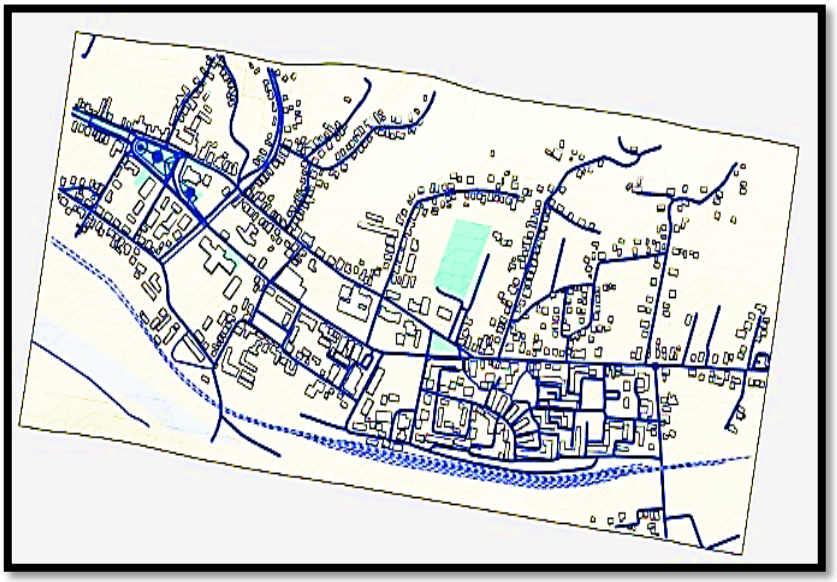

Fig. 25. Road network and spatial organisation in Năsăud
Source: https://cadmapper.com/pro

- File Type: AutoCAD DXF (fig. 25)
- Area: 1.57 km²
- Buildings: 758 total, 1 with height value (0%)
- Topography: Included, 311.00 m above sea level
- Settings: Road meshes (highways 8.0, major 8.0, minor 8.0, paths 5.0), 3D buildings (no value = 3.0 m), 10 m contours
- Spatial Reference System: Meters; UTM Zone: 35, Easting: 303243.99, Northing: 5239585.92. 3D Axonometric View
- 1:10.000

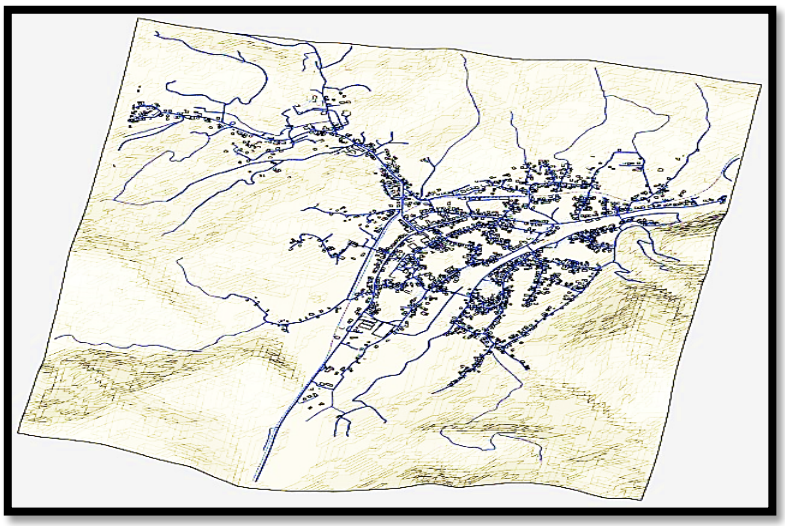

Fig. 26. Urban structure and land features of Sângeorz-Băi
Source: https://cadmapper.com/pro

- File Type: AutoCAD DXF (fig. 26)
- Area: 10.907 km^2
- Buildings: 2312 total, 0 with height value (0%)
- Topography: Included, 417.00 m above sea level
- Settings: Road meshes (highways 8.0, major 8.0, minor 8.0, paths 5.0), 3D buildings (no value = 3.0 m), 10 m contours
- Spatial Reference System: Meters; UTM Zone: 35, Easting: 322467.10, Northing: 5246501.33. 3D Axonometric View.
- 1:20.000

4. CONCLUSION

This research emphasises the essentially interdependent nature of road transport system typologies and the spatial organisation of the urban settlement types along the Bistriţa–Beclean–Năsăud–Sângeorz-Băi geography axis. The typological mapping and geospatial analysis of all the road networks (using open-source tools such as Cadmapper and OSM) was one of the typological spatial contextualisation of essential urban functions: commercial, cultural, tourist, and economic.

The results concluded that road typologies and hierarchies along urban road networks modulate patterns of accessibility and the structural distribution of metropolitan functions, contributing to spatial coherence. The relevant urban organisation types identified were axial, central, linear, and grouped, suggesting local responses to geography and the short histories of existing infrastructure-based urban development, with responses related to spatial aspirations towards sustainability. The application of the '15-minute city' concept was closely associated with urban geography, morphology and connectivity, and was most evident in the less dispersed forms (Beclean, Năsăud). In contrast, daily activity connectivity was inhibited in more hilly/mountainous forms (Sângeorz-Băi).

Alternative mobility infrastructure (commonly bike lanes, bike-sharing programs, and electric transport modes) radically improves the quality of life (urbanity), reduces emissions, and relieves pressure on urban space.

The ANOVA supports the study's general conclusions and reports reliable population measures that are viable in the context of addressing urban and regional planning policy recommendations.

A typological analysis, such as the one proposed here, provides a replicable methodological basis for making sense of urban diagnostics and sustainable territorial planning, which can be applied in comparable areas. The analysis underscores the significance of open geospatial data in urban decision-making and highlights the crucial need for polycentric and ecologically sustainable development of transport infrastructure.

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TOURIST SATISFACTION AND ITS SOCIO-DEMOGRAPHIC ANTECEDENTS: A CASE STUDY OF THE TURDA SALT MINE IN ROMANIA

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ABSTRACT. – Tourist Satisfaction and Its Socio-demographic Antecedents: A Case Study of the Turda Salt Mine in Romania. Customer satisfaction is a cornerstone of tourism, with extensive literature confirming its direct link to loyalty through repeat visits and positive word-of-mouth. Despite this established importance, a notable research gap exists concerning visitor satisfaction within industrial tourism, particularly at salt mine attractions. Furthermore, the influence of sociodemographic factors on these satisfaction levels remains underexplored. This study aims to address this dual gap by evaluating tourist satisfaction at a historic salt mine and determining if significant differences exist across various socio-demographic groups. Using the Turda Salt Mine in Romania as a case study, this research employed a self-administered questionnaire for data collection. The data were analyzed using SPSS (v26), beginning with descriptive statistics to profile the sample and initial responses. To refine the satisfaction measurement, the 18 experience statements were subjected to Principal Component Analysis (PCA), reducing them into core dimensions. These dimensions were then analyzed using t-tests and ANOVA to identify statistically significant differences across socio-demographic groups. The findings indicate that visitors reported high overall satisfaction, demonstrating a strong likelihood to return and recommend the attraction. While feedback on specific attributes was generally positive, neutral ratings for several items revealed tangible opportunities for enhancement. The analysis also confirmed several statistically significant differences in satisfaction

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based on socio-demographic characteristics, although their overall influence was less pronounced than anticipated. The paper concludes by discussing the implications, practical applications, and limitations of the study.

Keywords: *visitor satisfaction, salt mines, Turda Salt Mine, Romania, socio-demographic variables.*

INTRODUCTION

Customer satisfaction is a cornerstone of tourism research (Altunel & Erkurt, 2015; Egresi, 2017). For destination management organizations (DMOs), accurately measuring and understanding tourist satisfaction is paramount. As Yu and Goulden (2006) argued, this understanding is essential not only for improving a destination's products and services but also for marketing it effectively to target audiences. This process directly informs service improvements and strategic planning (Alrawadieh et al., 2019; Sirakaya et al., 2004; Truong et al., 2018), with the primary goal of maximizing visitor satisfaction and minimizing dissatisfaction in order to foster loyalty (Egresi & Lungu, 2015; Egresi et al., 2020; Maunier & Camelis, 2013; Yuksel et al., 2010).

Extensive literature confirms that high satisfaction leads to customer loyalty, which manifests through revisits and positive recommendations; conversely, dissatisfied tourists can significantly damage a destination's reputation (Altunel & Erkurt, 2015; Anderson et al., 1994; Bayih & Singh, 2020; Chen & Chen, 2010; Egresi & Prakash, 2019; Fuchs & Weiermair, 2003; Huete-Alcocer et al., 2019; Kozak, 2003; Lee, 2015; Lee et al., 2011; Maunier & Camelis, 2013; Oppermann, 2000; Yoon & Uysal, 2005). This is particularly critical as research shows that dissatisfied tourists—especially those unhappy with a core attraction—are more likely to share negative reviews than satisfied tourists are to share positive ones (Lee, 2015). It is also important to note that satisfaction does not always guarantee a return visit to the same site; however, a positive experience can reinforce a tourist's habit of visiting similar types of attractions, such as salt mines or industrial sites in general (Lee, 2015).

Despite its recognized importance, current assessment methods often rely on generic destination attributes, failing to capture the unique qualities of specific tourism sectors, such as industrial tourism. This gap highlights the necessity of defining sector-specific attributes that establish a baseline for tourist satisfaction (Lee, 2015). Furthermore, the influence of sociodemographic characteristics on satisfaction remains an under-explored area in the literature (Huete-Alcocer et al., 2019).

This study has a dual purpose: to evaluate tourist satisfaction with specific attributes and the overall experience at a historic salt mine, and to determine if satisfaction levels differ significantly across socio-demographic groups. It employs the Turda Salt Mine as a case study. Located in Northern Transylvania, the mine has a history of salt extraction spanning two millennia, from the Roman era until its closure in 1932. After serving various non-touristic purposes[3], it opened to the public in 1992 but saw limited interest[4]. A pivotal €6 million modernization project funded by the European Union[5] culminated in a 2010 reopening[6]. This investment triggered a dramatic surge in visitors, culminating in almost 690,000 in 2024,[7] 20% increase from the previous year. Romania is home to several such salt mines which have been modernized since 1990 to accommodate tourists (Kimic et al., 2019). These sites attract domestic and international visitors seeking halotherapy in their specific microclimates, as well as their cultural and recreational facilities (Chiricheş & Egresi, 2024; Sandu et al., 2009; Stănciulescu & Molnar, 2016). It is, thus, important to understand how visitors have perceived their experience in the mine.

The paper proceeds with a literature review, followed by an outline of the methodological approach. The subsequent sections present the empirical findings and a discussion that interprets these results, delving into their implications, practical applications, and the study's limitations.

LITERATURE REVIEW

Customer satisfaction in tourism is predominantly understood through a "confirmation-disconfirmation" paradigm, where tourists compare their pre-travel expectations against their actual experiences. When performance meets or exceeds expectations, satisfaction results; when it falls short, dissatisfaction occurs (Oliver, 1980; Parasuraman et al., 1985 – see also Baker & Crompton, 2000; Chadee & Mattsson, 1996; Fuchs & Weiermair, 2003; Lee et al., 2011; Maunier & Camelis, 2013; Yeh et al., 2019; Yoon & Uysal, 2005). However, a significant scholarly debate exists. The Scandinavian school of thought argues for a "performance-only" measurement, though this approach makes it difficult to discern if high satisfaction stems from excellent service or low initial expectations (Fuchs & Weiermair, 2003).

3 https://www.welcometoromania.eu/Turda/Turda_Salina_Turda_e.htm
4 https://gazetadecluj.ro/salina-turda-spectacol-pe-bani-europeni/
5 https://www.mediafax.ro/economic/nou-record-de-turisti-la-salina-turda-anul-trecut-numarul-s-a-apropiat-de-populatia-clujului-17811797
6 https://www.europafm.ro/cum-ii-cucereste-salina-turda-pe-vizitatori-galerie-foto/
7 https://ebsradio.ro/stiri/record-aproape-690-000-de-turisti-au-vizitat-anul-trecut-salina-turda/

While some debate exists regarding the distinction between satisfaction and service quality (Cho, 1998), a predominant view positions perceived service quality as an antecedent to satisfaction (Lee et al., 2011; Parasuraman et al., 1985, 1988). Furthermore, tourist motivation is a key factor that enhances perceived quality, as greater personal and emotional investment in a trip leads to more positive evaluations of its attributes (Alegre & Garau, 2010; Lee et al., 2011).

The measurement of tourist satisfaction generally follows two primary approaches: one that assesses a holistic, general attitude towards the experience, and another that evaluates multiple specific dimensions (Chi & Qu, 2009; Fuchs & Weiermair, 2003; Kozak, 2003). The former defines satisfaction as an overall post-visit evaluation (Chen & Tsai, 2007; Huete-Alcocer et al., 2019; Yeh et al., 2019), while the latter conceptualizes it as an aggregate formed from perceptions of individual destination attributes (Alegre & Garau, 2010; Biswas et al., 2021; Maunier & Camelis, 2013). Fundamentally, when these attributes successfully meet tourist needs, they culminate in a positive overall experience (Bayih & Singh, 2020).

A common methodological approach involves measuring satisfaction by having tourists evaluate a customized pool of destination attributes on a rating scale (Dmitrovic et al., 2009). As there is no universally standardized set of attributes, researchers typically develop context-specific dimensions. This is exemplified by the evolution of frameworks such as Cooper et al.'s (1993) foundational “4 A's” (Attractions, Accessibility, Amenities, Available Packages), which was later expanded by Buhalis (2000) to include Activities and Ancillary services. Further demonstrating this customization, Lee's (2015) study on industrial tourism defined seven distinct dimensions, including lodging and dining facilities, internal and external accessibility, and the provision of safety and information services.

Tourist satisfaction is often complex and multifaceted; individuals can simultaneously hold both positive and negative perceptions of different attributes within a single destination (Lee, 2015). Positive attributes create a favorable impression, while negative ones generate an unfavorable view (Alegre & Garau, 2010). Despite this duality, a significant methodological bias exists in the literature, with many studies disproportionately focusing on positive attributes (Oh, 2001) and systematically neglecting negative aspects such as crowding, congestion, and over-commercialization (Alegre & Garau, 2010).

Furthermore, research indicates that attribute-level satisfactions do not contribute equally to overall satisfaction; certain destination features exert a stronger influence than others (Chi & Qu, 2009; Kozak, 2003; Lee, 2015; Varela Mallou et al., 2006). Beyond specific attributes, overall satisfaction is also shaped by interpersonal factors and tourists' perceptions of service accessibility (Huete-Alcocer et al., 2019).

Tourist satisfaction is also influenced by socio-demographic characteristics and cultural background (Fuchs & Weiermair, 2003; Huete-Alcocer et al., 2019; Perović et al., 2012; Shahrivar, 2012). Research indicates that individual-level variables such as gender, age, income, and employment status can shape the perception of a destination (Huete-Alcocer et al., 2019).

The impact of specific demographics, however, shows nuanced patterns. Regarding gender, while some studies contest its influence (Baloglu, 2000), others have found significant differences (Huh, 2002), with females generally reporting higher satisfaction than males (Martin et al., 2019). Age is another significant factor, with older tourists, particularly those between 56 and 65 years old, demonstrating higher satisfaction levels than their younger counterparts (Assaker et al., 2015; Martin et al., 2019). Furthermore, income level could also influence satisfaction (Beerli & Martin, 2004), with more affluent tourists reporting higher levels of satisfaction with a destination (Perović et al., 2012).

Beyond individual demographics, a number of studies highlight that cultural differences in attitudes and behavior profoundly influence expectations and perceptions (Chadee & Mattsson, 1996; Fuchs & Weiermair, 2003; Jia, 2020; Martin et al., 2019). Consequently, what is measured in satisfaction surveys may not be a purely objective evaluation of destination performance. Instead, it is often a mixture of individual experiences and deeply ingrained, country-of-origin-specific values and attitudes (Fuchs & Weiermair, 2003; Weiermair & Fuchs, 2000).

METHODOLOGY

Data collection

The primary data collection instrument for this study was a self-administered questionnaire. The initial dissemination strategy involved distributing the questionnaire on-site to visitors exiting the Turda Salt Mine in April 2023, which resulted in 89 usable responses. Due to the low initial response rate, a second phase of online distribution was implemented via social media platforms, yielding a further 78 responses. The total sample size was therefore 167.

The questionnaire was structured into four distinct parts. Part one gathered data on travel behavior, including past visitation history, frequency, trip duration, travel party composition, and per-visit expenditure. Part two contained nine statements designed to evaluate visitation motives. The findings from these two sections have been published previously (Chiricheș & Egresi, 2024). Part three quantified participant satisfaction with their mine experience through a series of statements measured on a 5-point Likert scale. This is the main focus of the present study. The concluding section recorded socio-demographic characteristics of the participants.

Data processing

The data were analyzed using SPSS version 26. The analysis began with descriptive statistics—including frequencies, percentages, median, and interquartile range (IQR)—to delineate the socio-demographic composition of the sample and to evaluate initial responses to the experience statements. To refine the satisfaction measurement, the 18 statements were subjected to Principal Component Analysis (PCA) to reduce them into a smaller set of dimensions. These resulting satisfaction dimensions were then analyzed using independent samples t-tests and ANOVA to identify statistically significant differences across various socio-demographic groups.

ANALYSIS OF FINDINGS AND DISCUSSION

Socio-demographic characteristics of our respondents

The sample consisted primarily of women under 40, who had less than a higher education and resided in Romania (outside Cluj County) (table 1).

Table 1. Socio-demographic characteristics of respondents

Socio-demographic characteristic	Frequency	% from total	Socio-demographic characteristic	Frequency	% from total
Gender (n=166)			***Education*** (n=167)		
Male	69	41,6	Less than university degree	94	56.3
Female	97	58,4	University degree and higher	73	43.7
Age group (n=167)			***Residence*** (n= 167)		
18 – 39 years	114	68.2	Cluj County	26	15.6
40+ years	53	31.8	Romania (excl. Cluj)	112	67.1
			Abroad	29	17.4

Source: the authors

Visitors' satisfaction with their experience

Most respondents agreed that the atmosphere in the salt mine was pleasant (median= 5). They were also satisfied with the signage, availability of parking, ease of entering, descending and moving around the mine and with the

opportunities to play different sports or engage in various leisure activities (median for each= 4). None of the attributes were evaluated negatively; however, visitors were neutral (median= 3) when asked about crowdedness, entrance fees, fees for various activities inside the mine, availability of cultural and religious activities, adequacy of food services and organization of the medical treatment area (table 2). Overall, the visitors were satisfied with their experience, planned to return in the future and to recommend the salt mine to others (all medians= 5) (table 3).

Table 2. Visitors' satisfaction with their experience

After visiting the salt mine, my assessment is the following:	Totally disagree (%)	Disagree (%)	Not sure (%)	Agree (%)	Totally agree (%)	Median	IQR
The signage in the mine is adequate (n=167)	2.4	6.0	24.0	31.7	35.9	4.00	2.00
There is plenty of parking for visitors (n=166)	6.0	7.2	25.9	29.5	31.3	4.00	2.00
Entering, descending underground and moving around in the salt mine are not too difficult (n=165)	4.8	13.9	22.4	33.9	24.8	4.00	2.00
The salt mine is not too crowded with visitors (n=165)	10.3	17.0	29.7	24.8	18.2	3.00	2.00
Entrance fees are reasonable (n=164)	6.7	19.5	31.1	22.6	20.1	3.00	2.00
Fees for participating in the various activities organized within the salt mine are reasonable (n=164)	9.8	15.9	41.5	20.7	12.2	3.00	1.00
Visitors can play various sports while in the salt mine (n=165)	2.4	10.9	35.2	27.9	23.6	4.00	1.00
Visitors can engage in various leisure activities (n=167)	2.4	10.2	32.3	30.5	24.6	4.00	2.00

After visiting the salt mine, my assessment is the following:	Totally disagree (%)	Disagree (%)	Not sure (%)	Agree (%)	Totally agree (%)	Median	IQR
There are numerous cultural and religious activities visitors can participate in while in the salt mine (n=164)	8.5	27.4	37.2	16.5	10.4	3.00	2.00
The treatment area is well organized and the salt therapy programs are effective (n=157)	5.7	9.6	45.9	23.6	15.3	3.00	1.00
Food services were adequate (n=160)	8.1	10.6	31.3	27.5	22.5	3.00	1.00
The guide was very professional (n=148)	4.7	4.7	33.8	27.0	29.7	4.00	2.00
The staff was kind (n=160)	1.3	3.1	16.9	41.9	36.9	4.00	1.00
The atmosphere in the salt mine is pleasant (n=162)	0.6	1.9	12.3	34.6	50.6	5.00	1.00

Source: the authors

Table 3. Overall satisfaction with the experience

Visitors' satisfaction	Totally disagree (%)	Disagree (%)	Not sure (%)	Agree (%)	Totally agree (%)	Median	IQR
I was impressed by the beauty of the salt mine (n=165)	0	0.6	9.7	20.0	69.7	5.00	1.00
The entire experience was unique (n=166)	0	1.8	15.7	28.9	53.6	5.00	1.00
I plan to return in the future (n=164)	2.4	2.4	18.9	22.0	54.3	5.00	1.00
I will recommend the salt mine to others (n=167)	0	0	10.8	27.5	61.7	5.00	1.00

Source: the authors

In the next phase, a principal component analysis (PCA) was run on 18-item questionnaire that measured visitor's satisfaction with their experience in the Turda salt mine. The suitability of the PCA was assessed prior to analysis. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.771 which is "middling" according to Kaiser (1974). Also, all individual KMO measures were greater than 0.5 (with the majority being greater than 0.7). Bartlett's test of sphericity was statistically significant (p=.000), indicating that the data was factorizable. PCA revealed six components that has eigenvalues greater than one. Together these explain 69.170% of the variance. Visual inspection of the scree plot indicated that six components should be retained (Cattell, 1966). A Varimax orthogonal rotation was employed to aid interpretability.

Table 4. Results of the Principal Component Analysis

Factors and items	**Factor loading**						**Comm-**	**Vari-ance expl. (%)**
Factor 1: Overall satisfaction (α)	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**		30.77
I will recommend the salt mine to others	.813						.789	
I was impressed by the beauty of the salt mine	.762						.702	
The entire experience was unique	.756						.681	
The atmosphere in the salt mine is pleasant	.721						.681	
I plan to return in the future	.679						.580	
Factor 2: Satisfaction with the staff								9.63
The guide was very professional		.762					.640	
Food services were adequate		.723					.649	
The treatment area is well organized and the salt therapy programs are effective		.680					.552	
The staff was kind		.588					.568	
Factor 3: Satisfaction with the activities								8.90
Visitors can engage in various leisure activities			.814				.764	

Factors and items	Factor loading						Comm-	Vari-ance expl. (%)
Visitors can play various sports while in the salt mine			.835				.749	
There are numerous cultural and religious activities visitors can participate in while in the salt mine			.431				.488	
Factor 4: Satisfaction with prices								8.18
Fees for participating in the various activities organized within the salt mine are reasonable				.880			.848	
Entrance fees are reasonable				.853			.815	
Factor 5: Satisfaction with accessibility								6.02
The salt mine is not too crowded with visitors					.814		.787	
Entering, descending underground and moving around in the salt mine are not too difficult					.694		.627	
Factor 6: Satisfaction with signage & parking								5.67
The signage in the mine is adequate						.705	.752	
There is plenty of parking for visitors						.823	.780	
Total variance explained								69.17
KMO measure of sampling adequacy = .771								
Bartlett's test of sphericity: 920.36								
Significance: .000								

Rotation method: Varimax with Kaiser normalization

Source: the authors

Differences in satisfaction between groups based on socio-demographic characteristics

Further, our analysis revealed several statistically significant differences in satisfaction based on socio-demographic characteristics.

Regarding **overall satisfaction**, a significant difference was found based on **residence** ($F(2,132) = 5.44$, $p = .005$). Tourists residing abroad reported the lowest satisfaction ($M = -0.70$). Tukey's HSD post-hoc tests confirmed that their satisfaction was significantly lower than that of tourists from Romania (mean difference = -0.82, 95% CI [-1.41, -0.23], $p = .031$) and from Cluj County (mean difference = -0.77, 95% CI [-1.48, -0.06], $p = .004$). No other socio-demographic variables (sex, age, or education) were significant predictors of overall satisfaction ($p > .05$).

For **satisfaction with staff**, significant differences were associated with both **education level** and **residence**. Tourists with a university degree were more satisfied ($M = 0.25$) than those without one ($M = -0.16$; $t(133) = -2.34$, $p = .021$). A significant effect of residence was also found ($F(2,132) = 9.04$, $p < .001$). Again, tourists residing abroad were the least satisfied ($M = -0.87$), while those from Romania ($M = 0.11$) and Cluj County ($M = 0.23$) reported higher satisfaction. Post-hoc analyses indicated that the satisfaction of tourists from abroad was significantly lower than that of both tourists from Romania (mean difference = -0.98, 95% CI [-1.56, -0.41], $p < .001$) and from Cluj County (mean difference = -1.10, 95% CI [-1.79, -0.41], $p = .001$).

A statistically significant difference in satisfaction with activities (the 3rd dimension) was found only for age ($t(133) = 2.433$, $p = .016$). Younger tourists (18-39 years) reported higher satisfaction ($M = 0.14$) than older visitors ($M = -0.31$), with a mean difference of 0.45 (95% CI [0.08, 0.81]).

No statistically significant differences were observed for the other three satisfaction dimensions across any of the socio-demographic groups examined ($p > .05$).

DISCUSSION AND CONCLUSION

The goal of this study was to evaluate tourist satisfaction with specific attributes and the overall experience at a historic salt mine, and to determine if satisfaction levels differ significantly across socio-demographic groups.

Overall, visitors reported high satisfaction with their experience, indicating a strong likelihood to return and recommend the salt mine to others. At an attribute level, feedback was universally positive, with no areas receiving negative evaluations.

The results suggest that management has been successful in creating a pleasant atmosphere within the mine. Furthermore, unlike comparable sites (Lee, 2015), this mine received positive ratings for both external accessibility—such as signage and parking—and internal accessibility, including ease of movement and descent.

Visitors also appreciated the diverse opportunities for sports and leisure activities. However, neutral ratings for several attributes highlight clear opportunities for improvement. Key areas for development include:

- Expanding on-site dining options.
- Introducing more cultural and religious activities.
- Improving the organization of the medical treatment area.

To preserve the high levels of visitor satisfaction, it is recommended that management avoids significant increases to visitor capacity, which could lead to overcrowding, and maintains reasonable pricing for all activities.

Furthermore, our analysis revealed several statistically significant differences in satisfaction based on socio-demographic characteristics, although their overall influence was less pronounced than anticipated. For instance, we found that gender had no significant effect on tourist satisfaction. This finding aligns with the work of Perović et al. (2012) but contrasts with Huete-Alcocer et al. (2019), who reported that women are generally more satisfied.

However, our study diverges from both Perović et al. (2012) and Huete-Alcocer et al. (2019) in concluding that age is a source of statistically significant differences. Specifically, younger tourists expressed greater satisfaction with the mine's organized activities than older visitors. We also found that education level can act as a satisfaction discriminant, contrary to Huete-Alcocer et al. (2019), with more highly educated visitors reporting greater satisfaction with the staff.

Finally, a visitor's place of residence proved significant. International tourists reported lower overall satisfaction than domestic visitors (including those from Cluj County). Foreign visitors also had higher expectations of the staff and, consequently, reported lower satisfaction levels in this area. These findings have critical implications for destination management and marketing. To enhance the mine's appeal to an international audience, managers must develop a deeper understanding of their specific needs and expectations.

The main limitations of this study are its modest sample size and constrained data collection period. Fieldwork was conducted over a brief timeframe, which did not capture potential variations in visitor demographics across different days, seasons, or times of day. As a result, the findings may have been influenced by atypical events during the survey period, and the sample is not representative of the general salt mine visitor population.

Despite these limitations, this research holds significant value as the first known study to directly measure tourist satisfaction with a salt mine visit. These pioneering results provide encouraging foundational insights and underscore the need for future research with longitudinal designs and larger, more diverse samples.

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EXTRACTIVE AND INCLUSIVE INSTITUTIONS IN AFRICA: THE CASES OF MADAGASCAR, MOROCCO, SENEGAL, AND BOTSWANA

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ABSTRACT. – Extractive and Inclusive Institutions in Africa: the Cases of Madagascar, Morocco, Senegal, and Botswana. The models of inclusive and extractive institutions within the economic and social systems of the countries are described by Daron Acemoglu, James Robinson and Simon Johnson in their works, rewarded with the Nobel Prize in Economics in 2024. The great majority of the states of Africa belong to the extractive model, with a weak state, a narrow elite dominating the institutions of power and spoiling the meager resources of the countries, which results in underdevelopment and chronic social and political instability, like in Madagascar. On the other hand, we have the inclusive model, with a strong state where the institutions are accomplishing their functions of security, protecting private property and enforcing a participative democracy, representing the best way into development and shared prosperity, like in Botswana. However, even in Africa each state is different, and various intermediary situations can be described between the two models, where the struggle between the power of the state and the power of society generates very particular cases, autocracy and democracy coexist in a peculiar combination at the top levels of power and this has also serious consequences on the economic and social situation of the peoples concerned, like in Morocco and Senegal.

Keywords: *Elites, Inclusive, Extractive, Cage of Norms, Corridor, Shackled Leviathan.*

As a geographer I had the opportunity to travel recently in several developing countries of Africa and Asia and compare their situation and way of life to that of the countries of Europe and North America that I have also visited.

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Besides the obvious and visible differences between the peoples' lives from developing and developed countries respectively, a staggering question remains to be answered: what is the cause of the significant differences between the living standards of some developing countries who are geographically situated on the same continent (Africa in this case) and shared a quite similar, if not common history in the last couple of centuries?

There is a very rich literature describing the causes and problems of economic development or underdevelopment of some countries. Among others, the best explanation I recently found was formulated in the writings of three winners (2024) of the Nobel Memorial Prize in Economic Sciences: Daron Acemoglu, Simon Johnson (both from the Massachusetts Institute of Technology) and James Robinson (from the University of Chicago). Since I visited Madagascar, Morocco and recently Senegal (but not Botswana yet), I thought about presenting in this study some of the aspects of their history and recent development that could justify their present situation or at least to which might partially apply the theories formulated by the above-mentioned authors.

WHY NATIONS FAIL

The first book of Acemoglu and Robinson is denying the theories according to which the differences in the development of the countries are firstly due to geographical, cultural or religious factors. One of the best examples is represented by the two parts of the town of Nogales, situated on the two sides of the USA/Mexico border, while the other is South and North Korea. In both cases the two sides are situated in the same geographic area, having identical geographic environments, natural and human resources and, until recently, sharing a common history and culture.

The difference between the two sides can only be explained by the essentially different institutions that were formed during the later evolution of the neighbouring countries. While the evolution of Nogales, Sonora illustrates the consequences of the Spanish colonial system in Latin America, Nogales, Arizona is an example of the development of former colonies in North America, inhabited mainly by Anglo-Saxon Europeans. The key factor lies in the institutional system that is very persistent and hard to change.

Economic prosperity is generated by free enterprise, where people can work and do business in similar conditions, creativity and innovation are encouraged, there is security, property is guaranteed and everyone can participate in the decisions concerning the communities. These conditions are provided only by a strong state, capable of making and enforcing laws and preventing abuses. This is what they call an *inclusive institutional system*.

On the other hand, those countries where a parasitic elite takes advantage of its political and institutional power, using it to extract the meager resources in order to maintain its dominance, without consideration for the development of the country and mercilessly exploiting the large majority of the population, are called *extractive institutional systems* (the authors are avoiding on purpose the term *exploitation* because of its Marxist connotation).

The theory is by no means a justification of colonialism, since Acemoglu and Robinson are underlining that the seeds of extractive institutional systems were in most cases spread by the European conquerors who installed typically extractive institutions of which many countries were not able to get rid until today.

As for Europe, the differences between East and West are to be looked for in the late Middle Ages, especially in the long-term effects of the Great Plague. In the West, the lack of manpower caused by the plague resulted in higher wages and the disappearance of serfdom, while in the East, where the death ratios caused by the plague were lower, the landlords reacted by reinforcing the exploitation of the peasants. The free workers later helped the blossoming of the Industrial Revolution in the western part of the continent, while in the eastern half a "second serfdom" became predominant by the end of the sixteenth century.

Africa was the part of the world with the institutions least able to take advantage of the opportunities made available by the Industrial Revolution. For at least one thousand years, Africa has lagged behind the rest of the world in terms of technology, political development, and prosperity. It is the part of the world where centralized states formed very late and very tenuously. Where they did form, they were likely as highly absolutist as in Egypt, in Morocco, in the Congo, in Zanzibar, or in Madagascar. How African institutions evolved into their present-day extractive form sharply illustrates the process of institutional drift punctuated by critical junctures, but with highly perverse outcomes, particularly during the expansion of the slave trade. Absolutism transmogrified from completely dominating societies, with extractive economic institutions that merely captured all the agricultural output of its subjects, to enslaving people en masse and selling them to traders in exchange for guns and luxury goods destined to the elites. Long distance trade opportunities thus created a critical juncture toward pluralistic political institutions in Europe, while they also extinguished any hope of absolutism being defeated in Africa, where the substantial profits to be had from slaving led not only to the intensification of slavery, but also to intense warfare and the destruction of many institutions. In this context, within a few centuries, any process of state centralization was totally reversed and many of the African states had largely collapsed.

Subsequent European colonialism not only threw into reverse nascent economic modernization in parts of southern and western Africa, but also cut off any possibility of indigenous institutional reform. This meant that even outside of areas such as Congo, Madagascar, Namibia and Tanzania, the areas where plunder, mass disruption and even whole-scale murder were the rule, there was little chance for Africa to change its institutional path (Acemoglu, D., Robinson, J., 2013).

Even worse, the structures of colonial rule let Africa with a more complex and pernicious institutional legacy in the 1960s than at the start of the colonial period. The development of the political and economic institutions in many African colonies meant that rather than creating a critical juncture for improvements in their institutions, independence created an opening for unscrupulous leaders to take over and intensify the extraction that European colonialists presided over. The political incentives these structures created led to a style of politics that reproduced the historical patterns of insecure and inefficient property rights under states with strong absolutist tendencies but nonetheless lacking any centralized authority over their territories. The Industrial Revolution has still not spread to Africa because that continent has experienced a long vicious circle of the persistence and re-creation of extractive political and economic institutions (*idem*).

THE NARROW CORRIDOR

The second book of D. Acemoglu and J. Robinson is further developing the idea that liberty has beneficial effects on economic development, at least on the long term, but this time the accent falls on the balance between political liberty (or the power of society, as they formulate) and the power of the state. For the latter, the authors are using Thomas Hobbes's metaphor of the biblical sea monster called Leviathan. This entity is as old as the states themselves, born at the beginning of each nation's history, each time when a new state is being created. The Leviathan does not appear from nothing or by no means is a divine creation, but is the result of the necessity of order, to prevent the state of *warre* (or anarchy, in another formulation), a situation of "war of all against all, of every man against every man, where life is nasty, brutish and short" (Hobbes, Th., 2012).

However, the authors do not agree with Hobbes's opinion about the necessity of absolute power of the state. On the one hand, they enumerate a series of examples of functional societies (like the Tiv from Nigeria) where the state never existed because the people there were reluctant to accept any kind

of political power, or it only existed nominally (like in Montenegro or Lebanon), and the relations between people were regulated by a strong set of traditional norms and intergroup agreements (this is what they call the *Cage of Norms*). So, it turns out that stateless societies are quite capable of controlling violence and putting a lid on conflict, though this does not bring much liberty. If we add here the societies (like in many African countries) where the state is so weak that practically it only exists on paper (the *Paper Leviathan*), these are forming a larger category called the "*Absent Leviathan*". On the other hand, there is a natural tendency of political power to abuse of its situation and evolve towards despotism. But this might does not make right, and it certainly does not make for liberty. Life under the yoke of the state can be nasty, brutish and short too, and this is what they call the *Despotic Leviathan*.

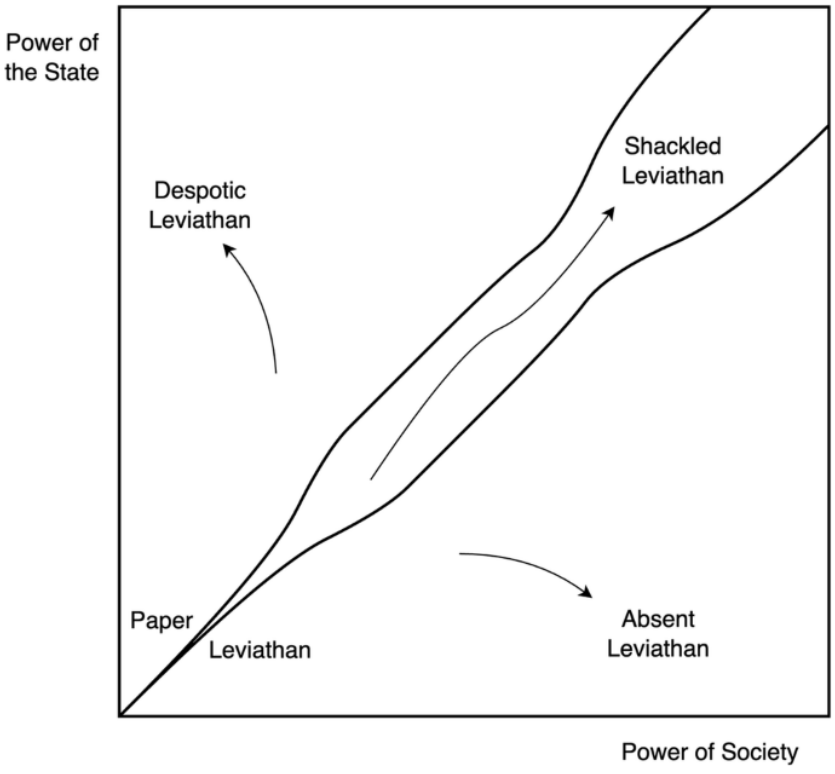

Fig. 1. The Narrow Corridor model
Source: Acemoglu, D., Robinson, J. (2019)

A very different type of Leviathan, a shackled one, emerges when there is a balance between its power and society's capacity to control it. The balance is the result of the constant struggle between the power of the state and the power of society, which are mutually "shackling" each other and generate the *Red Queen Effect* (another metaphor, taken this time from Lewis Carroll's book *Alice in Wonderland*), when this mutual control provides a stable and secure state that can resolve conflicts fairly, provide public services and economic opportunities, and prevent dominance, laying down the basic foundations of liberty. This is the Leviathan that people, believing that they can control it, trust and cooperate with and allow to increase its capacity. This is the Leviathan that also promotes liberty by breaking down the various cages of norms tightly regulating behavior in society, or shortly, the *Shackled Leviathan* (Acemoglu, D., Robinson, J., 2019).

The forces shaping the evolution of different types of society mentioned above can be represented on a simplified graphic model (in a system of two coordinates) illustrating the two main variables (Fig. 1): the horizontal axis shows *the power of society*, i.e. how powerful a society is in terms of its norms, practices and institutions, especially when it comes to acting collectively, coordinating its actions and constraining political hierarchy. The second (vertical) axis represents *the power of the state*. This is similarly combining several aspects including the power of political and economic elites and the power and capacity of state institutions. The cases where the first force is prevalent (the Absent Leviathan) are situated on the right /lower side, while the cases where the power of the state dominates (the Despotic Leviathan) appear on the left/upper side. The figure also shows that we can have capable states matched by capable societies. This happens in the *Narrow Corridor* in the middle where we see emerging the Shackled Leviathan. It is precisely in this corridor that the Red Queen Effect is operative, and the struggle of state and society contributes to the strengthening of both and can help maintain the balance between the two. The Red Queen – the race between state and society – does more than render both of them capable. It also reconfigures the nature of the institutions and makes the Leviathan more accountable and responsive to citizens. In the process, it transforms people's lives too, not just because it removes the dominance of states and elites over them, but also because it relaxes and breaks down the cage of norms, advancing individual liberty and enabling more effective popular participation in politics. Consequently, it is only in this corridor that true liberty emerges and evolves. Outside the corridor, liberty is curved either by the absence of the Leviathan or by its despotism (Acemoglu, D., Robinson, J., 2019).

The *Paper Leviathan* is a sort of state that is common in Latin America, Africa, and other parts of the world and is founded and supported by the weakness and disorganization of society. It combines some of the defining

characteristics of the Despotic Leviathan, in being unaccountable to and unchecked by society, with the weaknesses of the Absent Leviathan. It cannot resolve conflicts, enforce laws, or provide public services. The fragmented, ineffective nature of the Paper Leviathan has major consequences for liberty, in particular for the control of violence. Because of the way they use power, Paper Leviathans cannot have the monopoly of legitimate physical force as Max Weber defined it, this is why the state is just like "an orangutan in a tuxedo": the tuxedo is the outward appearance of an orderly state with a functioning bureaucracy, even if it is used for looting the country and is often disorganized, while the orangutan is all the things the Paper Leviathan cannot and does not wish to control. These are societies with enormous inequalities and hierarchy, where there is no room for a Weberian state. Rather the government is a tool for controlling power and the law an instrument for stabilizing this unequal status quo.

According to Acemoglu and Robinson, this is also the characteristic form of state in sub-Saharan Africa, where the mechanisms underpinning the continued weakness and disorganization of the state operate with a vengeance. There are several factors that cause this weakness. On the one hand, the dense web of norms, mutual obligations and the remnants of the supporting institutions from the colonial era lived on. This cage of norms heavily shaped how post-independence politics worked and created a social environment that perpetuated the Paper Leviathan, blocking society's ability to act collectively while at the same time stunting the state's capacity. The more the Paper Leviathan exploited the network of mutual dependences and ethnic ties, the more it reaffirmed the cage of norms that these created in many African societies. Another factor weakening both state and society is the arbitrary nature of postcolonial countries. The ethnic and religious diversity, the very different stages of development and types of social organization, the lack of cultural unity generated a state of incoherence where there was little societal mobilization, and this made it particularly attractive for leaders to make discretionary use of the state and the law to maintain power. In essence, Paper Leviathan formed in the terrain left by colonial empires, which created weak states and weak societies and a situation wherein both were likely to perpetuate each other (*idem*).

POWER AND PROGRESS

The third book of Daron Acemoglu (having this time Simon Johnson as co-author) emphasizes on the effects of technological development on social inequality and on the political power structures. According to the authors, shared prosperity emerged because, and only when, the direction of technological

advances and society's approach to dividing the gains were pushed away from arrangements that primarily served a narrow elite. We are beneficiaries of progress, mainly because our predecessors made that progress work for more people: most people around the globe today are better off than our ancestors because citizens and workers in early industrial societies organized and challenged elite-dominated choices about technology and work conditions, and forced ways of sharing the gains from technical improvements more equitably. However, progress is never automatic. Today's "progress" is again enriching a small group of entrepreneurs and investors, whereas most people are disempowered and benefit little. A new, more inclusive vision of technology can emerge only if the basis of social power changes. This requires the rise of counterarguments and organizations that can stand up to the conventional wisdom. Confronting the prevailing vision and wrestling the direction of technology away from the control of a narrow elite may even be more difficult today than during the glorious days of the Industrial Revolution (Acemoglu, D., Johnson, S., 2023).

Optimism regarding shared benefits from technological progress is founded on the idea of the "*productivity bandwagon*", meaning that new machines and production methods that increase productivity will also produce higher wages. As technology progresses, the bandwagon will pull along everybody, not just entrepreneurs and owners of capital. On the other hand, just how productivity benefits are shared depends on how exactly technology changes and on the rules, norms, expectations that govern how management treat workers. Productivity growth increases the demand for workers as businesses attempt to boost profits by expanding output and hiring more people, then the demand for more workers increases the wages that need to be offered to attract and retain employees. Unfortunately, neither step is assured, because what really matters to companies is *marginal productivity*, i.e. the additional contribution that one more worker brings by increasing production or serving more customers. Automation often raises average productivity but does not increase, in fact may reduce worker marginal productivity. So, productivity growth does not necessarily deliver broad-based prosperity. It will do so only when technologies increase worker marginal productivity and the resulting gains are shared between firms and workers, but these outcomes depend on economic, social and political choices. They can generate shared prosperity or relentless inequality, depending on how they are used and where new innovative effort is directed. In principle, these are decisions a society should make collectively. In practice, they are made by entrepreneurs, managers, visionaries, and sometimes political leaders, with defining effects on who wins and who loses from technological advances (*idem*).

THE CASE OF MADAGASCAR

The rivalry for colonies in Africa between the French and British peaked in the second half of the 19th century. However, before the construction of the Suez canal, France and the United Kingdom signed in 1862 an agreement concerning the future division of East Africa. According to this, the British recognized the priority of French interests in Madagascar, while the French ceded Zanzibar and the eastern coast of Africa to the British Empire. The French territorial claims in and around the Big Island resulted in the first Franco-Hova War in 1883 and the forced cession of the Malagasy territories situated North of the 16th paralel (Randriamamonjy, F., 2008).

The Berlin Conference of 1884/1885 sealed the fate of Madagascar (the French protectorate of Madagascar was already recognized by the British in 1890), resulting in the final conquest of the island by a French army in 1894-1895. A year later the Malagasy monarchy was abolished and Madagascar became a French colony. The colonial regime abolished slavery in Madagascar in 1896, but also introduced in 1901 the discriminative legal system of the *indigénat*, in order to control the individual and social life of the natives by severe administrative and punitive measures (Blanc, G., 2022).

Anticolonial resistance never ceased on the island. As a result, on June 26th, 1960, Madagascar proclaimed its independence. The first Malagasy Republic remained strongly attached to France by bilateral cooperation agreements, while its economy was substantially aided by the former colonial power. The dependance from France, perceived as neocolonial exploitation, eventually led to the fall of president Tsiranana in 1972, replaced by an army general, Gabriel Ramanantsoa, former prime minister, until 1975, when Didier Ratsiraka was declared president and chief of the government. Ratsiraka proclaimed the Democratic Republic of Madagascar (the second Malagasy Republic), of Marxist inspiration, establishing a political system on the Cuban model, with the unique party AREMA (Avantgarde of the Malagasy Revolution) and relying mainly on the Eastern Bloc for the functioning of the economy. The socialist experiment proved to be a total failure and in 1990 the government was forced to admit the access of private investors, not least in order to cease the famine affecting ever larger parts of the country. After new riots and political instability, a new Constitution was adopted in 1993 (the third Malagasy Republic), followed by the election of Albert Zafy as president. However, the economic and political liberalization did not produce the expected growth, so a new crisis and a deep conflict between the president and the parliament resulted in the destitution of Zafy and the election of Norbert Ratsirahonana as interim president.

In 1997 former president Didier Ratsiraka was reelected, this time sustained by the French government. A short period of economic stability (until 2001) followed, during which Madagascar's average annual growth rate was 4.3%. After a long political turmoil that put the country on the verge of civil war, the former mayor of Antananarivo Marc Ravalomanana was elected president in 2002, then reelected in 2006. In 2007 the Constitution was amended by referendum, allowing the president to rule by decree in case of emergency or catastrophe. On January 26th 2009 a new Malagasy political crisis began, started by the manifestations of the opposition in the capital city, under the leadership of mayor Andry Rajoelina, which resulted in violence and casualties (dead and wounded), caused by the intervention of the police and of the presidential guards. The final intervention of the army led to the resignation and escape from the country of president Marc Ravalomanana, the declaration of Rajoelina as interim president on March 18th and the suspention of both chambers of the parliament on March 19th. The second round of the postponed presidential elections was held in December 2013 with Hery Rajaonarimampianina as winner. In December 2018 former president Andry Rajoelina won the second round of the election, then in November 2023 he was re-elected to another term in the first round. In September 2025 (two weeks after similar events in Nepal), new manifestations against corruption erupted among the young people in the capital, resulting in more than 20 deaths. The president sacked prime minister Christian Ntsay and his government, than in October 2025 the army associated to the manifestants. President Rajoelina fled the country on a French military plane. On October 14th, colonel Michael Randrianirina declared having taken the power after the National Assembly voted the destitution of the president.

Just like in many other countries of Africa, rival factions of the elites in Madagascar, supported by foreign powers, are permanently fighting for power and periodically shifting each other at the top functions of the country. The Malagasy elite, associated by definition with the ruling class, has though remained the same on the whole in Madagascar since independence. It is made up largely of the *Andriana* and *Hova* bourgeoisie, which has inherited symbolic power (before colonisation for the *Andriana*, and before and during colonisation for the *Hova* who were responsible for managing public affairs). Members of the *côtier* high families have joined this group based on the place they had secured on the national scene as representatives of their region, among others, since the colonial period. This role of ethnic groups and castes in Malagasy society (despite their late 19th century abolition) is a persistently nagging question in the country's history. Access to elite status may stem more or less directly from parental lineage. In the case of Madagascar, there is clear evidence of a family-based elite social reproduction mechanism. Nearly half (46%) of the elites have

at least one parent who is (or was) a member of the elites. This phenomenon is more marked among the younger generations. With their investment in school and capacity for a level of education largely above the Malagasy average (including studying abroad), it is relatively easy for the children of elites to attain privileged positions in the different spheres of power. So it is not surprising to find the same family names since independence in the ruling class. There is no shortage of descendants of dignitaries of the First Republic in the political class. Granted, new names appear, but by and large an oligarchy made up of a bourgeois elite, including *côtier*, already in position following independence still holds an important place today. The elites who have a role in the political sphere differ in terms of their much higher rate of involvement in associations in general (87% vs. 81% on average), in hometown associations (67% as opposed to 46% on average) and in Freemasonry (14% compared with 11% on average). There is a specific link between associative participation and access to political power (Razafindrakotto et al., 2018).

The elites – especially political elites – consequently appear to be in a position to benefit from support and forms of legitimation by means of their membership in these circles. The elites in Madagascar form an extremely airtight world largely disconnected from the vast majority of the population. They use all the resources at their disposal to ensure their reproduction as a dominant group at the apex of the social hierarchy. If the system breathes at all, it is essentially internally (between the different spheres of power) as individuals juggle with a certain amount of give between one field and another. However, the elite world's borders are well guarded by strategies designed to limit and control newcomers' access to power. This modus operandi of preserving privilege is in itself already at odds with the principles of meritocracy and equal opportunities on which modern democratic societies are supposed to be founded. At the same time, this dominant class displays rather mixed attitudes to democratic principles. Although they join the population in criticising the poor successive leaderships, they look as if they are trying to extricate themselves somewhat from their share of responsibility, generally claiming other underlying reasons for Malagasy society's underdevelopment and deadlock: exogenous factors – colonial heritage and donor diktats – and the population's culture and reactionary mentality. Yet the main point of disagreement between elites and the rest of the population concerns the order of priorities on the political agenda. Although maintaining order counts most for the elites, the rest of the population prioritises improved living conditions for the poor. This discrepancy between the elite class's position and the wishes of the vast majority of the people is indicative of the divisions between these two groups. The situation is to the people's disadvantage in that the elites have the privilege of power and more easily influence which political

options are taken up. So by maintaining the social order's status quo, the elites have basically protected their status since the colonial period, if not the kingdoms, irrespective of the interests of the vast majority of the population (Razafindrakotto et al., 2018).

There is a remarcable contrast between the living standards of rural and urban areas of Madagascar, most of the former being characterized by extreme poverty, while in the cities, not very rich either, there is a visible class of nouveau riches who can afford almost European consuming patterns. These contrasts cause deep frustrations which, associated to the endemic corruption and indifference of the political leadership, is a permanent hotbed for political turmoil, errupting explosively in periodic uprisings, coups d'état and revolutions, while the economic and social situation of the masses does not change at all or sometimes even worsens. A relative calm was characteristic for the capital and its surroundings in November 2008 (while I was travelling there), but as it came out later, it was just the silence before the storm. Violent demonstrations, illegitimate power structures, disease (bubonic plague in 2014 and 2017, measles in 2019, Covid in 2020, botulism in 2025), catastrophic floods caused by tropical storms or extended drought in other regions, even locust invasions and famine were frequent if not chronic symptoms of Madagascar's crisis in the last decade. In 2021, Madagascar's worst drought in 40 years left more than a million people in southern Madagascar food insecure. This forced thousands of people to leave their homes to search for food.

The situation is aggravated by a demographic explosion which seems to be uncontrolled (the total population raised from 18.6 million in 2000 to 32 million in 2024) and has an increasing impact on the environment. All these facts sustain the positioning of Madagascar on the Narrow Corridor diagram below the corridor but somewhere close to the bottom left corner, as a typical case of Paper Leviathan, with a weak state controlled by corrupt elites and a weak society, dominated by divisions and superstitions, with a powerful cage of norms.

MOROCCO

Morocco was the only country in North Africa that was not conquered by the Ottomans in the 16th century. Several Arab-Berber dynasties ruled the kingdom, whose boundaries changed significantly during the ages. Nevertheless, the Atlas Mountains were always at the heart of this land finally fallen under French protectorate in 1912, except its northern province of If and the southern territories known today as Western Sahara, both overseas territories of Spain.

On March 2nd 1956 Morocco proclaimed its independence and one year later the last sultan from the Alaouite dynasty, Mohammed V, became the first king of Morocco, followed after his death in 1961 by his son Hassan II. The social unrest that started in 1965 with riots in Casablanca lead to the declaration of the state of exception until 1970. In the next years, after two failed coup attempts, the Constitution was modified, meaning the reinforcement of the monarchy and an even stronger influence of the royal family. In 1975, after the death of General Franco, the Spanish authorities abandoned their last colony of Rio de Oro (Western Sahara), which soon resulted in the occupation of the province by Morocco within the project called Green March.

Political reforms in the 1990s resulted in the establishment of a bicameral legislature with Morocco's first opposition-led government coming to power. King Hassan II died in 1999 and was succeeded by his son, Mohammed VI, a cautious moderniser who has introduced some economic and social liberalisation. During the 2011–2012 Moroccan protests, thousands of people rallied in Rabat and other cities calling for political reform and a new constitution curbing the powers of the king. In July 2011, the King won a landslide victory in a referendum on a reformed constitution he had proposed to placate the Arab Spring protests. Despite the reforms made by Mohammed VI, demonstrators continued to call for deeper reforms.

The changes of 2011 brought the separation of powers formally without affecting the power of the King, let alone the possibility of change at the top of power. Thus, the power structure remains intact: all powers and decisions start from the top and are delegated and granted. Indeed, the alternation was in the government and not an alternation in power, because in Morocco the power and its legitimacy reside in the person of the King, for that reason one cannot talk about the alternation of power. Despite the new constitution of 2011, the Moroccan monarchy has deployed a strategy of withering away and marginalizing political parties, while perpetuating a multi-party system that serves to maintain and consolidate its leadership. The multiple elections that have punctuated the political history of Morocco have provided a framework for the expression and renewal of the partisan field, carefully controlled by the Monarchy and devoid of any truly competitive dimension when it comes to the issues of appropriation of power. Political formations in Morocco have a more front-facing role in the service of the monarchy more than other functions, that is to say, to channel and regulate the political system on behalf of the monarchy. These political parties have agreed to continue to play the game of integration or co-option at the risk of weakening their social foundations and increasing their popular discredit; for the monarchy, to secure the support of partisan structures through a certain electoral legitimacy, to guarantee if not its hegemony at least its stability and survival (El Aalaoui, M., 2021).

The Moroccan power uses a carrot and stick approach to control the institutions of civil society and subordinate them to the state. The regime appoints loyalists as heads and directors of civic institutions, or other figures capable of managing civilian organizations, in a way that serves the interests of the political regime. The modernized traditional elites are represented by the sons as their fathers, they evolve at the crossroads of economics and politics. They assume proximity to the central power, that is to say to the palace. This elite is diverse by its origins, Makhzenian families, families of provincial notability, large religious families, families of the Istiqlal party, and by its type of linking to the Makhzen. Nevertheless, few members of these modernized traditional elites play an important role in the naturalization of Moroccan neoliberalism. They openly assume their link to the palace, they are explicitly part of this double relationship to power made up of legality and allegiance, even claiming the primacy of the latter. The members of these modernized traditional elites feel liberal and see themselves as Makhzenian. Most of them claim to be apolitical by the desire to distance themselves from political parties.

It is very likely, that the elites who prospered under the autocracy will resist normalizing the distribution of wealth and the democratization of political life, while democracy will remain incomplete. The Moroccan constitution reflects the will of the constituent to preserve the achievements of the traditional monarchy, by establishing the legitimacy of independent Morocco around the triptych God, the Nation and the King. Elections have failed to induce genuine political change in Morocco; however, they have been used as an instrument to reconstitute the existing political system. And besides, we are witnessing a stagnation in the production of the Moroccan political elite, in another way, the elections in Morocco only strengthen the elite, which stabilizes the Moroccan political regime in terms of change. Thus the constitutional changes in Morocco are only made to gain more support from Western powers and donors. We still live the recycling of traditional political elite system with colours of modernity and liberalism (*idem*)

These facts are determining the positioning of Morocco on the Narrow Corridor diagram above the corridor, as a case of a rather despotic regime, with a strong state controlled by the royal family but a quite weak society, even if formally a multiparty system with regular political elections, and still with a powerful cage of norms.

SENEGAL

After independence Senegal was largely relying on French trade and industry, while the president kept a French praetorian guard to ensure national security. Senghor refused to countenance a more rapid rate of Africanisation by allowing unqualified Africans to take over jobs from qualified Frenchmen. In Dakar the French population actually grew after independence. Despite French assistance, Senegal's economy remained largely stagnant, as demographic growth effectively canceled out the increase of the economy. At the same time Senegal became increasingly encumbered by external debt. Senghor steered through these difficulties with a mixture of compromise, coercion and pork-barrel politics. He kept the support of the Muslim Brotherhoods by providing marabouts with special favours, such as large loans and strategically placed development projects. He bought off political opponents by offering them government posts and material benefits. He reacted to student protests with strong arm tactics - tear gas and arrests. At the age of 74, Senghor announced his decision to resign in favor of his protégé, Abdou Diouf. Senghor thus became the first African leader since independence to give up power voluntarily. The tradition of multi-party politics he established in Senegal survived. In 1981 Diouf passed legislation allowing for the legalization of all political parties. He went on to win several elections until accepting defeat in 2000 (Meredith, M., 2011).

The presidential elections of March 19th 2000, won in the second round by the long time leader of the opposition, Abdoulaye Wade, brought the fall of president Abdou Diouf. Wade abolished the Senate and the Economic Council in 2000, then in 2001 succeeded in amending the constitution, reducing the presidential mandate from 7 to 5 years, dissolving the National Assembly and naming Mme Madior Bouaye as first female prime minister of Senegal in March 2001. Abdoulaye Wade, after being reelected as president in 2007, reestablished the Senate and a seven years presidential mandate in 2008. His liberal economic policy brought significant foreign investments into Senegal and spectacular investments in the infrastructures, but also resulted in the decay of the agriculture, the crash of several industrial sectors (like the chemicals' industry), a high unemployment rate, an increasing number of emigrants seeking refuge especially in the Canary Islands and a dependance on the Senegalese diaspora in covering the needs for foreign currency.

The opposition denounced on several occasions a drift into authoritarianism during the mandates of A. Wade, who presented himself for a third mandate in 2012, but was finally defeated by his former Prime Minister Macky Sall. The new president launched a series of institutional reforms in order to reduce government

spending and the corruption, creating a national antifraud and anti-corruption agency in 2012. The massive government investments resulted in a 6,8% economic increase in 2018, while the country became increasingly dependent on Chinese, Indian, and Middle Eastern capital. At the same time, the drift into authoritarianism did not cease: during his first mandate, the Constitution was amended ten times and the electoral law eighteen times. As a result, Macky Sall was reelected for a second term in 2019, then the Parliament abolished the office of Prime Minister between 2019 and 2022, installing a presidential form of government.

In March 2023, based on the opinion of the Constitutional Council of 2019, Macky Sall declared himself eligible for a third presidential mandate. His main opponent, Ousmane Sonko, mayor of Ziguinchor, was charged in 2021 with rape and murder threatening, and condemned in March 2023 to two years of prison. His conviction started a series of violent riots in the capital with several deaths and injuries, and resulted in his elimination from the list of eligible presidential candidates. In June 2023, president Macky Sall declared that he would not candidate in 2024 for a third term, sustaining as presidential candidate for the Benno Bokk Yakaar coalition Prime Minister Amadou Ba. In March 2024, opposition candidate Bassirou Diomaye Faye won Senegal's presidential election over the ruling coalition's candidate, becoming the youngest president in Senegal's history.

The present situation of Senegal allows the positioning of the country within the Narrow Corridor on the previously mentioned diagram, but close to the bottom left corner, as a state at the beginning of democracy, with a multiparty system that resisted until now to the authoritarian tendencies of its leaders and managed to change the president with democratic elections, where the state is strong but so is society, in spite of some weaknesses connected to corruption and subsisting traditional structures, characteristic for most of the African countries.

BOTSWANA

Bechuanaland, the territory situated north of the Cape Colony, became a British protectorate in 1885. By the 19th century there were eight Tswana states which had developed a core set of political institutions. These involved an unusual degree of political centralization and collective decision-making procedures that can even be viewed as a nascent, primitive form of pluralism. The political institutions of the Tswana, in particular the *kgotla,* encouraged political participation and constrained chiefs. The Tswana chieftaincy was not

strictly hereditary but open to any man demonstrating significant talent and ability. Though in appearance the Tswana had clear rules stipulating how the chieftaincy was to be inherited, in practice these rules were interpreted to remove bad rulers and allow talented candidates to become chief. So, winning the chieftaincy was rather a matter of achievement, but was then rationalized so that the successful competitor appeared to be the rightful heir. The Tswana chiefs continued in their attempts to maintain their independence from Britain and to preserve their indigenous institutions even under the protectorate. They would avoid both intense indirect rule and the far worse faith that would have befallen them had Cecil Rhodes succeeded in annexing their lands. This was the result of the interplay between the existing institutions, shaped by the institutional drift of the Tswana people and the critical juncture brought about by colonialism. The three chiefs who traveled to London in order to ask the protection of the British Empire had made their luck by taking the initiative and they were able to do this because they had an unusual degree of authority, compared to other tribal leaders of sub-Saharan Africa, owing to the political centralization the Tswana tribes had achieved, and perhaps they also had an unusual degree of legitimacy, because of the modicum of pluralism embedded in their tribal institutions (Acemoglu, D., Robinson, J., 2013).

Though at independence, in 1966, Botswana was one of the poorest countries in the world, today it has the highest per capita income in sub-Saharan Africa, and is at the same level as successful Eastern European countries like Estonia and Hungary, and the most successful Latin American nations, such as Costa Rica. Botswana was able to achieve this by quickly developing inclusive economic and political institutions after independence. Since then, it has been democratic, holds regular and competitive elections, and has never experienced civil war or military intervention. The government set up economic institutions enforcing property rights, ensuring macroeconomic stability, and encouraging the development of an inclusive market economy. This was possible because Botswana already had some amount of state centralization and relatively pluralistic tribal institutions that survived colonialism. Even though land was owned communally, cattle was private property in the Tswana states and elites were similarly in favor of well-enforced property rights. Things could have turned out very differently if it had not been so fortunate as to have leaders who decided to contest power in elections rather than subvert the electoral system, as many post-independence leaders in sub-Saharan Africa did. The management of natural resources in Botswana also differed markedly from that in other African nations when diamonds were discovered. Before the discovery was announced, president Khama instigated a change in the law so that all subsoil mineral rights were vested in the nation, not the tribe. This ensured that diamond

wealth would not create great inequities in Botswana. It also gave further impetus to the process of state centralization as diamond revenues could now be used for building a state bureaucracy and infrastructure and for investing in education (*idem*).

All these features allow the positioning of Botswana clearly in the Narrow Corridor, with a strong state controlled by a strong society, a typical case of shackled Leviathan, unique in Africa and also a remarkable example for the whole developing world.

CONCLUSIONS

Most of the sources mention the heritage of colonial system as one of the main causes of underdevelopment. However, their appearance and spread was based on the cooperation of the local elites, whether it started with the slave trade or simply by any kind of trade. The local potentates had usually no scruples when selling into slavery or mercilessly exploiting their subjects. On the contrary, they saw advantages for themselves and later the colonial regimes were primarily based on the cooperation of these elites. Most of these elites have survived until today and represent the link between the new nation states and their former colonizing countries. They are still dominating the countries' political systems and their main goal is to maintain their privileges, even if this means exploiting the people, being involved in corruption and electoral fraud or imposing dictatorships by force.

Fortunately the extractive model did not become a general pattern for all the developing countries, not even in the so-called third world, with a longer or shorter colonial history. Though the best examples of stable democracies with developed or fast developing economies (such as South Korea, Malaysia, Costa Rica, Chile, Uruguay etc.) are usually found outside Africa, the positive examples of Botswana, Namibia, Senegal, and recently Angola are giving hope for other countries too, Africa included. The recent spectacular economic growth and social progress of the emerging states (like India, Indonesia, Vietnam, Brazil or Mexico) are hopeful signs for a better future world, though the power of society in these states is often weak. We should not forget that things can always change for the worse, no matter if they are about political or social questions (like in Russia, Iran, Pakistan, Bangladesh, Sri Lanka, Myanmar, the D.R. of Congo, Nigeria, the Sahel states, Ecuador, Venezuela, and even Argentine) or just stay essentially unchanged for decades, even if periodically revolutions, civil wars or coups are shaking the whole system (like in Egypt, Algeria, Ethiopia, Peru, Bolivia, Afghanistan or Nepal).

Most of the former socialist countries of Eastern Europe are nowadays privileged EU members or candidates for membership, but this is by no means a guarantee for stable democracy with a strong state and a strong society. The example of Hungary is the most relevant in this sense. Once a leader in the demolishing of communist regimes and of the pro-democracy movement in Europe, Hungary is more and more drifting out of the Narrow Corridor, becoming a black sheep within the European Union. The populist Orbán government, installed for 15 years, is very successful in brainwashing the electorate, liquidating most of the checks and balances of power and weakening the rule of law. Furthermore, it is overtly speaking against European values with anti-Brussels slogans, shamelessly linking itself to authoritarian and anti-democratic regimes such as Russia or China.

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SPORTS IDENTITY, PERFORMANCE, AND EFFICIENCY IN WOMEN'S HANDBALL. CASE STUDIES: VIPERS KRISTIANSAND (NORWAY), CSM BUCUREȘTI (ROMANIA), AND GYŐRI AUDI ETO KC (HUNGARY)

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ABSTRACT. – Sports Identity, Performance, and Efficiency in Women's Handball. Case Studies: Vipers Kristiansand (Norway), CSM București (Romania), and Győri Audi ETO KC (Hungary). This study examines the sports identity, performance, and management efficiency of three leading European women's handball teams: Vipers Kristiansand (Norway), CSM București (Romania), and Győri Audi ETO KC (Hungary), during the 2018–2023 period. By analyzing their distinct strategies and outcomes, the research highlights how these teams achieved varying degrees of success through different approaches to recruitment, identity building, and operational management. Vipers Kristiansand demonstrated a clear identity centered on developing young, locally nurtured talent. The team maintained a stable coaching staff and fostered cohesion, which contributed to significant international achievements, including three Champions League titles. Despite these successes, financial mismanagement culminated in the team's bankruptcy in 2024, raising questions about long-term sustainability. CSM București, on the other hand, adopted an expensive strategy, investing heavily in internationally renowned players. While this approach ensured domestic dominance, a lack of managerial continuity and frequent roster changes diluted its sports identity and led to underwhelming results in European competitions. The club's inefficiency highlights the challenges of balancing

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high investment with tangible outcomes. Győri Audi ETO KC achieved balanced success, blending national talent with select international players to create a competitive and cohesive team. With a stable management structure and consistent performances in the Champions League, the Hungarian team exemplified how national pride and international aspirations can coexist effectively, culminating in a Champions League victory in 2019 and consistent Final Four appearances. The findings reveal that strong sports identity, effective management, and strategic performance planning are key to achieving sustained success in elite women's handball. The study offers valuable lessons for sports organizations across team sports, emphasizing that financial investment alone is insufficient without clear strategic alignment and operational efficiency.

Keywords: *sports identity, women's handball, management efficiency, performance metrics*

1. INTRODUCTION

In recent years, women's handball has become a major force in European sports, drawing in passionate fans, sponsors, and significant media attention. Unlike many other sports where female participation has lagged, women's handball is immensely popular across Europe, with national leagues playing a central role in countries like Norway, Romania, and Hungary. For these nations, handball is more than just a game; it's a symbol of national pride, sustained by major investments in talent development and elite competition. The European Handball Federation (EHF) ('EHF Competition Archive', n.d.) has been instrumental in promoting this sport, particularly through the EHF Champions League, where top teams compete on the continent's biggest stage. Among these elite clubs, Vipers Kristiansand from Norway ('Vipers Kristiansand', n.d.), CSM București from Romania ('CSM București (women's handball)', n.d.), and Győri Audi ETO KC from Hungary ('Győri Audi ETO KC woman handball team', n.d.) have emerged as leading contenders, dominating both their national leagues and international tournaments.

The success of these teams is not only due to athletic talent but also to their unique approaches to sports identity, performance measurement, and management efficiency (Wagner, Finkenzeller, Würth, & von Duvillard, 2014). Each of these teams has carefully constructed a distinct identity, utilized data-driven performance metrics, and adopted strategic management practices to build and maintain their competitive edge. This study examines the period from 2018 to 2023, exploring how Vipers Kristiansand, CSM București, and Győri Audi ETO KC balance these elements to achieve success. By focusing on these top European women's handball clubs, the research addresses a gap in sports studies, where most analyses have historically centered on men's teams, and aims to shed light on the unique dynamics of women's team sports.

Sports identity forms the foundation of a team's culture, cohesion, and public image. It encompasses the shared characteristics, values, and symbols that a team projects to its players, fans, and the broader community (Wagner et al., 2014). For elite women's handball teams, a strong identity is crucial for standing out in a crowded sports landscape and for fostering unity among players from diverse backgrounds (Prisacaru, 2011). Vipers Kristiansand, for example, emphasizes local, young talent, mirroring Norway's commitment to developing homegrown players. In contrast, CSM Bucureşti has taken a cosmopolitan approach, assembling a multinational roster that reflects Romania's ambitions on the global stage. Meanwhile, Győri Audi ETO KC has built an identity around a mix of Hungarian players and carefully selected international stars, achieving a balance between national pride and international competitiveness (Lock & Heere, 2017).

A cohesive sports identity not only strengthens internal team bonds but also plays a key role in recruitment. Athletes are often drawn to teams that align with their personal values and career goals. Vipers' focus on nurturing local talent, for instance, appeals to young Norwegian players who seek growth opportunities within a supportive environment. In contrast, CSM's international orientation attracts established players looking to join a high-profile team that values diversity and global recognition. Thus, a team's identity influences not just its internal dynamics but also its appeal to top-tier talent, impacting recruitment and retention (Lock & Heere, 2017).

Performance metrics, meanwhile, serve as essential tools for assessing and enhancing success. In women's handball, these metrics include scoring averages, defensive statistics, individual contributions, and team-level achievements like win-loss records and tournament titles (Gutiérrez & Ruiz, 2013). For elite teams in competitions like the EHF Champions League, performance metrics provide insights not only into past achievements but also into areas for improvement and strategic refinement. Coaches and managers use these statistics to evaluate specific aspects of performance, such as defensive success or shooting accuracy, and to make data-driven decisions about training, recruitment, and player development.

Metrics also reflect how effectively a team's identity translates into tangible results. For example, Vipers Kristiansand's focus on defense and teamwork might show up in metrics related to blocks and opponent scoring efficiency, while CSM Bucureşti's emphasis on offensive impact could be evident in scoring efficiency and high-impact plays from its international stars. By aligning performance goals with the team's identity, management creates a shared purpose that motivates players to excel in areas aligned with the team's values. Additionally, performance

data can be used predictively: if a team consistently underperforms in high-stress games, management might intervene with specialized training or mental conditioning to help players perform better under pressure.

Management efficiency is another crucial component of long-term success, especially in women's sports, where resources are often limited (Hemmestad & Jones, 2019). Efficient management encompasses recruitment strategies, financial planning, staff stability, and fostering a positive team culture. Each of the case study teams has taken a unique approach to maximize resources while staying true to its identity and competitive goals. Recruitment, for example, is not simply about acquiring talent; it's about finding players who align with the team's values and playing style. Vipers Kristiansand's strategy of focusing on young, local players not only supports a Norwegian identity but also lowers recruitment costs and strengthens community support (Hemmestad & Jones, 2019). On the other hand, CSM București's international recruitment approach elevates the team's profile, though it requires higher financial investment. Győri Audi ETO KC strikes a balance, combining Hungarian talent with a few international stars to maintain both local appeal and competitive strength.

Staff stability is also a vital aspect of management efficiency. Teams with consistent coaching and administrative staff are better positioned to develop long-term strategies and implement complex tactical systems. Frequent changes in leadership can disrupt team cohesion and lower performance as players struggle to adapt to new styles and expectations (Varzaru & Cojocaru, 2016). Financial management is equally important, as it dictates the quality of facilities, training resources, and support staff available to players. While Vipers achieves efficiency through its focus on player development rather than costly transfers, CSM's higher investment in top talent requires careful budget management to sustain the team's ambitions. A supportive organizational culture further enhances management efficiency, reducing burnout and improving player retention by creating an environment where athletes feel valued and motivated (Prieto, Gómez, Volossovitch, & Sampaio, 2016).

This study focuses on three leading European women's handball teams—Vipers Kristiansand, CSM București, and Győri Audi ETO KC-selected for their distinctive approaches to sports identity, performance, and management. Each team exemplifies a different philosophy in elite handball, making them ideal case studies for examining the interplay between these elements. Vipers Kristiansand emphasizes local talent development, aligning with Norway's focus on community and sustainability. CSM București's international approach highlights how a globally oriented identity can elevate a team's competitive profile, while Győri Audi ETO KC's balanced strategy combines national pride with international aspirations, appealing to both local and European audiences.

The main goal of this study is to analyze how sports identity, performance metrics, and management efficiency contribute to the success of elite women's handball teams in Europe. By examining Vipers Kristiansand, CSM București, and Győri Audi ETO KC, the research aims to reveal how different strategies impact performance outcomes. Beyond handball, these insights may provide valuable lessons for sports management in other team-based sports.

2. AIM, OBJECTIVES AND METHODOLOGY

The aim of this study is to explore the interplay between sports identity, performance metrics, and management efficiency in achieving high-level success in European women's handball. By analyzing the case studies of Vipers Kristiansand, CSM București, and Győri Audi ETO KC during the 2018–2023 period, the research seeks to identify the key factors and strategies that contribute to their varying degrees of success (European Handball Federation, n.d.; EHF Competition Archive, n.d.; Handball Base, n.d.; International Handball Federation IHF, n.d.; Sofascore, n.d.).

The specific objectives of the study are:

-To analyze the *sports identity* of each team, considering player recruitment strategies, age, height, and fame at the time of joining the clubs, as well as the influence of coaches.

-To evaluate the *performance metrics*, both individual and collective, achieved by each team during the analyzed period, in domestic and international competitions.

-To assess the *efficiency of management*, focusing on player retention, infrastructure quality, audience engagement, and financial strategies.

-To *compare and contrast the strategies* adopted by the three teams and their outcomes to derive lessons applicable across women's team sports.

The methodology employed a comparative case study approach, focusing on the three elite teams. Quantitative data, such as the number of medals won, player turnover rates, and individual achievements, were combined with qualitative analysis of management strategies and team identities. Sources included official team statistics, European Handball Federation (EHF) reports, media coverage, and scholarly literature (Balint Elena, 2020; Gutiérrez & Ruiz, 2013; Hemmestad & Jones, 2019; Lock & Heere, 2017; Shilbury, Popi Sotiriadou, & Christine Green, 2008; Varzaru & Cojocaru, 2016; Varzaru Cristina & Manescu Cătălin Octavian, 2023). Descriptive statistics, along with statistical and graphical tools, were used to highlight correlations between identity, performance, and management practices, providing a comprehensive understanding of how these elements interact to influence success (Sotiriadou, Brouwers, & Le, 2014).

3. RESULTS

European women's handball has been dominated in recent years by a few teams whose sports performances are remarkable, both nationally and in international competitions. Among the most prestigious women's handball teams, based on their success in national and European competitions (or reaching the advanced stages of European tournaments), the following stand out: Brest Bretagne Handball and Metz Handball (France), Győry Audi ETO KC and FTC–Rail Cargo Hungaria (Hungary), Team Esbjerg, Handball Club Odense, Viborg HK, and Herning Håndbold (Denmark), Vipers Kristiansand and Larvik HK (Norway), CSM București and CS Rapid București (Romania), Krim Mercator Ljubljana (Slovenia), SG BBM Bietigheim (Germany), RK Podravka Koprivnica (Croatia), ŽRK Budućnost T-Mobile (Montenegro), and Handball Club Rostov-Don (Russian Federation—this team, like all other Russian sports teams, has been excluded from European competitions over the past three years due to the Russian Federation's military invasion of Ukraine).

Among these, teams with outstanding performances during the analyzed period (2018–2023) include *Vipers Kristiansand* (Norwegian champions in 2019, 2020, 2021, 2022, and 2023; winners of the Norwegian Cup in 2019, 2020, 2021, and 2023; winners of the Champions League in 2021, 2022, and 2023; and third place in the Champions League in 2019), *Győry Audi ETO KC* (Hungarian champions in 2019, 2022, and 2023; runners-up in the Hungarian championship in 2021; winners of the Hungarian Cup in 2019 and 2021; runners-up in the Hungarian Cup in 2022 and 2023; winners of the Champions League in 2019 and 2024; runners-up in the Champions League in 2022; semifinalists in the Champions League in 2021; and third place in the Champions League in 2023), and *CSM București* (Romanian champions in 2021 and 2023; runners-up in the Romanian championship in 2019 and 2022; winners of the Romanian Cup in 2019 and 2022; runners-up in the Romanian Cup in 2021; winners of the Romanian Supercup in 2019 and 2022; runners-up in the Romanian Supercup in 2020 and 2021; and consistent participants in the advanced stages of the Champions League, a competition they won in 2016).
The performances of these three European women's handball teams justify their selection as case studies for this material, aimed at explaining their undeniable achievements on both national and European levels. Despite their differing approaches to managing sports competitions and achieving success (Figure 1), their results stand out as exemplary.

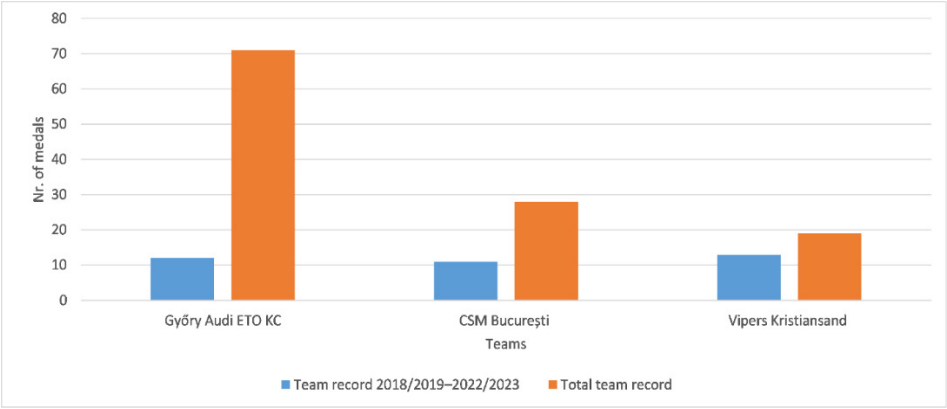

Fig. 1. The Achievements (Number of Medals Won) of Vipers Kristiansand, Győry Audi ETO KC, and CSM București Between 2018–2023 and in Total.

If we refer strictly to the data presented in Figure 1, we could assert that the most successful team among the three analyzed is Győry Audi ETO KC, with a total of 71 medals throughout its history (12 of which were earned during the analyzed period, 2018–2023). In second place is CSM București, with a total of 28 national and European medals (11 medals earned during 2018–2023). Lastly, Vipers Kristiansand ranks third, with only 19 medals overall (13 of which were earned in the analyzed period).

This approach, however, is simplistic and has limited relevance to our topic, as the Norwegian team Vipers Kristiansand has won the most medals (13) and the most prestigious ones during the analyzed period, securing three European titles (2021, 2022, and 2023) in the most prestigious European competition, the EHF Champions League ('Vipers Kristiansand', n.d.).

Hungarian team Győry Audi ETO KC is in second place with 12 medals, some of which are of European significance, including winning the EHF Champions League in 2019, finishing second in 2022, and taking third place in 2023. Its achievements are further reinforced by winning the EHF Champions League in the current competition year (2024) ('Győri Audi ETO KC woman handball team', n.d.; 'Győri ETO KC', n.d.).

Finally, the Romanian team CSM București ('CSM București (women's handball)', n.d.) ranks third in this regard, lacking any notable European performance during the analyzed period. Despite consistently reaching the advanced stages of the EHF Champions League every competition year, its last major European achievement was winning the prestigious trophy in 2016.

Therefore, we can conclude that Vipers Kristiansand has shown the most significant progress in recent years in terms of efficiency, performance, and sports management, with its performance indicators reaching superior levels.

The Hungarian team, Győry Audi ETO KC, has maintained relatively high sporting standards, while the Romanian team, CSM București, has been the least efficient in this regard during the analyzed period.

Starting from this observation, our comparative analysis considers three main indicators: sports identity, sports performance, and management efficiency, for the period 2018–2023, in the case of the three women's handball teams. We aim to argue and justify the fact that sports success (both nationally and internationally) is directly related to these three important factors. Each factor's quantification is based on a series of relevant elements from our perspective.

Thus, we analyze sports identity based on the following indicators (Lock & Heere, 2017):

1. The number of players recruited during 2018–2023 and their origin (from countries with strong women's handball traditions or from countries less familiar with the sport);
2. The players' age at the time of joining the club;
3. The players' height;
4. The players' fame (their global recognition and market value at that time);
5. The origin and fame of the coaches.

Sports performance is assessed through the analysis of the following indicators (Balint Elena, 2020):

1. The players' performance (medals won) with previous teams;
2. Individual achievements prior to joining one of the three analyzed clubs (individual medals won before their transfer);
3. Team and individual performances (of players and coaches) with the analyzed teams during 2018–2023.

Management efficiency is determined by the performance management strategies (Parent & Chappelet, 2017) adopted by the administrative staff of the three clubs. From our perspective, this is based on additional indicators, such as:

1. The duration of players' stays at the analyzed club (player and coach turnover rate);
2. The quality of the club's infrastructure;
3. The capacity of the sports hall where the team competes and the number of spectators attending events hosted on home ground;
4. The budget allocated for investments or the salaries of players and coaches (the latter two indicators are subject to strict confidentiality clauses, which may limit the accuracy of the information).

The three indicators mentioned above will be analyzed comparatively for the three teams considered as case studies and for the analyzed period (2018–2023), in order to highlight different approaches regarding actions and involvement on multiple levels, all aimed at a common goal: achieving sports performance, both nationally and especially at the European level.

Thus, the sports identity of the three teams is analyzed from the perspective of the following relevant indicators: the number of players and their country of origin, their age at the time of joining the club, the players' height and fame, as well as the country of origin and fame of the coaches.

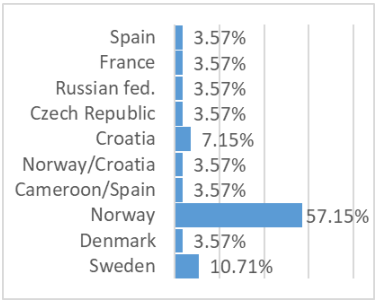

Fig. 2. Vipers Kristiansand: Players' Distribution by Country of Origin (2018–2023)

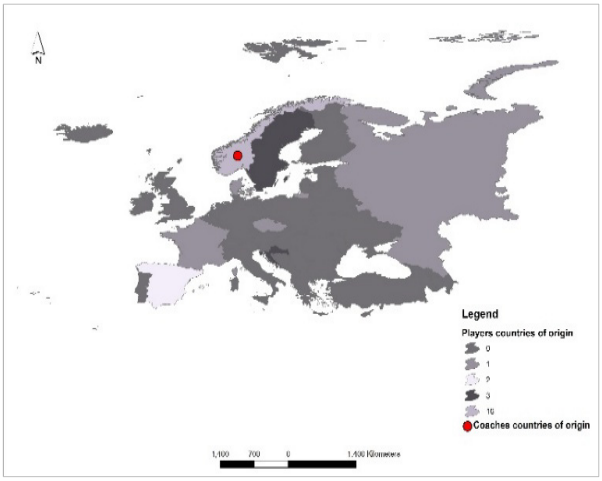

Fig. 3. Vipers Kristiansand: Origins of Players and Head Coaches (2018-2023).

The most efficient team (among the three analyzed), from the perspective of the number of players utilized during the analyzed period (2018–2023), is Vipers Kristiansand (Norway), with only 28 players. This demonstrates stability and complete trust in its roster (Figure 2). All players belonging to the team are from Europe (with only one player holding dual nationality, Cameroonian-Spanish), and more than half (57.15%) are from the home country, which is the leading global force in women's handball. Additionally, youth and junior clubs in Norway are numerous and very well-organized.

The European countries best represented in the analyzed team are Sweden (10.71%) and Croatia (7.15%), while players from other countries account for 3.57% of the total each, namely Spain, France, the Russian Federation, Czechia, Norway/Croatia, Cameroon/Spain, and Denmark.

The analyzed team is the most selective (compared to the other two) regarding the number of players recruited, focusing primarily on players from the domestic league, which is exceptionally strong on the European stage. Additionally, Vipers Kristiansand's philosophy emphasizes using young players from the domestic league who can develop alongside foreign players with proven records at national, European, and world levels.

The Romanian team, CSM București, utilized the highest number of players during the analyzed period, a total of 54, compared to the other two teams, yet achieved the weakest international results. From this perspective, it can be stated that it is the least efficient team, as its player recruitment policy has not been successful in achieving international performance.

Notably, it has the lowest share of domestic players (46.29% of the total) and has recruited foreign players from a greater number of countries, although all these countries are European and well-regarded globally in women's handball (Figures 4 and 5).

While the previous team shows a clear preference for recruiting players from the Nordic and Western regions of Europe, CSM București does not exhibit such specific regional targeting. Instead, players are brought in from all European countries with well-developed handball programs.

Notably, Montenegro accounts for 9.25% of the total players, followed by France, Norway, and Sweden (each with 7.40%), the Netherlands (5.55%), and Serbia (3.70%). The remaining players, each representing smaller shares of 1.85%, come from Norway/Sweden (dual citizenship), Spain/Portugal (dual citizenship), Spain, Slovenia, Croatia, Bulgaria/Slovakia (dual citizenship), and the Russian Federation.

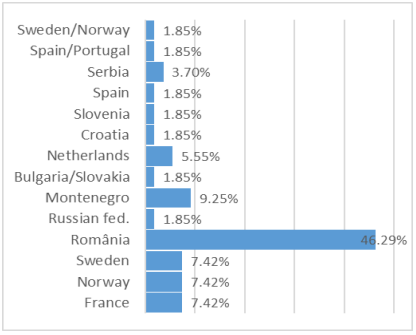

Fig. 4. CSM București. Players' Distribution by Country of Origin (2018–2023).

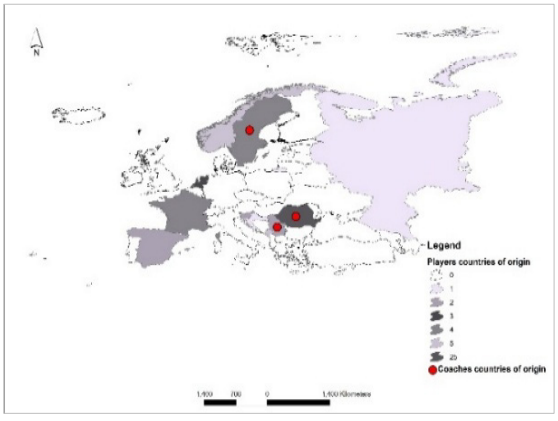

Fig. 5. CSM București. Origins of Players and Head Coaches (2018-2023).

The main source of players for the team is Hungary, which is perfectly natural for a team representing the country, especially considering the notable performances of Hungarian club teams and national teams in this sport over recent decades. During the analyzed period, 41.88% of the players came from Hungary. The remaining European players originated from countries where handball is recognized as a national or highly important sport, with remarkable results achieved by teams from those nations. Specifically, 13.96% of Győry Audi ETO KC players came from Norway (a multiple world, European, and Olympic champion in women's handball), 9.31% from France (whose international results in this sport are nearly comparable to Norway's), 6.98% from Denmark (another country with outstanding international handball performance), and 4.65% each from Montenegro, the Netherlands, and Sweden (all with tradition and significant achievements on the international stage).

The Hungarian team, Győry Audi ETO KC, utilized 43 players during the analyzed period, originating from 13 countries, 11 of which are European and two non-European (Figures 6 and 7).

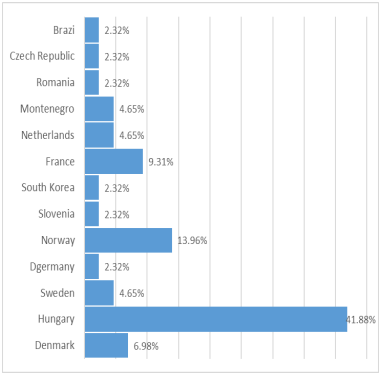

Fig. 6. Győry Audi ETO KC. Players' Distribution by Country of Origin (2018-2023).

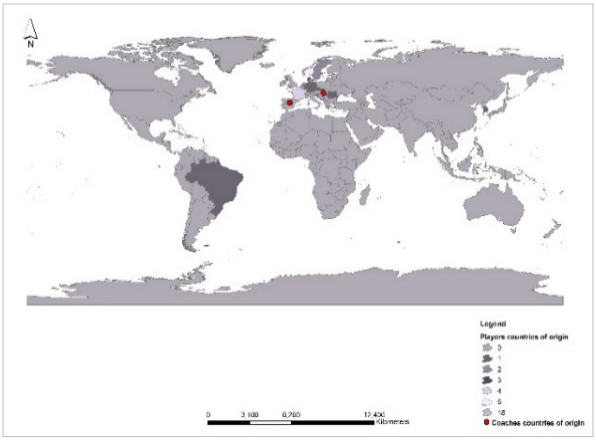

Fig. 7. Győry Audi ETO KC. Origins of Players and Head Coaches (2018-2023).

With shares of 2.32% each, players came from the Czech Republic, Romania, Slovenia, and Germany (countries also known for strong club teams, long-standing traditions, and notable international results in women's handball). The only non-European players came from two countries, Brazil and South Korea, which, alongside the European countries mentioned above, rank highly on the

global hierarchy in terms of tradition and international results in this sport. Thus, it can be deduced that the Hungarian team has a very rigorous selection pool, favoring players from countries with certified traditions and international results in women's handball, both at the club and national team levels.

Based on this first indicator defining sports identity, namely the number of players recruited during 2018–2023 and their country of origin, a ranking of the three analyzed teams can be established. Thus, Vipers Kristiansand (Norway) ranks first, as it utilized the fewest players (28/5 seasons), most of whom were from its home country, and achieved the most notable performances in European competitions. The second place is held by the Hungarian team, Győry Audi ETO KC, which, despite recruiting a large number of players (43/5 saesons), achieved significant performances at the European level (maintaining a positive trajectory as the Champions League winner in 2024). Lastly, CSM București is undoubtedly ranked last, as it relied on the highest number of players (54/5 seasons), sourced from across Europe's handball-strong countries, yet achieved the weakest performances in European competitions.

Another indicator we considered for analyzing the sports identity of the three European women's handball teams is the age of the players at the time of joining the club, which is relevant for determining the identity of the analyzed handball clubs from this perspective (whether they prefer young, promising players or experienced, established ones). We believe this indicator is more expressive when analyzed in correlation with two other performance-related indicators:

The performances of the players prior to joining one of the three clubs (the number of medals won with their previous teams).

The players' individual achievements before joining one of the analyzed clubs (the number of individual medals won prior to their transfer).

For Vipers Kristiansand, the average age of players at the time of joining the club was 24.82 years, which is relatively young for top-level performance. Most players who signed with the club, specifically 15 (53.58% of the total), were aged between 20–25 years, 6 players (21.43%) were 30 years or older, 4 players (14.28%) were aged 26–30, and 3 players (10.71%) were under 20 years old.

Despite this, the subsequent performances achieved by the team (2018–2023) were remarkable and superior to the other two analyzed teams, demonstrating that the club's management decisions were correct and well-inspired.

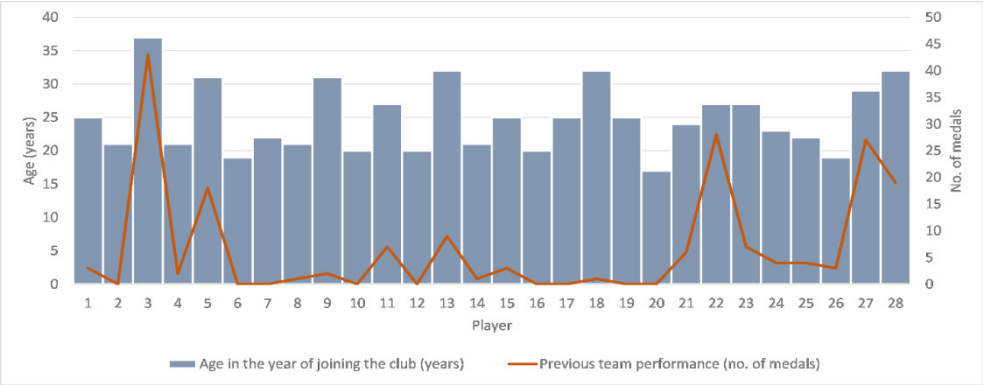

Fig. 8. Vipers Kristiansand: Players' Age at the Time of Joining the Club and the Number of Medals Won with Previous Teams.

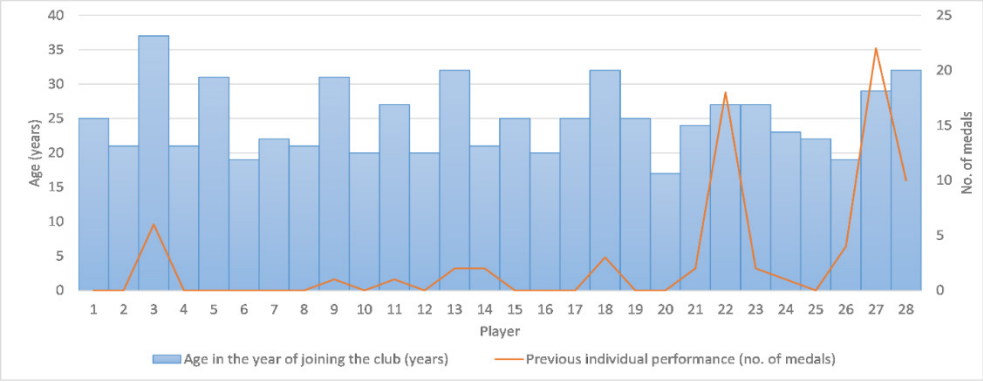

Fig. 9. Vipers Kristiansand: Players' Age at the Time of Joining the Club and the Number of Individual Medals Won Prior.

The players who were part of Vipers Kristiansand during 2018–2023 had an average of 6.71 medals per player at the time of joining the club (achieved with their previous teams), with a total of 188 medals won with prior teams—the lowest number of such medals among the three analyzed teams (fig. 8). In other words, Vipers Kristiansand primarily recruited young and promising players who did not have an impressive track record at the time of joining the club. This observation is further supported by the number of individual medals earned before joining, which totalled 74, lower than for the other two analyzed teams (Figure 9).

Thus, during the analyzed period (2018–2023), Vipers Kristiansand recruited young players, most of whom were aged between 20–25 years and had previous performances (both team and individual) that were inferior to those of the other two analyzed teams. However, during the same period, the Norwegian team achieved the most significant European performances, allowing us to rank it first from this perspective as well.

A completely different approach from that of Vipers Kristiansand is observed in the case of the Romanian team CSM București, which, during the 2018–2023 period, recruited much more accomplished players (with more medals won both with their previous teams and individually). However, despite this, the team's international performances during the analyzed period are the weakest compared to the other two analyzed teams, even though it was the most successful team in Romania's domestic handball competitions.

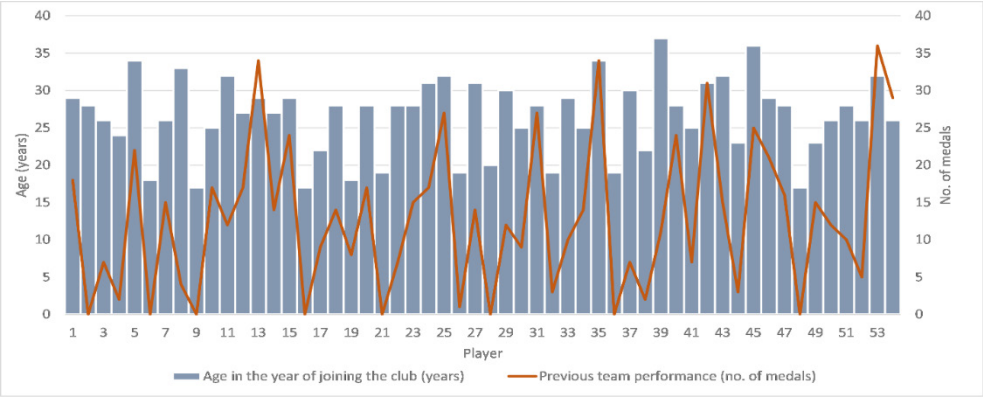

Fig. 10. CSM Bucuresti: Players' Age at the Time of Joining the Club and the Number of Medals Won with Previous Teams.

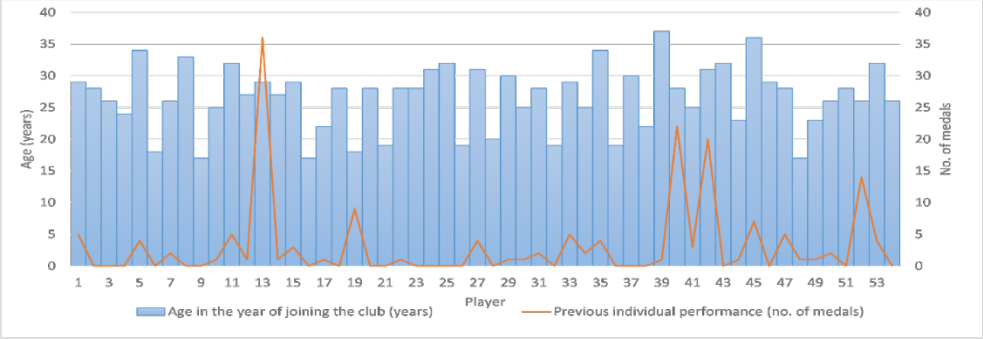

Fig. 11. CSM Bucuresti: Players' Age at the Time of Joining the Club and the Number of Individual Medals Won Prior.

The average age of players at the time of joining CSM București (2018) was 26.54 years, approximately two years older than the average age of players at Vipers Kristiansand and about 1.5 years older than those at Győry Audi ETO KC. The average age range of 25–30 years is considered by specialists to be the most suitable for achieving high-level sports performances, as players are at their peak physical condition. Of the 54 players who played for CSM București during the 2018–2023 period, the majority were aged between 26–30 years (22 players, or 40.74% of the total) at the time of joining. A total of 12 players (22.22%) were over 30 years old, another 11 players (20.37%) were aged 20–25, and 9 players (16.67%) were under 20 years old. In other words, the managers of CSM București preferred to transfer mature and well-known players in the world of European and international women's handball, with significant prior achievements, both individually and with their previous teams (e.g., Cristina Georgiana Neagu, Grâce Zaadi Deuna, Amanda Kurtović, Nora Mørk, Andrea Lekić, etc.).

The majority of players had an impressive track record at the time of signing contracts with CSM București. Collectively, they held 693 medals won with their previous teams and 169 individual medals (Figures 10 and 11). A total of 30 players had won more than 10 medals each with their previous teams, while 4 players had earned over 10 individual medals prior to joining. CSM București invested significant sums in transferring a large number of players and paying their salaries, aiming to achieve notable performances in European competitions such as the Champions League. However, the results achieved on the international stage were disappointing. While CSM București has been and continues to be the most successful team domestically (multiple-time Romanian champion and winner of the Romanian Cup and Supercup in women's handball), its European results have been insignificant. This highlights an inefficient, if not flawed, management approach. Based on the analysis of these correlated indicators, CSM București must be placed last among the analyzed teams for the 2018–2023 period.

Based on the values of these analyzed correlated indicators—namely the age of players and their previous performances (both team and individual)—the Győry Audi ETO KC team occupies an intermediate position among the three analyzed teams for the 2018–2023 period. The average age of the 43 players who were part of this club during 2018–2023 was 25.04 years, lower than the average age of CSM București players and higher than that of Vipers Kristiansand players. The majority of players at the time of signing with this team—18 players (41.87% of the total)—were aged between 26–30 years. Next was the under-20 age group, which included 11 players (25.58%), followed by the over-30 age group (8 players, 18.60%) and the 20–25 age group, with 6 players (13.95%). From the perspective of player selection correlated with their age at the time of

joining the club, Győry Audi ETO KC seems to have adhered most closely to the conventions common in team sports, with the most balanced age group proportions among all three teams analyzed in this study.

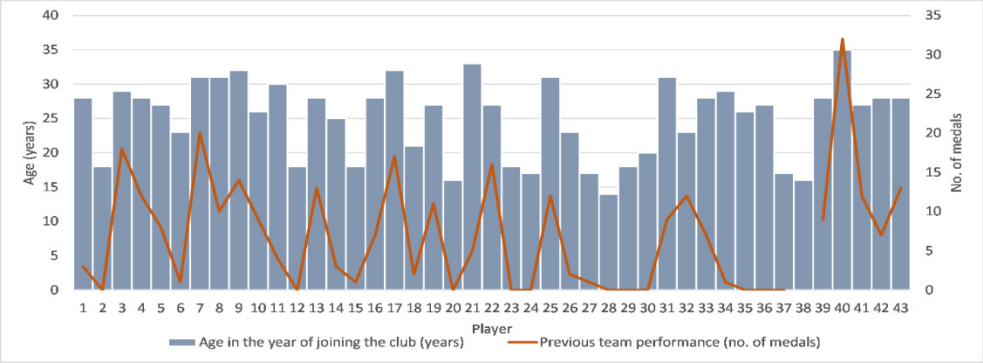

Fig. 12. Győry Audi ETO KC: Players' Age at the Time of Joining the Club and the Number of Medals Won with Previous Teams.

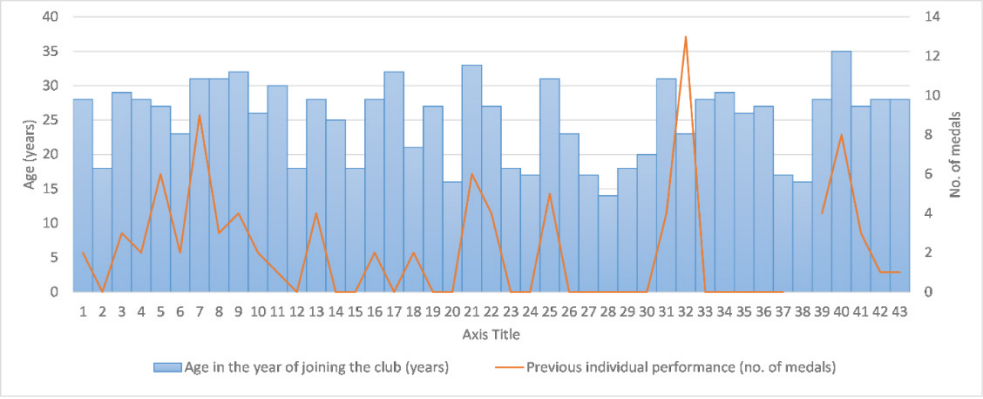

Fig. 13. Győry Audi ETO KC: Players' Age at the Time of Joining the Club and the Number of Individual Medals Won Prior

The players who joined Győry Audi ETO KC by 2018 collectively held a total of 291 medals won with their previous teams and 91 individual medals earned prior to joining (fig. 12 and 13). From this perspective, the team ranks in the middle—behind CSM București but ahead of Vipers Kristiansand. With these players, Győry Audi ETO KC achieved notable performances in both domestic and international competitions during the 2018–2023 period, surpassing CSM București in terms of overall achievements but falling behind Vipers Kristiansand regarding performances in European women's handball competitions. Most of

the recruited players excelled primarily with their previous teams (14 players had won at least 10 medals each with their former teams) rather than individually, as only one player, Eduarda Idalina Amorim Taleska, had more than 10 individual medals prior to joining.

Therefore, based on the correlated indicators analyzed above (the age of players at the time of joining the club and their prior team and individual achievements), the most effective identity model is that of Vipers Kristiansand. During the 2018–2023 period, the team primarily recruited young, promising players with few prior achievements, with whom it won the most prestigious European women's handball trophies in these competitive seasons (2018–2023). The team with the most ambiguous identity and the least performance was CSM București, which brought in a large number of players (without a well-defined player profile) from many European countries, renowned in European and global sports (both at the team and individual levels). However, with these players, the team failed to achieve any noteworthy European success, with its only accomplishments being in domestic competitions. In second place is the Hungarian team Győry Audi ETO KC, which, for the analyzed period, recorded reasonable European performances and significant domestic achievements, with players less established than those of CSM București but more experienced than those of Vipers Kristiansand. However, this team excelled in 2024, once again winning the most important European women's handball competition, the Champions League.

Another relevant indicator for achieving sports performance, considered as such by most sports analysts, is the height of athletes, as competitions are becoming increasingly athletic. In other words, there is a direct connection between athletes' height and sports performance, although no optimal height has been identified for success in women's handball or any other individual or team sport.

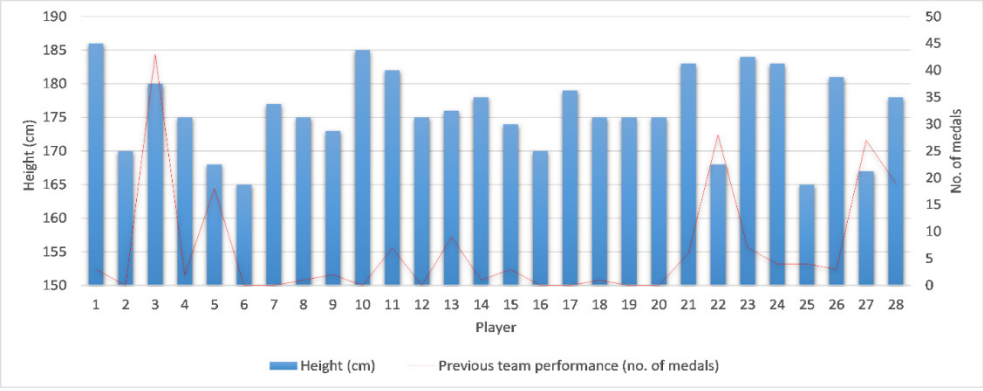

Fig. 14. Vipers Kristiansand: Players' Height at the Time of Joining the Club and the Number of Medals Won with Previous Teams.

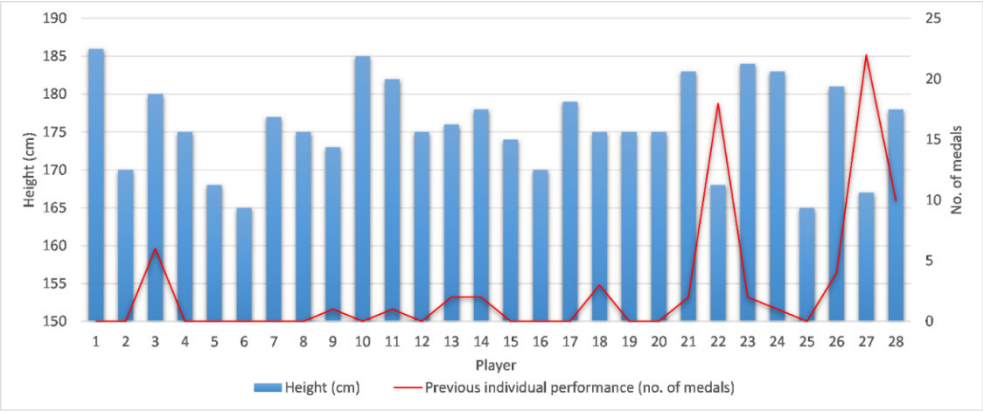

Fig. 15. Vipers Kristiansand: Players' Height at the Time of Joining the Club and the Number of Individual Medals Won Prior.

The players who competed for Vipers Kristiansand during the 2018–2023 period had an average height of 175.78 cm, the lowest among the analyzed teams. Despite this, the team achieved the most significant international performances. The largest group of players (16 players, or 57.14%) fell within the height range of 170–180 cm. This was followed by players measuring 181–190 cm (7 players, or 25.00% of the total), and those under 170 cm (5 players, or 17.86%). None of the players in the team during this period exceeded 190 cm in height. Thus, we can deduce a sports identity for Vipers Kristiansand from this perspective as well, favoring medium-height players who possess exceptional motor abilities.

A possible correlation between players' height and team and individual sports performance (Figures 14 and 15) shows that the most successful players prior to joining this club (with the highest number of team and individual medals) were those whose height ranged between 160–180 cm.

In conclusion, Vipers Kristiansand has a well-defined sports identity, focusing on recruiting young, medium-height players with moderate prior achievements but exceptional athletic potential and a strong drive for continued success.

The analysis of the same indicator for the other two teams, namely CSM Bucureşti and Győri Audi ETO KC, reveals approximately similar coordinates. The conclusion is that, from the perspective of the players' height, correlated with previous team and individual performances, these three clubs display a comparable sporting identity, while still showing a few minor differences.

For CSM Bucureşti, during the analyzed period, the average height of the 54 players was 176.92 cm, with the dominant group being players measuring 170–180 cm (24 players, or 44.44%). Notably, there was only one player taller

than 190 cm, the Romanian pivot Crina Elena Pintea (192 cm), who played for the club during two different periods within the analyzed timeframe.

As in the previous case (referring to Vipers Kristiansand), the most successful players of CSM Bucureşti (with the highest number of team and individual medals earned prior to joining the club) were those in the height range of 170–180 cm (Figures 16 and 17).

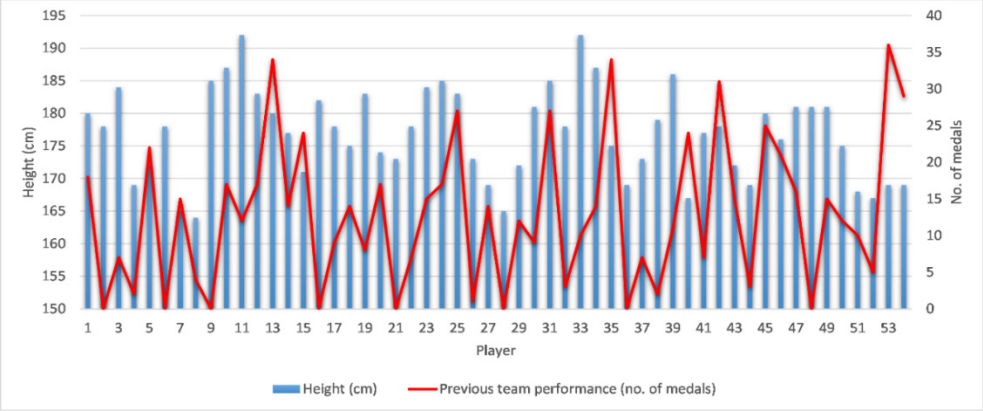

Fig. 16. CSM Bucureşti: Players' Height at the Time of Joining the Club and the Number of Medals Won with Previous Teams

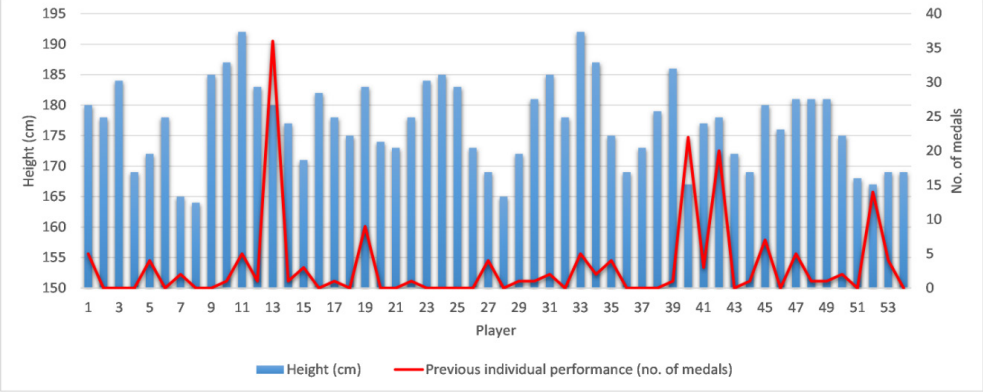

Fig. 17. CSM Bucureşti: Players' Height at the Time of Joining the Club and the Number of Individual Medals Won Prior.

The analysis of Győry Audi ETO KC from the perspective of the same indicator confirms the trend observed in the previous teams, although the average height of the 43 players who competed during 2018–2023 was higher, at

177.95 cm, compared to the others. Players in the 170–180 cm height range dominated, totaling 23 players (53.49% of the total), followed by those in the 181–190 cm range, with 11 players (25.58%). The same player, Crina Elena Pintea, was the exception, standing at 192 cm, and played for this team during two separate periods within the analyzed timeframe.

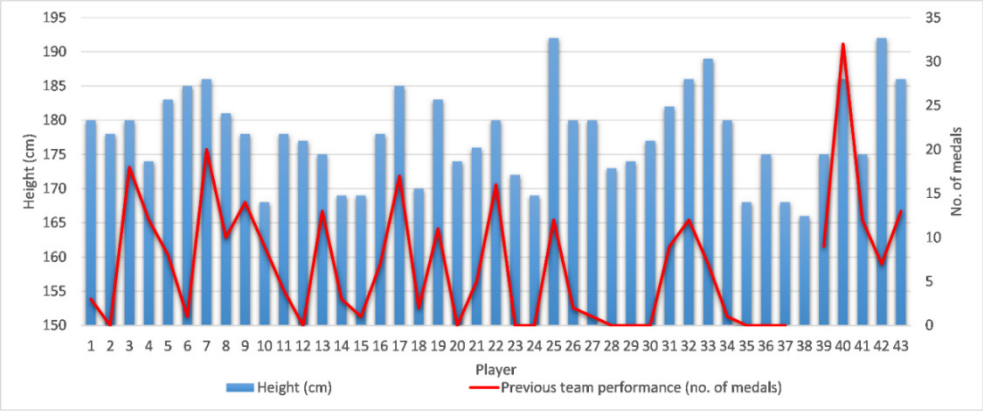

Fig. 18. Győry Audi ETO KC: Players' Height at the Time of Joining the Club and the Number of Medals Won with Previous Teams.

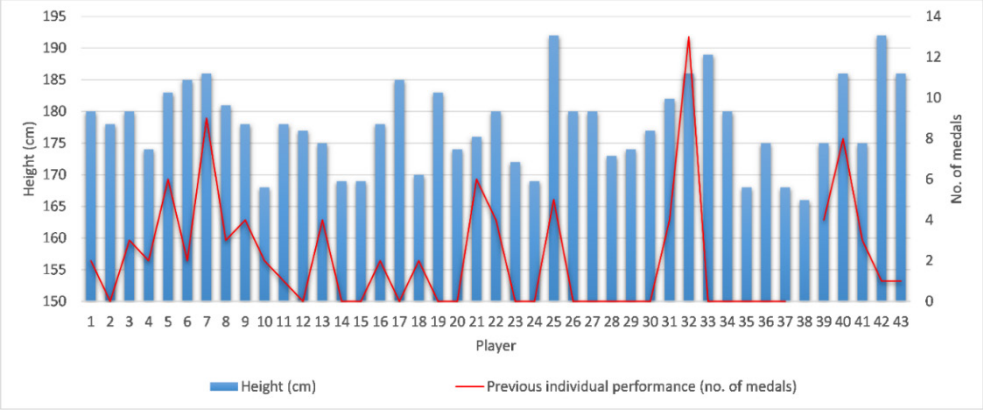

Fig. 19. Győry Audi ETO KC: Players' Height at the Time of Joining the Club and the Number of Individual Medals Won Prior

As with the previous teams, the most successful players, prior to joining this club, were those with a height in the 170–180 cm range (Figures 18 and 19).

Based on this indicator, no specific sports identity can be attributed to any of the teams, as they are similar in terms of the numerical dominance of medium-height players (170–180 cm) and the fact that these players held the most medals at the time of joining one of the three clubs.

The fame of the players at the time of joining one of the three analyzed clubs constitutes another indicator of sports identity and how each club approaches this aspect. Fame primarily results from the overlap of two other indicators: the number of individual medals and the number of team trophies won throughout a player's sports career. The difference lies in managerial policies, with some clubs favoring young players while others opt for established and renowned athletes. Naturally, a club's player acquisition policy is also influenced by the size of its budget allocated for transfers. In this study, to identify differences in this regard, we will consider only the number of individual medals won by the players of the three clubs before joining. Players who had won at least five individual medals prior to joining one of the analyzed clubs are classified as famous players.

The Vipers Kristiansand club collaborated with 28 players during the 2018–2023 period, who collectively totaled 74 individual medals prior to joining, averaging 2.64 individual medals per player. Among these, the majority (15 players, or 53.57% of the total) had no prior individual medals but were considered high-potential players—a fact later proven correct by their subsequent team and individual performances. In addition to these young, relatively unknown players, Vipers Kristiansand also recruited 4 renowned and established players during this period, who together held 56 individual medals: Katrine Lunde with 6 individual medals, Anna Viktorovna Vyakhireva with 18, Nora Mørk with 22, and Isabelle Theresse Gulldén with 10. Thus, Vipers Kristiansand adopted the most efficient model, building the team primarily with young, unknown players with high potential while acquiring only 4 established players with more than 5 individual medals, considered the top performers in their positions. This model is deemed the most effective compared to the other two analyzed, both in terms of financial investment and subsequent sports performances.

The CSM Bucureşti team also demonstrates, in this regard, the most costly and inefficient model. During the 2018–2023 period, the team recruited 54 players who collectively held 169 individual medals prior to joining (an average of 3.13 medals per player). Among these players, 9 had more than 5 individual medals, being considered highly accomplished in their respective positions and in individual performance. Both theoretically and practically, this is the team that invested the largest budget in bringing in renowned and established players. However, its international achievements during 2018–2023 were at best modest. Famous players such as Laura Glauser (5 individual medals), Crina

Elena Pintea (5 medals), Cristina Georgiana Neagu (36 medals), Alicia Gogîrlă (9 medals), Nora Mørk (22 medals), Andrea Lekić (20 medals), Paula Claudia Ungureanu (7 medals), Sabina Detloff Rosengren Jacobsen (5 medals), and Nathalie Mari Hagman (14 medals) should have guaranteed notable international successes. Yet, of the three teams analyzed, CSM București performed the least. It seems that the lack of success cannot be attributed to the quality and notoriety of the players, although some appeared complacent and lacking the drive to perform during their time with the team.

The Győry Audi ETO KC team once again occupies an intermediate position compared to the other two teams from the perspective of this indicator. During the 2018–2023 period, the team recruited 43 players who collectively held a total of 91 individual medals prior to joining. The majority (20 players, or 46.51% of the total) had no prior individual medals. Another six players had at least five individual medals, serving as role models for younger players with potential. The model adopted by the Hungarian team Győry Audi ETO KC is closer to that of Vipers Kristiansand, although its international performances during the analyzed period were below those of the Norwegian team. The most renowned and established players who collaborated with Győry Audi ETO KC during 2018–2023 include Kari Brattset Dale (6 individual medals), Ana Gros (9 medals), Sandra Toft (6 medals), Crina Elena Pintea (5 medals), Eduarda Idalina Amorim Taleska (13 medals), and Katarina Bulatović (8 individual medals).

In conclusion, based on the indicator of player notoriety (celebrity), derived from their market value at that time and the number of individual and team medals earned prior to 2018, the most efficient model is that of the Norwegian team Vipers Kristiansand. This team recruited few renowned players, who performed exceptionally well alongside the majority of young, high-potential players. At the opposite end is the Romanian team CSM București, which spent considerable sums of public money to fund contracts for numerous famous players who achieved almost no international success.In the middle, in terms of efficiency, is the Hungarian team Győry Audi ETO KC.

From the perspective of the coaches who worked with these three analyzed teams, we can again observe distinct identity elements, which led to differing sports results. The most consistent club was, once again, Vipers Kristiansand, which collaborated with a single coach during the 2018–2023 period, namely the Norwegian Ole Gustav Gjekstad. He was younger, less well-known (at the time of joining the club), and had fewer international achievements compared to some of his counterparts from the other two analyzed teams. With this sole coach, Vipers Kristiansand achieved the most significant international results during the analyzed period compared to the other two competitors. At the opposite end, once again, was CSM București, which worked with four coaches

during the same period: Karl Magnus Johansson (July–October 2018), Dragan Djukić (2018–2019 competitive season), Tomas Ryde (a few months in 2019), and Adrian Vasile (2019–2023). Managerial inconsistency is likely the primary reason for this team's lack of success in European competitions. While Vipers Kristiansand maintained a clear identity policy (a single coach over a long period, Norwegian, and familiar with Norwegian women's handball), CSM Bucureşti showed impatience with its coaches, frequently changing them and, consequently, the playing concept and system, depending on their mentality and experience. As a result, the team's sports identity became diluted, and its results in European competitions were nonexistent. Positioned between these two distinct identity policies was the approach adopted by Győry Audi ETO KC, which worked with two coaches during the analyzed period: Ambros Martín (two terms) and Gábor Danyi. The results achieved indicate that this team delivered average performances in European competitions.

Therefore, from the perspective of the sports identity indicator, constructed by assembling the sub-indicators analyzed above, it can be stated that Vipers Kristiansand had the most consistent identity policy during the analyzed period. The team worked with the fewest players and coaches (among the three analyzed) and achieved the most significant European performances. The team with the most diluted and unclear identity was the Romanian CSM Bucureşti, which had the highest number of recruited players and coaches, resulting in a lack of high-level performance on the European stage. In the middle, from the perspective of this composite indicator, lies the Hungarian team Győry Audi ETO KC, exhibiting a moderate identity and achieving average results in European competitions compared to the other two teams.

In our view, *sports performance* is based on the prior achievements (both team and individual) of the players who joined the three clubs during the 2018–2023 period, as well as the results obtained during this competitive interval. The prior achievements have already been analyzed in combination with certain indicators defining sports identity. Therefore, we will now focus solely on the sports performances (domestic and international) achieved by the three teams during the analyzed period, as well as the individual performances of their players, which are the most relevant indicators for the objectives of this study.

During the 2018–2023 period, Vipers Kristiansand won a total of 13 domestic and international competitions, as follows: five times Norwegian champions (2019, 2020, 2021, 2022, and 2023), four times winners of the Norwegian Cup (2019, 2020, 2021, and 2023), three times winners of the Champions League, the most prestigious European club competition (2021, 2022, and 2023), and one third-place finish in the Champions League (2019).

Individually, the players of this team won a total of 175 medals (of national and international significance) during the 2018–2023 period, resulting in an average of 6.25 medals per player.

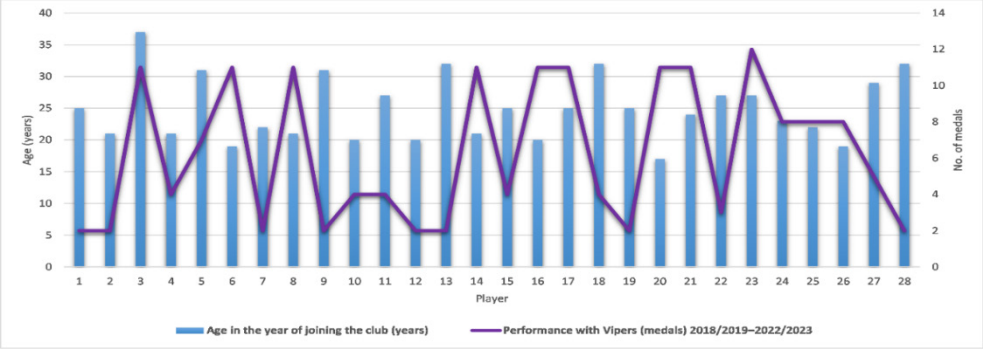

Fig. 20. Vipers Kristiansand: Number of Individual Medals Won During 2018–2023

Most players (15) won a maximum of 5 individual medals, 4 players earned 6 to 10 individual medals, and 9 players achieved more than 10 individual medals during this period. The team is the most successful (of the three analyzed) in terms of collective achievements and the significance of the competitions won. However, it had the lowest number of individual medals earned due to having the smallest roster, with only 28 players. Vipers Kristiansand stands out as the most successful sports team among the three analyzed during the 2018–2023 period.

The CSM București team is the least successful (of the three) during the analyzed period, having won no European international competitions in which it participated. Its only achievements are at the national level, making it the most decorated women's handball team in Romania, a status maintained during the analyzed period. Domestically, the team became Romanian champions twice (2021 and 2023), finished second in the Romanian championship twice (2019 and 2022), won the Romanian Cup twice (2019 and 2022), was runners-up in the Romanian Cup once (2021), won the Romanian Supercup twice (2019 and 2022), and was runners-up in the Romanian Supercup twice (2020 and 2021). In other words, CSM București performed well domestically but disappointed internationally. The team's management was harshly criticized in the Romanian sports press for the lack of recent international results, although the team did win the Champions League in 2015.

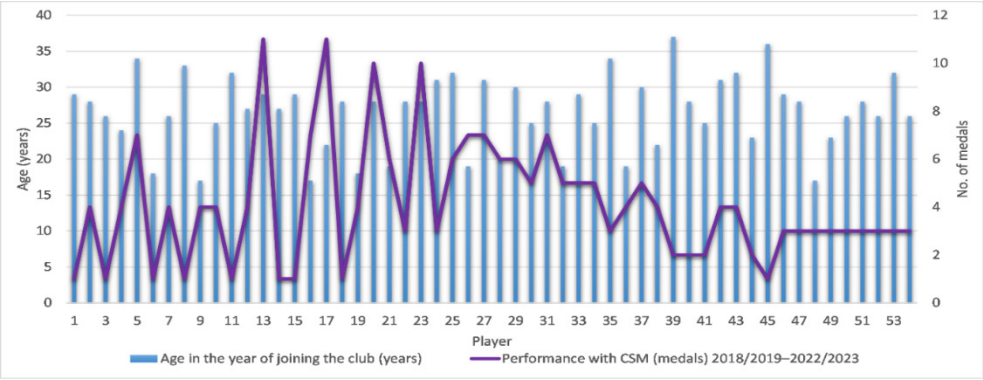

Fig. 21. CSM Bucureşti: Number of Individual Medals Won During 2018–2023.

Regarding the individual performances of players during the 2018–2023 period, the 54 players of CSM Bucureşti earned a total of 223 individual medals (Figure 21), the vast majority of which were of national significance. This results in an average of 4.13 medals per player, with most players (41, or 75.93% of the total) winning a maximum of five individual medals. Another 11 players (20.37%) earned between 6 and 10 individual medals, while only two players (3.70%) stood out with more than 10 individual medals.

The large number of individual medals earned by the players of CSM Bucureşti during the analyzed period does not represent a notable achievement for two reasons. First, a high number of players were utilized, resulting in the lowest average medals per player among the three analyzed teams. Second, the value of the medals earned holds no European significance, as they were won exclusively in domestic competitions.

The Győry Audi ETO KC team ranks second among the three analyzed teams in terms of collective and individual performances achieved during the 2018–2023 period, both in domestic and international competitions. The team won the Hungarian Championship three times (2019, 2022, and 2023), finished second once (2021), won the Hungarian Cup twice (2019 and 2021), and finished second in the Hungarian Cup twice (2022 and 2023). Internationally, the team won the Champions League in 2019 (a feat also achieved in 2024, which falls outside the analyzed period), finished second in the Champions League in 2022, reached the semifinals in 2021, and secured third place in 2023. Although during the analyzed period, the team won the most prestigious European competition, the Champions League, only once (2019), it consistently reached the advanced stages (Final Four) of the competition nearly every year.

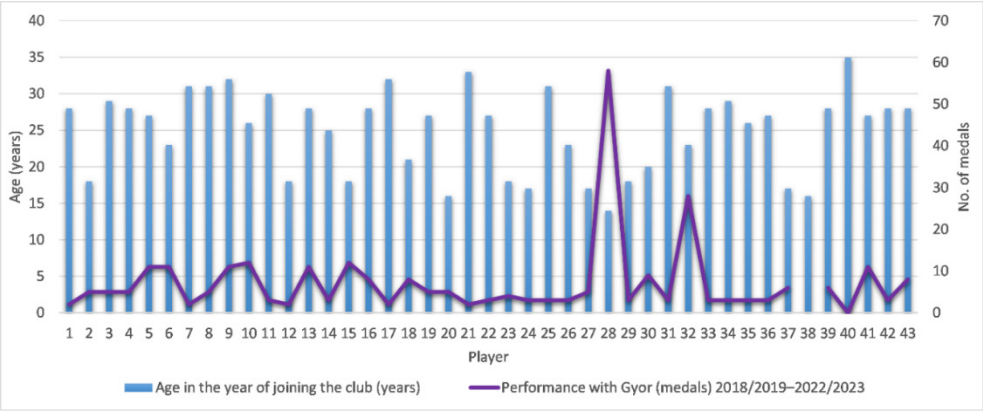

Fig. 22. Győry Audi ETO KC: Number of Individual Medals Won During 2018–2023.

The 43 players who were part of this team during the 2018–2023 period earned a total of 298 individual medals, resulting in the best average among the three analyzed teams, at 6.93 medals per player. Most players (28, or 65.12% of the total) won a maximum of 5 individual medals, 9 players (20.93%) earned more than 10 medals, and 6 players (13.95%) won between 6 and 10 individual medals, both nationally and internationally (Figure 22).

In conclusion, based on team and individual performances during the 2018–2023 period, the Norwegian team Vipers Kristiansand ranks first, followed by the Hungarian team Győry Audi ETO KC, while the Romanian team CSM București occupies the last position.

The third composite indicator, management efficiency, results from the characteristics of specific elements that define the main features of managerial efforts, namely: the duration of players' stay at the analyzed club (player turnover rate); the quality of the club's infrastructure; the capacity of the sports hall where the team competes and the number of spectators attending sports events held in front of home supporters; the investment budget; and the salaries of players and coaches. The efficiency of a sports club's management increases when the duration of athletes' stay at the club is longer (the player turnover rate is lower), meaning that athletes are selected exclusively based on performance criteria and deliver the expected results. The infrastructure for sports performance is of superior quality, such as training and recovery facilities, medical services, and the quality of nutrition. The sports hall capacity is larger, and its facilities are more advanced. The average number of spectators at matches is higher, indicating the supporters' loyalty to the team, aligning with the proposed objectives and financially supporting the team through ticket and subscription purchases. The investment budget is balanced according to the

proposed performance objectives and is transparent. The level of salaries for athletes and technical staff is fair (according to the proposed performance) and competitive.

The duration of players' stay (player turnover rate) at the three analyzed clubs during the 2018–2023 period reveals the following specific traits. In the case of Vipers Kristiansand, the percentage of players who were active for only one season is the highest (9 players, representing 32.15% of the total 28 players active during the mentioned period), followed by the most stable players, who remained with the club for over four seasons (25.00%, or 7 players). Players with two seasons at the club numbered 6 (21.43%), followed by those who played three and four seasons, with both categories accounting for 10.71% each (3 players in each category). The Győry Audi ETO KC team had 43 players during the mentioned period, with the largest group consisting of those who stayed for more than four seasons (14 players, or 32.55% of the total), followed by players who stayed for only one season (12 players, or 27.91%), and those who stayed for two seasons (11 players, or 25.58%). The lowest percentages were for players who stayed three or four seasons, with each category accounting for 6.98% (3 players in each group). The CSM București team used the most players during the analyzed period (54), having the highest player turnover rate. Players who stayed for only one season numbered 18 (33.33%), while those who stayed for two seasons accounted for 26 players (48.14%). Players who stayed for more than four seasons represented 9.26% (5 players), followed by those who stayed for three seasons (7.42%, or 4 players), and those who stayed for four seasons (1.85%, or 1 player). Based on this indicator, the team with the most efficient management is Győri Audi ETO KC, which had the lowest player turnover rate and notable international performances, with players carefully selected at the time of their recruitment. In second place is the Norwegian team Vipers Kristiansand, which had a moderate player turnover rate (compared to the other two analyzed teams) but achieved the most significant European performances. From this perspective, the Romanian team CSM București had the least efficient management model, using the highest number of players, with the highest turnover rate during the analyzed period, the largest investments in player acquisitions, and the weakest international results.

However, it appears that the sports management of the Norwegian team Vipers Kristiansand was only effective in the short term, as in October 2024, the team was declared financially bankrupt. This raises several concerns about the management of the club's operations in recent years, despite the notable international sports achievements it had recorded.

The infrastructure dedicated to sports performance does not indicate significant discrepancies among the three teams. The facilities for training and match hosting, physical training equipment, recovery-specific resources, and the quality of medical services have been (and remain) of a high standard, designed to achieve top performance. Moreover, there are specific requirements set by international bodies that stipulate concrete standards, with regular evaluations conducted. A notable difference arises from the analysis of the capacities of the sports halls where these teams played their matches during the analyzed period. The hall with the largest capacity is the Audi Aréna in Győr, Hungary, with 5,500 seats, home to the Hungarian team Győry Audi ETO KC. The second-largest venue is the Sala Polivalentă in Bucharest, with 5,300 seats, used by CSM București. The third is the Aquarama in Kristiansand, Norway, with a capacity of 2,200 seats, where Vipers Kristiansand played their matches.

The capacities of the sports halls indicate, to some extent, the level of support from fans through ticket and season pass purchases. The most advantaged teams in this regard are Győry Audi ETO KC and CSM București, whose larger venues are almost fully occupied during major international matches and national derbies. Among the average number of spectators, approximately 40% are the most loyal supporters, holding season passes for the entire season.

One of the main limitations (weak points) of this study stems from the existence of very clear confidentiality clauses related to the salary levels of players and coaches, as well as the annual budgets allocated to achieving the proposed sports objectives. While in the case of the Győry Audi ETO KC and Vipers Kristiansand teams, things can be understood to some extent because private financial funds are involved, in the case of the CSM București team, there should be total transparency, as the financial funds are public (the main sponsor is the Bucharest City Hall), along with those from other sponsorships. The lack of financial transparency can lead to certain discrepancies in the efficiency of spending annual budgets (e.g., see the case of the Vipers Kristiansand team, which went bankrupt in October 2024). Nevertheless, the Liga Florilor (the national women's handball championship of Romania) is considered one of the most attractive women's handball championships in Europe and the world, especially from a financial point of view, with the CSM București team being the richest in Romania.

We consider that, based on the analyzed indicators, we can present a clear overview (with certain information gaps) of how high-level sports performance can (or cannot) be achieved in European women's handball. There are no infallible models, but a series of conclusions can be drawn regarding sports management and its implications for achieving performance.

4. CONCLUSIONS

The analysis of three elite women's handball teams-Vipers Kristiansand, CSM Bucureşti, and Győri Audi ETO KC-reveals significant insights into their contrasting strategies and outcomes. Vipers Kristiansand emerged as the most efficient and successful team during the period studied (2018-2023), achieving remarkable international success through a clear identity focused on young, locally nurtured talent, a stable coaching staff, and a cohesive management strategy. This approach not only minimized costs but also fostered a strong sense of team culture, leading to three Champions League titles.

In contrast, CSM Bucureşti, despite its substantial investments in recruiting internationally renowned players, struggled to replicate similar success on the European stage. While the team dominated domestic competitions, its lack of continuity in management and frequent roster changes diluted its sports identity and hindered its performance in international tournaments.

Győri Audi ETO KC, positioned between the two extremes, showcased balanced success. Its strategy involved blending Hungarian talent with select international players, resulting in consistent appearances in the Champions League's final stages and a victory in 2019. The team effectively balanced national pride with international competitiveness, achieving strong results while maintaining a stable management and player structure.

This comparative study underscores the critical role of clear sports identity, strategic performance metrics, and efficient management in determining the success of elite women's handball teams. The findings offer valuable lessons for sports management across various team sports, emphasizing that long-term success requires more than financial investment-it demands strategic alignment of identity, talent development, and operational efficiency.

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Author Contribution

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B.C. and H.C.; visualization, P.H., G. D.; supervision, H. C., B. C. and; project administration, B.C.. All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

The authors declare no conflict of interest.

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THE FRENCH GEOGRAPHER EMMANUEL DE MARTONNE AND HIS CONTRIBUTION TO ROMANIAN GEOGRAPHY

Ileana-Cristina VASILIȚĂ-CRĂCIUN[1]

ABSTRACT. – The French Geographer Emmanuel de Martonne and His Contribution to Romanian Geography. Emmanuel de Martonne (1873–1955) was a prominent geographer of the 20th century, recognized for his essential contributions to the development of geography as a scientific discipline, his interest in cultural diversity, and his balanced perspective on the relationship between humans and nature. His work is well known not only in France but also internationally. A significant portion of his research focused on the Romanian geographical space. During the interwar period, he played an important role in the delineation of the borders of Greater Romania. Moreover, he distinguished himself by conducting the first detailed analysis of the geography of Romania, with particular emphasis on the Făgăraş Mountains, which he referred to as the "Alps of Transylvania."

Keywords: *Emmanuel de Martonne, Romanian geography, Romanian Academy.*

1. INTRODUCTION

Emmanuel de Martonne, born in Chabris, France, in 1873, is recognized as one of the founders of modern geography. "With an impressive body of work, he laid the foundations of general physical geography. He also made significant contributions to the development of human geography, being the founder of the French school of geopolitics. Part of his prestigious academic career was devoted to the study of the Romanian geographical space and to the advancement of academic geography in our country" (V. Loghin, 2018, p. 22).

Fig. 1. Emmanuel de Martonne (1873-1955).
Source: ***

Today, Emmanuel de Martonne's ideas and approaches challenge us to reconsider the role of geography in shaping a fair and sustainable future, where interactions

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between humans and the environment are examined with responsibility and foresight. In this context, on the occasion "of the 150th anniversary of Emmanuel de Martonne's birth, Romanian geographers pay tribute with gratitude to his scientific work, his dedication, and the life lessons he generously shared" (D. Petrea, 2015, p. 3).

2. LIFE AND ACADEMIC JOURNEY

Intelligent, diligent, passionate, and extremely disciplined in his scientific work, Emmanuel de Martonne completed his professional training under the guidance of his illustrious mentor, Paul Vidal de la Blache. He continued his education in Austria, studying under geologist Eduard Suess, and later in Germany with prominent geographers such as Ferdinand von Richthofen, Albrecht Penck, and Julius Hann (I. Gugiuman, 1973, p. 6).

His combined theoretical training and extensive field experience enabled him to hold a wide range of academic and institutional positions (J. Dresch, 1956, p. 626). Over nearly five decades, Emmanuel de Martonne had a major impact on university geography through both his teaching and his active involvement in national and international academic life. He held important academic positions at the universities of Rennes (1899–1905) and Lyon (1905–1909), and subsequently took over the Chair of Geography at the Sorbonne, becoming the successor to Paul Vidal de la Blache.

In this role, he trained numerous generations of geographers, placing particular emphasis on applied work: field excursions, map analysis, and graphic representations of landforms became central components of student preparation. De Martonne also made a significant scientific contribution, materialized in a vast number of publications that profoundly shaped the discipline.

He actively supported the establishment of a strong geographical school in France and played a key role in the international recognition and development of geography, especially in countries such as Romania, where his influence was particularly significant.

Thanks to these remarkable contributions, his recognition steadily grew. As M.D. David (1938, p. 56) stated: "From this moment on, De Martonne becomes the guiding light not only of the geographical movement in France but of all humanity".

Emmanuel de Martonne's life thus represents a remarkable fusion of scholarship, geographical exploration, and diplomatic engagement.

3. EMMANUEL DE MARTONNE'S CONTRIBUTION TO ROMANIAN GEOGRAPHY

De Martonne's work extended beyond the realm of theoretical scientific research devoid of practical implications. His geographical explorations, characterized by a careful examination of the relationship between humans and their environment, naturally intersected with the historical and political realities of his time. This dimension is particularly evident in his deep and lasting connection with Romania, where his work held both scientific relevance and strategic significance.

In fact, "De Martonne had shown interest in Romania as early as his university years at the Faculty of History at the École Normale Supérieure in Paris (1892–1895). This curiosity was sparked by his friendship with the Romanian student Pompiliu Eliade, a literary historian who later became a professor at the University of Bucharest and a corresponding member of the Romanian Academy. This explains his first visit to Romania in 1897, his decision to dedicate himself to the study of the Romanian space from various perspectives, and the choice of Romania as the subject of his two doctoral theses: a monographic study of Wallachia and a morphological analysis of the Southern Carpathians (the Transylvanian Alps)" (V. Loghin, 2018, p. 18), which brought a detailed and scientific perspective to the geography of Romania.

At the same time, L. Badea (2006–2008, p. 183) argued that, "If one were to examine carefully the geographical bibliographic heritage to assess which works were most frequently used and cited during the formative and consolidating period of the Romanian geographical school, certainly De Martonne's two works would be at the forefront..." (mentioned above).

The publication of La Valachie "can be regarded, in the field of Geography, as an epoch-making event, as it represents the most eloquent embodiment of the Monographic School as envisioned by the brilliant Vidal de la Blache. This major work dedicated to Romania was followed a few years later by Recherches sur l'évolution morphologique des Alpes de Transylvanie (Southern Carpathians). This research marked a new direction in the study of relief forms and stood as a tribute to the teachings of the genius Suess" (M.D. David, 1938, p. 57).

In other words, both works drew the attention of the international academic community and became landmarks in geographical research. The accolades received from prestigious institutions in France confirmed their scientific value, and in the following years, the ties between De Martonne and Romanian geographical research grew stronger, paving the way for increasingly active collaboration.

Before the researcher turned his attention to the Romanian mountain regions, existing geographical writings on the subject were sparse and lacked structured information. He thus discovered a fertile and largely unexplored field of research. To deepen his investigations, he devoted nearly one-third of his scholarly work to this area. His understanding of the Romanian geographical space was achieved in a subtle and profound manner through direct contact with both the natural environment and local communities, ultimately resulting in a strong bond between the geographer and the landscape he explored.

Possessing thorough knowledge of Romania's geographical and human realities, Emmanuel de Martonne identified striking similarities between "the structure of settlements in the sub-Carpathian zones of Oltenia, Muntenia, and Moldavia and those in Transylvania, located at the foothills of mountainous massifs. He interpreted these as specifically Romanian settlement patterns, formed within 'ţări' ("countries") - regions with an ancient population" (1902a) (D. P. Idu, 1974, p. 4). Furthermore, "during his expeditions in the high Carpathian region, in a natural environment far more inaccessible than today, he observed that '[the frontier] everywhere separated populations speaking the same language and having the same origin'" (Emm. de Martonne, 1921; cited by D. Petrea, 2015, p. 2).

Reviewing his extensive scientific output—published in Romanian, French, or British academic contexts—we find works that interpret the Romanian environment in a characteristically geographical manner. These include general studies in geomorphology and human geography that address Romania as a whole, as well as more focused works dealing with specific, homogeneous regions such as Transylvania and the Carpathian space. His body of work, the result of long journeys throughout the country, was presented and appreciated in academic conferences and published works, offering invaluable contributions to both national and international geographic scholarship.

According to V. Loghin (2018, p. 23), de Martonne's writings on Romania can be grouped into the following thematic categories (table 1):

Table 1. Thematic categories of Emmanuel de Martonne's works on Romania

Glacial Periods and Glacial Landforms in the Southern Carpathians	(„Sur la période glaciaire dans les Karpates méridionales", 1899; „Recherches sur la période glaciaire dans les Karpates méridionales", 1900; „Nouvelles observations sur la période glaciaire dans les Karpates méridionales", 1901; „Sur les anciens glaciers dans les Karpates méridionales", 1905);
Erosion platforms in the Carpathians	(„Sur la plate-forme des hauts sommets des Alpes de Transylvanie", 1904; „Sur les plate-formes d'érosion des monts de Bihor (Roumanie)", 1921; „Sur les plate-formes d'érosion des Monts Métaliferes du Banat", 1921; „Sur le massif de Poiana Rusca et la corrélation des cycles d'érosion des Karpates méridionales", 1922);
Transverse valleys	(„Sur l'histoire de la vallée du Jiu/Karpates méridionales", 1899);
Geomorphology of the Southern Carpathians and the Western Carpathians	(Recherches sur l'évolution morphologique des Alpes de Transylvanie / Karpates méridionales", 1907; „Le massif du Bihor / Roumanie", 1922);
Geography of the Carpathians as a whole	("The Carpathians", 1912; „Sur la position systématique de la chaîne des Karpates", 1910; „The Carpathians: Physiographic features controlling human geography", 1917; „Essai de synthèse morphologique des Carpates", 1932);
Geography of the Subcarpathians	(„Sur les terrasses des rivières subkarpatiques en Roumanie", 1904; „Sur l'évolution de la zone des dépressions subkarpatiques en Roumanie", 1904; „Le village roumain subcarpatique", 1933);
Geography of Transylvania	(„La Transylvanie", 1922; „Transylvania. A Geographical Study", 1924; „Colinele Transilvaniei", 1929);
Human geography, ethnography, toponymy	(„Sur la toponimie naturelle des régions de haute montagne, en particulier dans les Karpates méridionales", 1901; „Recherches sur la distribution de la population

	en Valachie avec un étude critique sur les procédés de représentation de la répartition de la population", 1902; „La vie pastorale et la transhumance dans les Karpates méridionales; leur importance géographique et historique", 1904; „Viaţa pastorală în Carpaţii României", 1912; „Essai de carte ethnographique des pays roumains", 1920; „La répartition et le rôle des minorités nationales en Roumanie", 1929);
Geography of Romania as a whole	„La Roumanie. Géographie phisique, Géologie, climat, Biogéographie, Géographie économique, Géographie politique" (in La Grande Encyclopédie, 1900); „La Valachie. Essai de monographie géographique", 1902; „La Roumanie et son rôle dans l'Europe Orientale", 1915; „La nouvelle Roumanie", 1921; „La nouvelle Roumanie dans la nouvelle Europe", 1922; „La Roumanie", in Géographie Universelle, vol. IV, Europe Centrale, 1931);
Works carried out within the Committee of Studies attached to the Paris Peace Conference (1918-1920)	„Travaux du Comité d'Études (La Transylvanie, la Bessarabie, la Dobroudja, La question du Banat)"; „Répartition des nationalités dans les pays où dominent les Roumains. Carte 1:1.000.000", 1919.

Source: V. Loghin (2018, p. 23)

Emmanuel de Martonne dedicated an important part of his activity to study the territory and population of Romania, publishing numerous works on the geography and people of this country - including his two doctoral theses, which cemented his scientific prestige. He also served "the cause of Greater Romania": first as a "border draftsman" at the Versailles Conference, then as a "missionary" of France, especially in "liberated" Transylvania, and as a defender of the new borders against Hungarian revisionism and German Geopolitik (G. Bowd, 2023, p. 10).

Between 1897 and 1937, he returned repeatedly to Romania, conducting research activities. His involvement also included the role of "visiting professor, teaching at the University of Cluj-Napoca or delivering lectures at the Geographical Society, the Academy, and various universities - occasions on which he was honoured with awards for scientific excellence (honorary member of the Geographical Society in 1915, Doctor Honoris Causa of the University of Cluj-Napoca in 1929 and of Iaşi in 1938, corresponding member of the Romanian Academy in 1912, honorary foreign member of the Romanian Academy in 1919, honorary citizen of the city of Cluj-Napoca, etc.) (M. Ielenicz, Mariana Nae, 2013, p. 213).

De Martonne left a lasting mark on the way we understand the relationship between humans and the spaces they inhabit. His works continue to inspire generations of geographers, offering models of rigorous analysis and opening new perspectives on the complex dynamics between people, places, and environments. His name has become a reference point for the spirit of innovation and geographical thinking that significantly shaped the development of research in Romania.

4. CONCLUSIONS

As evidenced by his entire body of work, De Martonne's influence extends beyond his published writings, continuing through the ongoing interest of Romanian geography in the themes and methods he promoted.

Contemporary researchers and geographers continue to draw inspiration from his complex approach, which harmoniously integrated the physical and human dimensions of geographical space.

His perspective on cooperation between peoples—based on dialogue, understanding, and mutual respect—remains relevant today, in a world where building open and balanced global relationships is more important than ever.

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10. ***Fig.1.(Source: https://www.lifeder.com/emmanuel-martonne/, accessed 08.07.2025).

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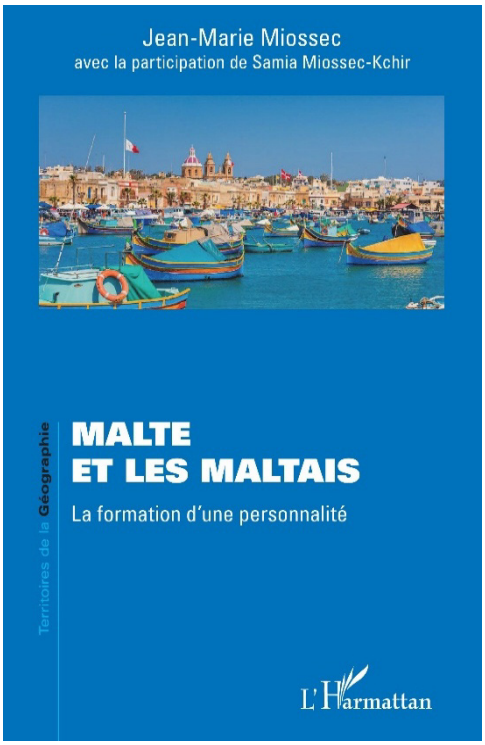
(RECOMMENDED CITATION)

COMPTE RENDU • BOOK REVIEW

Jean-Marie Miossec avec la participation de Samia Miossec-Kchir – *Malte et les Maltais. La formation d'une personnalité,* Editions L'Harmattan, 2025, 708 p, Paris.



L'ouvrage *Malta et les Maltais* du professeur Jean-Marie Miossec, avec la contribution de Madame Samia Miossec-Kchir, publié dans la collection déjà consacrée « Territoires de la géographie » chez les Editions L'Harmattan (2025), part d'une série d'augures stimulants, offerts par un territoire insolite, tout à fait original, caractérisé par des superlatifs géographiques et des paradoxes surprenants :

- Le plus petit État de l'Union européenne – environ 300 km² ;
- L'État le plus densément peuplé de l'UE – « pas moins de 1450 habitants au kilomètre carré » ;
- Un territoire totalement dépourvu de ressources mais devenu un « foyer de développement », avec des opportunités de localisation géographique exceptionnelle ;
- Une langue de mélange sémitique (arabe) avec les langues romanes, écrite en alphabet latin ;
- Un peuple original, unique, qui, malgré sa faible taille démographique, a joué un rôle marquant tout au long de l'histoire parmi les nations méditerranéennes, etc.

Le but de l'ouvrage, dévoilé par l'auteur dans une excellente préface, est d'offrir au lecteur non seulement « une présentation de la géographie, de l'organisation de l'espace et du développement de l'archipel », mais surtout « de mettre en perspective sa géohistoire et son identité » (p.13). Le professeur Miossec compare Malte à un « iceberg » qui « ne révèle qu'une petite partie de son visage, sur lequel j'ai tenté, modestement, de lever le voile » (p.14).

L'ouvrage est divisé en 5 parties et 23 chapitres, auxquels s'ajoutent, comme mentionné précédemment, un large avant-propos, et à la fin une synthèse conceptuelle de la démarche identitaire, d'une beauté philosophique et lyrique particulière (*La guise en transition),* une bibliographie extrêmement vaste ainsi qu'un répertoire de documents historiques d'une importance majeure pour Malte et son peuple.

La première partie de l'étude est consacrée au paysage maltais, abordé à travers ses composantes tectoniques, géologiques, géomorphologiques et bioclimatiques. Mais avant cela, il est souligné la localisation de l'archipel au centre du bassin de la mer Méditerranée, à la fois sur l'axe ouest-est, Gibraltar-Port Said, ainsi que sur l'axe nord-sud, entre l'Europe et l'Afrique. Malte occupe un rôle polyvalent du point de vue historique et géopolitique : « carrefour, relais, frontière plus ou moins ouverte, verrou, sentinelle ... » (p. 20).

Du point de vue tectonique, Malte est un fragment de l'ancienne passerelle mio-pliocène qui reliait l'Europe à l'Afrique, une connexion désintégrée par les phénomènes actifs de subduction de la plaque africaine sous la plaque européenne. Un rift segmenté en trois grabens apparaît dans la région, dont celui de Malte est le plus profond (-1731 m). La subduction dans la zone du rift entraîne l'inclinaison de la plateforme calcaire maltaise vers le nord-est, sa fragmentation intense, ainsi que des phénomènes volcaniques et sismiques associés.

La géologie est principalement donnée par de roches sédimentaires néozoïques, la colonne stratigraphique présentant un aspect de Hamburger, de « sandwich », avec une base et un toit formé de roches calcaires coralligènes d'âge oligocène-miocène, intercalant des formations tendres de sables et marnes du même âge.

Comme conséquence directe de la lithologie, le relief des îles est majoritairement karstique. Il se manifeste particulièrement dans la zone littorale, par des falaises impressionnantes, des vallées en recul de type calanque, des formes de dénudation karstique complexe (le célèbre arc Fenêtre d'Azur, effondré le 8 mars 2017), de nombreuses formes endo-karstiques (grottes et avens). Des lapiaz et dolines de dissolution ou d'effondrement ne manquent pas au paysage. Sur le substrat marneux apparaissent des bad-lands tandis que sur le substrat sableux se trouvent des formes instables d'érosion accélérée. L'évolution rapide des falaises s'accompagne d'une apparition faible des plages. Ainsi, un paysage spectaculaire, avec des potentialités touristiques remarquables.

Malte s'inscrit dans le type de climat méditerranéen, avec 520 mm de précipitations annuelles et une température moyenne des mois froids dépassant 12°C, accompagnée de vents chauds et secs, de type sirocco, venant d'Afrique, ainsi que des vents humides venant de l'ouest et du nord. Du point de vue biogéographique, en raison d'une forte et

ancienne anthropisation, les associations végétales naturelles sont rares et dégradées. On trouve, de manière insulaire, l'association garrigue, avec des buissons épineux sur des sols rocheux, et le maquis, dans des zones plus abritées et humides, avec des essences ligneuses (oliviers, chênes).

La deuxième partie de l'ouvrage est consacrée aux aspects historiques. C'est l'endroit où apparaît nettement le rôle de carrefour de Malte, de frontière et d'avant-poste. Un espace habité dès la préhistoire, avec une *culture mégalithique* abritant les plus anciens temples néolithiques au monde, initialement localisés en zone côtière. Ce fut la direction suivie ensuite par les Phéniciens, Carthaginois, Grecs, Romains et Arabes qui ont occupé l'archipel en vagues successives au cours des périodes historiques. Une empreinte unique, remarquée d'abord dans la langue maltaise, témoigne de l'appartenance des îles, entre 870 et 1127, à l'émirat aghlabide et au califat des Fatimides, période durant laquelle Malte est arabophone, toponymique, culturellement et économiquement arabisée. Elle entrera sous influence européenne catholique au XIIIe siècle, marquant le début d'une « christianisation lente ». Dans ce contexte, le livre aborde avec perspicacité et haute qualification philologique la question de la langue maltaise, Malte étant le « seul État de l'UE dont la langue est un dialecte arabe ».

Cette affirmation doit être fortement soulignée, l'auteure du chapitre concerné étant une spécialiste universitaire attestée en langues arabes, native du domaine, à savoir Samia Miossec-Kchir, fondatrice du Département de langue arabe à l'université « Paul Valéry » de Montpellier. Une nouvelle preuve, s'il en était besoin, de professionnalisme et de responsabilité, qui confère à l'ouvrage une plus grande valeur scientifique.

Une autre période historique bouleversante est celle des XIIIe au XVIe siècles, quand, dans le contexte de la diminution de l'influence arabe, le bassin méditerranéen devient un théâtre de confrontation entre les puissances de l'époque. Pendant le Moyen Âge, Malte joue le rôle d'une frontière entre l'est et l'ouest de la Méditerranée, entre l'Afrique arabe et l'Europe chrétienne, s'imposant comme un espace traversé par de nombreuses croisades (VII, IX), par la piraterie et l'installation des ordres religieux (Ordre des Hospitaliers de Saint-Jean de Jérusalem, fondé en 1113, devenu, après son arrivée dans l'archipel en 1530 suite à la décision de Charles Quint, Ordre des Chevaliers de Malte). Pendant plusieurs siècles, Malte devient un pôle d'attraction des ressources d'un vaste espace continental d'Europe occidentale et centrale, où ces derniers détenaient plus de 650 Commanderies et des propriétés foncières étendues. Comme événement majeur, l'auteur décrit le siège de Malte par l'Empire ottoman en 1565 ; par suite de la victoire remportée, l'île devient une « frontière de la chrétienté » en Méditerranée. Entre les XVIe et XVIIIe siècles, les Maltais se distinguent dans le domaine du transport maritime, devenant un véritable hub de la région, souvent combiné avec la piraterie proprement dite contre les navires turcs, mais pas uniquement. La période de l'Ordre est considérée d'une grande importance dans l'histoire du peuple maltais, grâce aux nombreuses fortifications, édifices religieux et constructions publiques élevés dans les styles de l'époque, classique, baroque, etc. Elle prendra fin en 1798 lorsque la flotte française accoste à La Valette, envahissant Malte.

Si durant la Première Guerre mondiale Malte est restée en dehors des opérations militaires, durant la Seconde Guerre mondiale elle a joué un rôle important grâce à son infrastructure navale mise à disposition de la flotte britannique, ainsi que comme espace stratégique et théâtre opérationnel pour le débarquement des partenaires en Afrique du Nord, puis en Europe du Sud. C'est celle-ci la raison des nombreux sièges des forces germano-italiennes et les destructions massives subies.

La quatrième partie de l'ouvrage couvre une période historique comprise entre la chute de l'Ordre, en 1798, et la Seconde Guerre mondiale, lorsque Malte devient, malgré ses très faibles dimensions géographiques et démographiques, une partie intégrante de l'empire britannique mondial. Mais pas n'importe laquelle : un pivot stratégique unique. Malte représentait « un relais sur l'artère amirale de l'empire, sur la route commerciale et stratégique principale ». Son rôle croît de manière exponentielle avec l'ouverture du canal de Suez en 1869. Le statut de colonie anglaise se reflète également dans les transformations économiques, sociales et culturelles subies par la société maltaise durant cette période. Des changements visibles dans le paysage, dans l'organisation spatiale, dans les mœurs et mentalités.

La cinquième et dernière partie de l'étude concentre son débat sur la migration, l'exode des Maltais. L'un des devises choisies par l'auteur explique la causalité du phénomène : « Malte est un rocher ; ce rocher ne produit que des hommes » (Cardinal Charles Lavigerie). La migration s'oriente principalement vers les espaces voisins de l'archipel : Sicile, Tunisie, Algérie, France, Espagne. De grands groupes de populations d'origine maltaise se retrouvent aussi en Australie et au Royaume-Uni. La tendance semble s'inverser après 1975, quand le volume de l'exode diminue significativement.

Enfin, un détail que nous ne pouvons ignorer : tant dans la préface que dans la postface de l'étude, Jean-Marie Miossec n'oublie pas de mentionner la Roumanie, un pays dont la quintessence symbolique est la *montagne*, prêt à affronter avec optimisme les aspirations du troisième millénaire.

Après cette brève traversée du contenu de l'ouvrage *Malte et les Maltais. La formation d'une personnalité*, quelques conclusions générales s'imposent :

- Comme il nous y a déjà habituer dans ses travaux antérieurs, Jean-Marie Miossec se révèle, une fois de plus, un encyclopédiste des causalités géographiques. Il analyse le phénomène géographique à travers le filtre systémique de l'intégralité et de l'intégration organique, sous toutes ses formes, l'information sur le sujet étant exhaustive. Partant de l'impact profond des conditions naturelles et de la localisation géographique, il fait appel, avec l'agilité d'un chercheur expérimenté familier de son travail depuis longtemps, à un arsenal d'arguments d'ordre historique, social, économique, culturel ou psychologique (mental) ;

- Sans exception, les analyses proposées par l'auteur sont interdisciplinaires et transdisciplinaires, il démontre à chaque fois une connaissance approfondie du contexte dans lequel le phénomène géographique prend naissance et évolue, son horizon scientifique et culturel lui permettant des démarches convaincantes, stimulantes, novatrices ;

- Un autre aspect à souligner c'est le fait que Jean-Marie Miossec écrit d'une manière fluide et nuancée, rapprochant le texte de l'essai scientifique captivant. Les innombrables références à des arguments culturels (littéraires, artistiques, philosophiques) stimulent la lecture et ouvrent dans l'âme du lecteur de larges fenêtres vers une compréhension complexe et profonde des réalités.

- Bien que les Roumains aient des références écrites sur Malte depuis un siècle et demi (n'oublions pas la Troisième lettre du poète national Mihai Eminescu, où il a mentionné les Chevaliers des Malte), l'ouvrage de Jean-Marie Miossec est bien plus : une tomographie du destin d'un territoire inédit et d'un peuple unique qui mérite pleinement d'être connu non seulement par des géographes, mais de tous ceux pour qui la géographie, l'histoire et la culture représentent ensemble une source inépuisable de valeurs impérissables.

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RECENZIE • BOOK REVIEW

Teodor Onișor, 2025, *Între etnografie și poezie*, ediție îngrijită de Laura Goia și Ioana Onișor, Editura Galaxia Gutenberg, Târgu Lăpuș

Acest masiv volum de 748 pagini este dedicat unuia dintre cei mai meritoși etnografi de la Institutul de Geografie al Universității Regele Ferdinand I din Cluj, format la școala etnografică clujeană a profesorului Romulus Vuia: Teodor Onișor. Cartea a fost editată și îngrijită de Laura Goia de la Biblioteca Județeană „George Coșbuc" din Bistrița și de nepoata etnografului, Ioana Onișor. Ea a apărut cu sprijinul financiar al Consiliului Județean Bistrița-Năsăud, prin biblioteca mai sus amintită, constituind o inițiativă lăudabilă și de bun augur pentru readucerea în memoria contemporanilor și valorificarea scrierilor unor personalități cu adevărat remarcabile ale spațiului cultural bistrițean și năsăudean deopotrivă. Inimoasele și harnicele editoare au materializat astfel îndemnul ilustrului geograf și etnograf evocat, care spunea:

Simbolistica copertei volumului.

„Noi, Zugrenii nu trebuie să căutăm prea departe, în timp sau spațiu, să căutăm modelele de urmat. Va trebui numai să ne cunoaștem înaintașii noștri și vom găsi «tipuri de conducători» după dorințele noastre. Vom găsi modele în fețele bisericești, în dascălii de toate categoriile, vom găsi și eroi și personaje militare. Noi trebuie numai să-i căutăm și să-i studiem" (coperta IV).

Iată că acest îndemn s-a materializat în chip fericit, incluzându-l chiar pe autorul lui între vrednicii săi înaintaşi, pe care i-a dat solul mănos în personalităţi al Bistriţei şi Năsăudului, cel puţin în ceea ce-i priveşte pe geografi, fiindcă de acolo au mai plecat Laurian Someşan şi controversatul, dar nu mai puţin importantul, Tiberiu Morariu. Îi mai amintesc în acest sens şi pe Nicolae Drăganu, ilustrul lingvist, profesor la Universitatea românească din Cluj şi rector al ei (1931-1932), primar al oraşului de pe Someşul Mic o lungă perioadă de timp (1933-1939), precum şi pe Ştefan Jarda (1883-1927), întâiul secretar general al aceleiaşi Universităţi (1919-1927) în perioada punerii pietrei sale de temelie, toţi cu activitate meritorie în viaţa universitară clujeană şi nu numai. Iar lista ar putea continua cu multe alte nume.

Volumul s-a bucurat de o frumoasă lansare la Muzeul de Etnografie din Cluj, pe data de 31 iulie 2025, ora 18, în prezenţa unui numeros public, ceea ce denotă interesul pentru personalitatea celui evocat şi pentru activităţile desfăşurate sub egida acestui vechi şi prestigios muzeu clujean, la a cărui piatră de temelie şi evoluţie geografii şi-au adus o contribuţie determinantă.

Lucrarea este structurată în opt părţi: I. *Prefaţă* (pp. 5-7), semnată de Tudor Sălăgean; II. *Notă asupra ediţiei* (pp. 9-11); III. *Cronologie* (pp. 13-17), o utilă datare a principalelor etape ale parcursului civil, şcolar şi profesional al lui Teodor Onişor; IV. opera etnografului, grupată în: 1) *Cuvântarea profesorului Teodor Onişor la serbarea omagială din comuna Zagra dedicată prof. univ. dr. Nicolae Drăgan, membru al Academiei Române-27 august 1939* (pp. 21-23); 2) studiul inedit *Contribuţii la cunoaşterea portului popular din Sud-Estul Transilvaniei* (pp. 25-116); 3) studiile, articolele, cronicele şi recenziile publicate în decursul timpului, respectiv 51 de materiale grupate în Etnografie, Muzeografie şi Geografie (pp. 117-622); 4) *Pagini de jurnal* (pp. 623-628); 5) *Ghidul Etnografic al Transilvaniei. Ghid ilustrat*, Cluj, 1957 (pp. 629-652); V. *Analize şi interpretări critice despre Teodor Onişor* (pp. 653-667; VI. *Evocări* (pp. 669-686; VII. o bogată *Iconografie* (pp. 688-745); VIII. *Cuprins* (pp. 746-748).

Prefaţa este semnată de Tudor Sălăgean, directorul Muzeului Etnografic al Transilvaniei din Cluj-Napoca. Acesta apreciază efortul predecesorului său, pe care îl caracterizează ca fiind „un nume de referinţă în geografia şi în etnografia românească şi un exemplu de profesionalism şi devotament într-o perioadă marcată de impostură şi ideologizare a culturii" (p. 5). Creionând succint parcursul formării şi evoluţiei sale profesionale, Tudor Sălăgean apreciază ca „demnă de întreaga noastră apreciere iniţiativa familiei profesorului şi omului de cultură Teodor Onişor" (p. 7) de a contribui la materializarea volumului.

De o manieră decisivă a contribuit la realizarea volumului bibliotecara Laura Goia, care semnează *Notă asupra ediţiei* (pp. 9-11). Contribuitoare la îngrijirea ediţiei, domnia sa descrie etapele demersului, explicând geneza titlului, a cărui paternitate îi aparţine lui Teodor Tanco, un exeget al personalităţilor locului, precum şi cuprinsul volumului. Mulţumind pentru sprijinul acordat unei lungi serii de colaboratori, domnia sa aduce calde aprecieri lui Ioan Toşa – etnograf –, fiicelor lui Teodor Onişor –Tereza şi Mariana, – precum şi nepoatei Ioana Onişor, dar şi fostei studente a celui evocat, profesoara Rodica Ana Dan.

Deosebit de utilă, *Cronologia* (pp. 13-17) marchează etapele stării civile, ale educației și ale parcursului profesional al lui Teodor Onișor, făcând o bine venită și mult așteptată „lumină" în derularea acestor praguri existențiale ale vieții și operei ilustrului geograf-etnograf.

Firesc, cea mai mare parte din economia volumului o reprezintă scrierile lui Teodor Onișor, unele inedite, care probează afilierea lui la Școala Etnografică a profesorului Romulus Vuia, strălucit membru al Institutului de Geografie al Universității Regele Ferdinand I din Cluj, unul dintre cei mai apreciați colaboratori ai savantului George Vâlsan, cel care a pus bazele Institutului, l-a încadrat cu personal de calitate și a deschis calea studierii etnografiei la Cluj. Avem astfel adunată în volum – cu excepția tezei de doctorat – opera lui Teodor Onișor, care reflectă efortul său constant de cercetare, analiză, sinteză și de editare a scrierilor sale de etnografie, geografie, memorialistică ș.a. Format în mediul universitar românesc atât de efervescent al Clujului interbelic, dar silit de împrejurări nefaste să-și desfășoare activitatea în perioada stalinistă și cea a anilor 1950-1960, bucurându-se doar de o scurtă vreme de liberalizarea regimului comunist introdus în țara noastră de tancurile sovietice în alianță cu partidul antinațional P. M. R., ulterior P. C. R. Până ce moartea l-a răpus la vârsta de numai 60 de ani, Teodor Onișor a parcurs, aidoma țării, calvarul drumului îndoctrinării ateiste, al înstrăinării de valorile neamului nostru... Chiar boala lui de inimă s-a datorat „cutremurelor" sociale pe care a fost nevoit să le trăiască, adaptându-se cu un imens efort material și psihologic. Interesant este studiul său inedit, bogat ilustrat, *Contribuții la cunoașterea portului popular din Sud-Estul Transilvaniei* (pp. 25-116), chiar dacă autorul nu a reușit să-l definitiveze, rămânând în manuscris, dar și studiile etnografice sau cele privind activitatea Cercului de Studii Etnografice de la Cluj, respectiv evocarea unor personalități precum Romulus Vuia și George Vâlsan.

Capitolul *Analize și interpretări critice despre Teodor Onișor* (pp. 653-667) este reprezentativ pentru efortul de adunare a aprecierilor scrise pe care o serie de personalități marcante ale vieții științifice românești le-au făcut asupra operei și activității lui Teodor Onișor, inclusiv aceea mai puțin cunoscută de bibliograf și care se caracterizează „prin metodă, bogăția materialului" (p. 656). Au contribuit autori ca Vintilă Mihăilescu, Ioachim Crăciun, Barbu Teodorescu, Victor Tufescu și Ana Toșa, Lucia Apolzan, Teodor Tanco, Corneliu Vaida sau, mai recent, postum, Ioan Toșa, Tudor Sălăgean, Mircea Prahase și Gavrilă Rus.

Emoționante sunt consemnările fiicelor sale – Tereza și Mariana Onișor – din capitolul *Evocări* (pp. 663-686), ale nepoatei Ioana, co-editor al volumului, precum și ale fostei sale studente, profesoara Rodica Ana Dan, dar și ale Laurei Goia. Dacă Tereza Onișor insistă asupra biografiei tatălui său din perspectiva familială a celor cinci copii – trei fete și doi băieți – pe care i-a avut cuplul Nastasia și Teodor Onișor, care „s-a stins aproape neștiut de universitari și geografi și […] aproape anonim pentru colegii de breaslă" (p. 673), Mariana Onișor insistă asupra atmosferei anilor sumbri de după război. Ea îi caracterizează astfel:

„Era în anii ’50, ani foarte tulburi. Spaima umplea viețile celor care nu cedau în fața compromisului și a dezonoarei, impuse de tancurile «roșii» care încă striveau pământul românesc și inimile celor care nu-și renegau botezul primit din apele credinței, rămânând mărturisitorii ei” (p. 675),

sau:

„Anii ’60 în Clujul de după război erau sub amprenta «roșie» a PCR-ului dictatorial, impus anume pentru a zdrobi integritatea, demnitatea, spiritul liber, speranța, visurile atâtor intelectuali plini de har și de entuziasm. Da, au fost ani de groază, anume studiată și infiltrată în inimile și conștiințele oamenilor, pentru a-i face să se teamă, să le fie frică pentru supraviețuirea lor și a familiilor lor.” (p. 676).

În acest context sumbru îi va fi fost iertată lui Teodor Onișor orice abatere în raport cu regimul comunist ilegal instituit la 30 decembrie 1947, fiindcă, parafrazând, da, fusese director al Muzeului Etnografic al Transilvaniei în perioada 1956-1959. Fiica Mariana Onișor afirmă că „tata lucra enorm în acea perioadă. Avea două norme, legate de cele două mari pasiuni ale sale: Muzeul Etnografic și catedra de la Facultatea de Geografie, unde preda” (p. 675), fiind obligat finalmente „să se hotărască să renunțe la conducerea Muzeului Etnografic” (p. 676).

Fiica a creionat perfect perioada sumbră a anilor 1950-1960, o perioadă neprielnică dezvoltării intelectuale autohtone, total neprietenoasă. Din această perspectivă, eu l-am încadrat pe Teodor Onișor în volumul ce va vedea în curând lumina tiparului *Membrii Institutului de Geografie al Universității Regele Ferdinand I din Cluj în vizorul securității, parte a procesului alterității proletcultiste de după 23 august 1944* în categoria celor cu destine frânte de o epocă cumplită...

Ca să susțin afirmațiile de mai sus, citez din nota informativă din 6 mai 1960 a „sursei Oprișan Valentin”, informator al Securității cu nume de cod:

„În ziua de 3 aprilie și în alte dăți, sursa l-a văzut pe profesorul universitar Teodor Onișor, Facultatea de Geografie, că merge cu familia la biserica Romano-Catolică din Piața Carolina. A fost văzut de sursă intrând la biserica Sf. Mihail (centru) împreună cu soția și copii. Este și membru de partid și cu toate acestea frecventează bisericile. Deși e om de știință, el crede în d-zeu”! (Dosar C.N.S.A.S., I 581492, f. 1).

Da, cumplite vremuri! Dar revoltător este că după anul 1990 această stare s-a perpetuat, desigur cu mijloace mult, mult mai perfide, dar din fericire identificabile! Fără să ajungă să-l cunoască, nepoata profesorului, Ioana Onișor, fiica fiului Ioan, a sintetizat figura bunicului său din memoria familiei: „un om, un creștin (ai cărui fii au devenit preoți), un idealist (care și-a jertfit sănătatea pentru principiile lui), un tată și un soț devotat, și un dascăl iubit și respectat” (p. 680).

Profesoara Rodica Ana Dan, fostă studentă al lui Teodor Onişor, îl descrie ca „un bărbat cu un chip blajin, cu o privire pătrunzătoare, de o înălţime între medie şi înaltă, cu pasul domol, dar impunător, prin seriozitate şi atitudine, atât prin ţinuta corpului, felul de a se comporta, dar şi prin modul în care îşi afirma cu hotărâre punctul de vedere" (p. 681). Domnia sa apreciază că „prelegerile, minuţios pregătite", au fost „deosebit de interesante" (*idem*), că profesorul era „riguros la examene", constatând că prin realizarea volumului „este scos din uitare un om special, un spirit sintetic şi analitic şi un geograf pasionat" (p. 682).

Seria de *Evocări* este încheiată de Laura Goia, care reiterează principalele elemente biografice, încununând motivaţia editării volumului astfel: „pentru a valorifica opera sa şi a-l aşeza pe Teodor Onişor în «Panteonul figurilor ilustre năsăudene»" (p. 685). Îi mai rămâne neobositei cercetătoare Laura Goia să recupereze şi să editeze teza de doctorat a celui evocat, manuscris încredinţat spre publicare Editurii Minerva din Bucureşti de către însuşi autorul în anii '70.

Volumul se încheie cu o bogată *Iconografie* (pp. 688-745), deosebit de valoroasă sub aspect documentar-ilustrativ, fiindcă prezintă membrii familiei profesorului, colegii săi de-a lungul timpului, precum şi documente vechi, acte, corespondenţă şi dedicaţii de autori, înscrise pe volume oferite profesorului. Cu ajutorul lor, putem astăzi reconstitui fresca lumii trecute, atât cea interbelică – aşezată, tihnită, mult mai morală, cât şi cea postbelică, rigidă, impregnată de „lupta de clasă" şi falsă prin dedublarea conştiinţelor…

Mărturisesc că sunt posesorul unui frumos exemplar al volumului semnat de Ion Simionescu, *Ţara noastră: Natură, oameni, muncă*, apărut la Editura Fundaţia pentru Literatură şi Artă „Carol II", 1938, Bucureşti, semnat şi datat („29. X. [1]938") de Teodor Onişor, volumul conţinând şi numeroase adnotări minuţioase realizate tot de el.

Exceptând unele inadvertenţe legate de tehnoredactarea volumului, precum şi câteva mici erori legate de personajele din iconografie, volumul reprezintă o lucrare valoroasă, de mari dimensiuni, care prezintă într-o manieră exhaustivă biografia şi opera celui care a fost geograful şi etnograful Teodor Onişor, director al Muzeului Etnografic al Transilvaniei din Cluj (1956-1959) şi, astfel, merituos continuator al operei magistrului său, profesorul Romulus Vuia, şi totodată conferenţiar la Facultatea de Geografie a Universităţii clujene. Fiind util geografilor, etnografilor, istoricilor şi sociologilor deopotrivă, dar şi cititorilor pasionaţi de curentul ideilor identitare româneşti, recomand cu căldură volumul, mai ales tinerilor care pot lua astfel cunoştinţă cu scrierile unuia care se înscrie perfect între „eternii noştri păzitori ai solului veşnic", cum spunea marele nostru poet – Mihai Eminescu.

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