UNIVERSITATEA DIN ORADEA

ANALELE UNIVERSITĂŢII DIN ORADEA

Seria GEOGRAFIE

TOM XXXII
Nr. 2/2022 (December)

Editura Universităţii din Oradea

UNIVERSITATEA DIN ORADEA
DEPARTAMENTUL DE GEOGRAFIE, TURISM ŞI AMENAJAREA TERITORIULUI

ANALELE UNIVERSITĂŢII DIN ORADEA

Seria GEOGRAFIE

TOM XXXII
Nr. 2/2022 (December)

Editura Universităţii din Oradea

ANALELE UNIVERSITĂŢII DIN ORADEA, SERIA GEOGRAFIE
ANNALS OF UNIVERSITY OF ORADEA, GEOGRAPHY SERIE
ORADEA UNIVERSITY PRESS

ISSN 1221-1273, E-ISSN 2065-3409

ANALELE UNIVERSITĂŢII DIN ORADEA, SERIA GEOGRAFIE
ANNALS OF UNIVERSITY OF ORADEA, GEOGRAPHY SERIE
ORADEA UNIVERSITY PRESS

The Journal is issued under aegis and with financial support of:

University of Oradea, Romania
Department of Geography, Tourism and Territorial Planning
Territorial Studies and Analysis Centre
1 University St., 410087, Oradea, Romania

PUBLICATION REQUIREMENTS OF ARTICLES IN THE ANALELE UNIVERSITĂŢII DIN ORADEA, SERIA GEOGRAFIE

The Editorial Board goes through each article, which in then submitted to two referees' judgment. Names of referees are confidential to the Editorial Board. Authors may be asked to make revisions to their manuscript. If substantial revision is required manuscripts may be re-reviewed before a decision to accept/publish is made. Final acceptance of manuscripts for publication is at the discretion of the Editors.

Authors alone are responsible for the opinions expressed in their papers.

The Analele Universităţii din Oradea, Seria Geografie is indexed in:

Erih Plus

Doaj, Directory of Open Acces Journals

Ebsco

Index Copernicus

Ulrichsweb, Global Serials Directory

Genamics

Scipio

WorldCat

Crossref

Review accredited by **CNCSIS**, Code 669 "B+" Category

Google Scholar

Price of journal:

Individual	8 €
Institutional	12 €
Annual subscription	15 €

Address of the Editorial Office:

University of Oradea
Department of Geography, Tourism and Territorial Planning
Territorial Studies and Analysis Centre
1 Universităţii St., 410087, Oradea, Romania
Phone : +40 259 408 475
e-mail: auog.uoradea@yahoo.com

On line version:
http://istgeorelint.uoradea.ro/Reviste/Anale/anale.htm

ANALELE UNIVERSITĂŢII DIN ORADEA, SERIA GEOGRAFIE
ANNALS OF UNIVERSITY OF ORADEA, GEOGRAPHY SERIE
ORADEA UNIVERSITY PRESS

C O N T E N T S

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **2/2022**, pp. 74-84
ISSN **1221-1273**, E-ISSN **2065-3409** **DOI** 10.30892/auog.322101-884

THE IMPACT OF LANDFILL DIVERSION ON LAND USE AND LIFESPAN: A CASE STUDY OF THE BOUGHAREB TECHNICAL LANDFILL CENTRE IN CONSTANTINE, ALGERIA

Imen SOUKEHAL*
Urban Techniques Management Institute, University Salah Boubnider Constantine 3 PO Box N°73 New City Ali Medjeli, Ain Lbey, Constantine, Algeria, e-mail: imen.soukehal@univ-constantine3.dz

Roukia BOUADAM
Urban Techniques Management Institute, University Salah Boubnider Constantine 3 PO Box N°73 New City Ali Medjeli, Ain Lbey, Constantine, Algeria, e-mail: roukia.bouadam@univ-constantine3.dz

Citation: Soukehal, I., & Bouadam, R. (2022). The Impact of Landfill Diversion on Land Use and Lifespan: A Case Study of The Boughareb Technical Landfill Centre in Constantine, Algeria. *Analele Universităţii din Oradea, Seria Geografie*, *32*(2), 74-84. https://doi.org/10.30892/auog.322101-884

Abstract: Land filling is one of the most common methods of disposing of solid waste all over the world, however, with constantly increasing waste volumes and land scarcity, waste diversion and recovery are more likely the best answer to these concerns. This research paper presents an estimation of the diversion impact on the required land area and on the lifespan of a technical landfill centre (TLC) in Constantine, Algeria. Our methodology consists in drawing up three scenarios of operation of TLC, over a period of 15 years, with each scenario, applying a different waste diversion rate, results show that: waste diversion reduces land consumption and increases the TLC's lifespan in all three scenarios but diverting for composting is the most efficient one.

Key words: Technical Landfill Centre, Waste Diversion, Land Use, Lifespan, Households and Similar

* * * * * *

INTRODUCTION

Developing and developed countries are facing increasing population growth, industrial development, financial progress and improvement, which are main factors, associated with production of huge amount of solid waste especially in the fast growing cities and urban dwellings (Akhtar et al., 2017). The disposal and management of municipal solid waste (MSW) is one of the most pressing issues confronting cities around the world. To ensure the protection of public health and the environment, effective solid waste management requires the use of a variety of treatment methods and technologies (Reza et al., 2013).

Land-filling is one of the dominant options for solid waste disposal all over the world (Laner et al., 2012). Landfills are the most environmentally friendly final destination for waste, but only waste that has no chance of being reused, recycled, or converted into energy should be disposed of there (Carević et al., 2021). However, landfills can pose serious risks to human health

*Corresponding author

and the environment, not designed or managed properly: in developing countries, the discharge of heavy metals into the ecosystem would have been decreased, but the use of landfills as a waste disposal method has been a big issue (Eludoyin and Gafar, 2020).

Landfills have been widely used for various reasons, which include their exploitation simplicity, low investment, and cheap operating costs (Vaverková et al., 2018), some studies indicated that almost 95% of municipal solid waste (MSW) was disposed of by land filling worldwide (Ghosh et al., 2015).

In Algeria, uncontrolled open dumping waste disposal has been applied for decades to dispose of solid waste, for many reasons including: low investment and low operation costs, but since 2001, the ministry in charge of environment has promulgated the first law on: management, control and waste elimination, and launched a national program of municipal solid waste management, whose objectives include: elimination of uncontrolled dumping sites, promoting recycling and selective sorting activities. Moreover, this program aims to ensure that solid waste is collected, stored and disposed of in a manner that guarantees public health and environment protection. According to Algerian regulations, MSW is identified as of household and similar waste (HSW), the total generation of HSW, in Algeria in 2018, is about 13.1 million tonnes with a rate of 0.8 kg/inhabitant/day (AND, 2019). According to a report published by the National Waste Agency: waste sorting and recovery could generate economic gains exceeding 56 Billion Algerian Dinars, thousands of job opportunities and rationalize the use of land required for land filling (AND, 2021).

Today, despite all the efforts made in the field of solid waste management, HSW is a major environmental issue in Algeria, as it is in many developing countries. The impact of dumping solid waste in uncontrolled landfills, population growth in urban communities, increases in per capita HSW generation rates, gaps in current related legislation, lack of strategic planning, limited collection services, lack of know-how, inappropriate technology and the inadequate financing are all major challenges facing solid waste management (AND, 2019). All HSW are collected in a mixed form without source sorting, which reduces the possibility of recycling and recovery and puts pressure on the capacity of the landfill which will push the authorities to build more landfills and thus consume more land. The choice of waste disposal technology is a key issue in the field of solid waste management; this decision may have long-term consequences for environmental development and economic growth (Torkayesh et al., 2021).

Land management and conservation objectives should be the foundation for proper landfill management. To limit landfill capacity loss, this should entail controlling the site to ensure that unsuitable waste is not accepted and the nature of received waste is known, as well as diverting waste that can be recycled or reused from landfills. Several research indicates that waste land-filling can be reduced by diverting recyclable waste fraction to alternative beneficial uses (Ajayi and Oyedele, 2017; Assamoi and Lawryshyn, 2012; Mueller, 2013; Smith, 2015), diverting waste from landfills is an important factor in increasing resource efficiency, reducing waste management's environmental impacts and increasing land availability. According to the United Nations Environment Programme, diverting organic waste from landfills can decrease methane emissions by 15-20 percent (Wilson et al., 2015), several countries have already started to encourage waste diversion from landfills, for example recycling and recovery are encouraged by European waste legislation, while disposal is avoided (Scharff, 2014) according to the Directive 1999/31/EC on landfill of waste: member states of the European Union, must reduce the amount of biodegradable municipal waste going to landfill to less than 35% (EEA, 2009). In Algeria, most of (HSW) are disposed in technical landfill centres or controlled disposals, only 7% of the global waste amount are recovered and recycled.

This study was carried out in 2017 in Boughareb technical landfill centre, a class II TLC for household and similar wastes, located in the Wilaya of Constantine, eastern of Algeria. The study's major aim is to shed light on the relationship between waste diversion from landfills and the availability of land required for this operation. The information it will provide is of interest on two

levels: at the local level, this data is necessary for better management of the Bouhareb TLC, and at the national level, it can provide state authorities with a different perspective on Algeria's only mode of disposal of household and similar waste, i.e. landfill. Furthermore, despite the fact that many researchers in developed countries have already addressed this issue, it is still relevant in developing countries such as Algeria. Indeed, in Algeria technical landfills centres are a novel method for disposing of more than 90% of waste generated in all the country. Despite the fact that landfilling consumes a significant quantity of land in Algeria, that's the only method of eliminating household and similar waste. Land is a scarce resource whose sustainable use could lead to the good social and economic adaptation capacity of communities (Linc et al., 2017).

Waste management in Algeria

Algeria has a surface area of 2,381,000 km^2 and a population of roughly 43 million inhabitants. Solid waste generation is at a rate of 0.8 kg/person/day. With an annual growth rate of around 3%, the country now generates 34 million tonnes of waste, comprising 13.1 million Mt of HSW. In Algeria, the waste management policy is part of the National Environmental Strategy (NES), as well as the National Environmental and Sustainable Development Action Plan (PNAE-DD), which was concretised by the promulgation of law 01-19 of 12 December 2001 relating to the management, control and disposal of waste. It is based on the National Programme for Integrated Solid Household Waste Management (PROGDEM), which was adopted in 2002. Solid waste management in Algeria, is divided into three sectors (the public sector, the formal private sector, and the informal private sector) (Swep-net, 2014):

- The public sector which is in charge of controlling and enforcing solid waste management and collection rules in communes;
- The official private sector which is involved in waste management, including collection and recycling;
- The informal private sector which is active in waste recovery.

Waste production and population growth in Algeria

Driven by significant demographic growth combined with a change in consumption patterns and a concentration in cities, in 2018, according to statistical data published by the national statistics office (ONS, 2018) more than 70% of Algeria's 42.22 million inhabitants were urban; whereas in 2014, the urban population was estimated at 65% (ONS, 2019). As for the production of waste per inhabitant, it has increased from 0.76 kg/d/h in 1980, to 0.8 kg/d/per inhabitant in 2018. The evolution of the population has been accompanied by a considerable increase in household and similar waste, after seven years (from 2011 to 2019), it has increased from 3.9 MT to 13 MT with a growth rate of about 3% per year (table 1).

Table 1. Population growth and waste generation in Algeria
(Data source: ONS & AND)

Years	Population M In.	Waste generation MT
2011	36.3	3.9
2014	39.1	11
2016	39.6	11.6
2018	42.23	13

Waste composition and disposal in Algeria

The 2018 waste characterization report shows that: 53.6% of waste composition is organic, plastic represents 15.2%, paper and cardboard are about 7.07%, disposal dippers are 11.5%, textile is 4.5%, and metal is about 1.72% (AND, 2019). Despite the fact that household and similar waste in Algeria includes large quantities of biodegradable materials which, when land-filled, this waste pose significant difficulties from a technical (operational), ecological, and economic point of view,

we note that the most common method of disposing of collected solid waste is land-filling: up to 95% of waste produced is dumped in various technical landfill centres and controlled dumpsites, without pre-treatment (AND, 2019). In Algeria, there are three classes of technical landfill centres (TLC): class I TLC for hazardous and special wastes, class II TLC for household and similar wastes (HSW) and class III TLC for inert wastes. Class II landfills are defined in Algeria as classified facilities designed for the storage of waste while minimizing the risks of pollution or contamination of the environment. The Algerian government has made significant investments in waste treatment facilities during the previous two decades. By 2020, around 221 treatment facilities have been built, with 191 of them already in service. Between 2014 and 2020, the number of operating waste treatment facilities in Algeria climbed from 141 to 191. This evolution is linked to demographic growth and economic development. Depending on the available acreage, each landfill typically consists of one to three or more cells (figure 1).

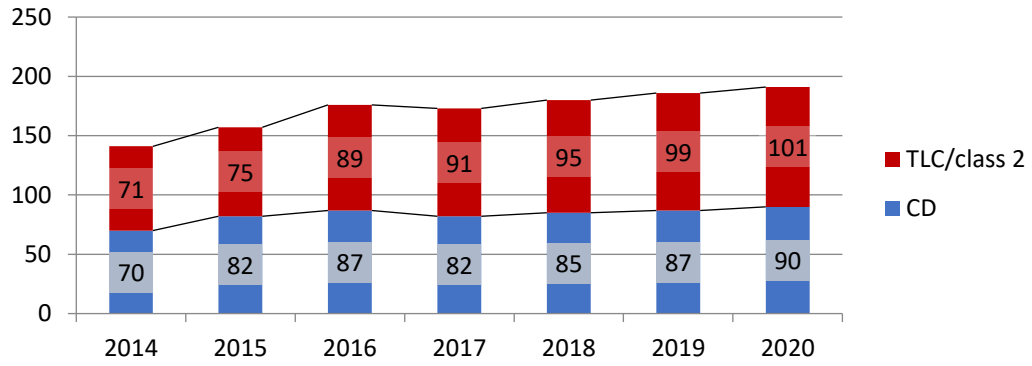


Figure 1. Evolution of HSW treatment facilities 2014-2020)
(Source: AND, 2021)

In 2020, there are 280 cells nationwide, 62 of which have achieved saturation and are thus closed, 197 of which are operational, and 21 that have been established but are not yet operational, figure 2 shows that, of the 197 cells in operation, 87 are between 50% and 100% saturated, 24 are saturated and 25 are oversaturated. This reflects a critical situation in terms of life span and future land consumption (AND, 2021).

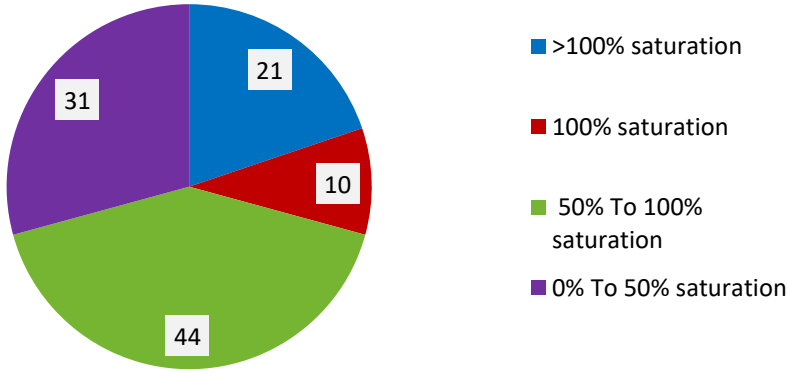


Figure 2. Cell's saturation rate (2020)
(Source: AND, 2021)

MATERIALS AND METHODS

Study area

As shown in figure 3, the study area is a technical landfill centre (TLC) in the wilaya of Constantine, in the East of Algeria, called Boughareb TLC. This class II (TLC) is located 40 Km EST of the wilaya of Constantine, precisely in Ibn Badis municipality. The geotechnical study carried out on the TLC site yielded the following results:

- The topography of the site is moderately uneven, with a slope ranging from 3 to 10%;
- The geological structure is not homogeneous: clay and sandstone are found together;
- Clays have extremely high impermeability indices, ranging from 10-6 to 10-9 cm/s;
- The sandstone has a strong compressive resistance.

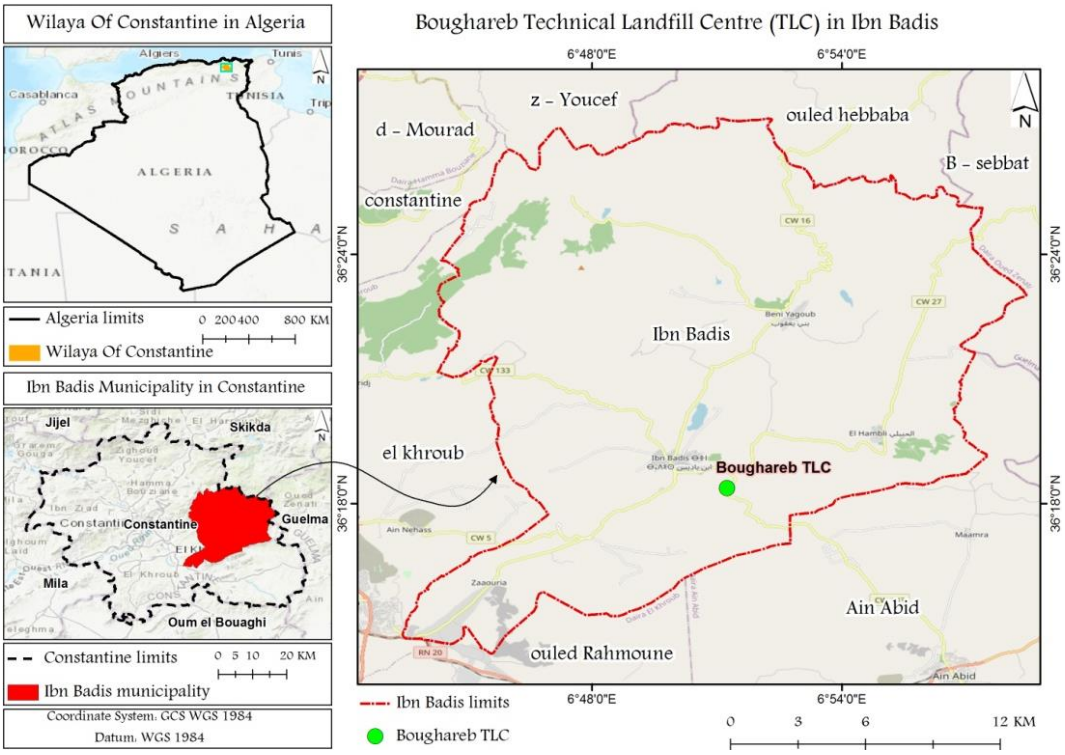


Figure 3. Localization of the study area
(Source: Authors)

Given the unavailability of land capable of housing a project as large as the TLC project, the choice of the municipality of Ibn Badis was imposed despite: the slight unevenness of the site, its remoteness from the collection communes, the vocation of the neighbouring land (agricultural) the livestock activities surrounding it.

Boughareb TLC covers a total area of 78 ha, of which 41 ha are allowed for landfilling. Currently, it consists of only one (01) realized cell that spreads over an area of 3 ha, the remaining area allowed for landfilling is 39 ha. With a volume of 200,000 m³ and a total number of cells of 9, the overall landfill volume is 1,800,000 m³, this volume will be filled with 80% of compacted waste which represent 1,440,000 m³, and 20% of cover land which represent 360,000 m³.

Since the TLC has only been operated for 05 years from a 20 years estimated service life, the remaining period is 15 years.

Data collection

For this research paper, data was collected from variety of sources and covers the entire landfill's first cell life service (from 2010 to 2014), consultation of legislative documents, annual operational reports prepared by the undertaking in charge of operating the landfill, characterization reports prepared by the national waste agency, in-depth reading of scientific studies and articles, and on-site observation were all part of the data collection process.

Primary data was collected from the technical landfill management company since it is required to provide monthly reports on received waste from each municipality and an annual report on the recovered waste, it consists; the amount and type of the waste arriving on the landfill facility, as well as the waste provenance.

Secondary data includes: demographic data and the national characterization report, it was collected from the national waste agency (AND). Both data were examined and synthesized into Excel files, graphs and tables.

Data treatment

The method consists of setting up three possible scenarios for the operation of the TLC over a period of 15 years (2022-2036), in order to demonstrate the impact of the diversion of TLC waste on the consumption of land as well as its duration of operation. The first scenario is a reference situation; it is based on waste land filling with no diversion (diversion rate = 00%), it is an operating method that was already used for the first cell; this scenario is known as BAU scenario, or business as usual. The second scenario is based on the use of only recyclable materials that are present in waste streams arriving at the TLC (textile, plastic, cardboard), Scenario A will be assigned to this scenario. In the third scenario (scenario B): the diversion will only affect the organic fraction and will be used for composting. Table 02 shows the different filling scenarios.

Table 2. Filling scenarios for Boughareb TLC
(Data source: Authors)

Waste global volume entering to the TLC (m^3)	Scenarios	Diversion rate	
		Recycling	Composting
9,110,271.62	Scenario BAU	0%	0%
	Scenario A	30.24%	0%
	Scenario B	0%	53.5%

However, the composition of waste admitted to the landfill has been only recorded for two years: 2011 and 2012. As a result, calculations will be based on data from the National Waste Agency's national characterization report established for the wilaya of Constantine for 2018. All of the equations used are listed below in chronological order.

"1" Waste diversion rate: WDR = (weight of diverted waste / weight of all waste) x 100.

"2" Landfill space: LFS = Σ (MSWT/ Waste density).

MSWT = Total Municipal solid waste disposed in the landfill (tonne): the equivalent of total household and similar disposed in the TLC (tonne).

Density of the waste = 0.75 tonne per cubic meter (t/m^3) (ME, 2018).

"3" Required Land Area (ha): RLA = Σ ({LFS/ Landfill height}/ 10000).

LFS: Landfill Space required annually in cubic meter per year (m^3/year).

Landfill height = standard height of landfill, Algerian standard = 15 meter (ME, 2018).

10,000 = the conversion of m^2 to hectare (ha).

Note that TLC area calculation is done using Gerard's recommended method from 1998, Eq.2 and Eq.3 were used (Uding Rangga et al., 2019).

RESULTS & DISCUSSION

The Boughareb technical landfill centre receives the waste generated by six of the twelve communes of the wilaya of Constantine, this waste is mainly composed of organic matter, which represents 53.50%, the recyclable fraction represents a total of 30.24%, and it is made up of: plastic, paper/cardboard and textiles (figure 4).

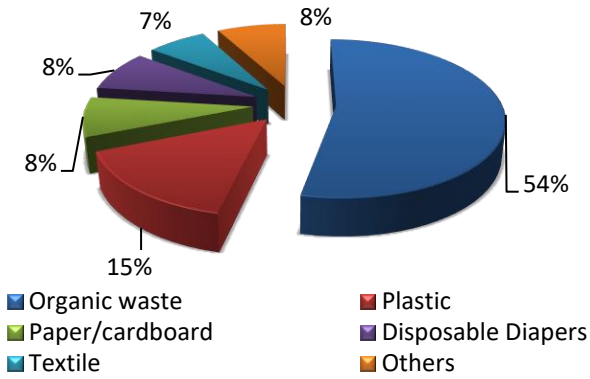


Figure 4. Constantine's waste composition 2018
(Source: AND, 2019)

Boughareb TLC is the only operational landfill in all the wilaya, it was receiving waste since 2010, from 06 municipalities: Constantine, ibnbadis, ainsmara, el khroub, ainabid and ouledrahmoun. Since it was put into operation, the quantity of waste admitted to the Boughareb landfill has steadily increased from 72,261.34 tons in 2011, to 331,930.5 tons in 2016, this increase is related not only to the parameters of population and consumption patterns but also the increase in the number of municipalities, which dump their waste in the landfill. There was a slight decrease in 2017 with 316,897.55 tons due to the commissioning of the transfer station in the municipality of Ain Smara, which is experiencing an evolving recovery activity.

Within the framework of the Study on the National Strategy and Action Plan for Integrated Waste Management and Recovery by 2035, the annual generation rate of household and similar waste was estimated at 3% (figure 5).

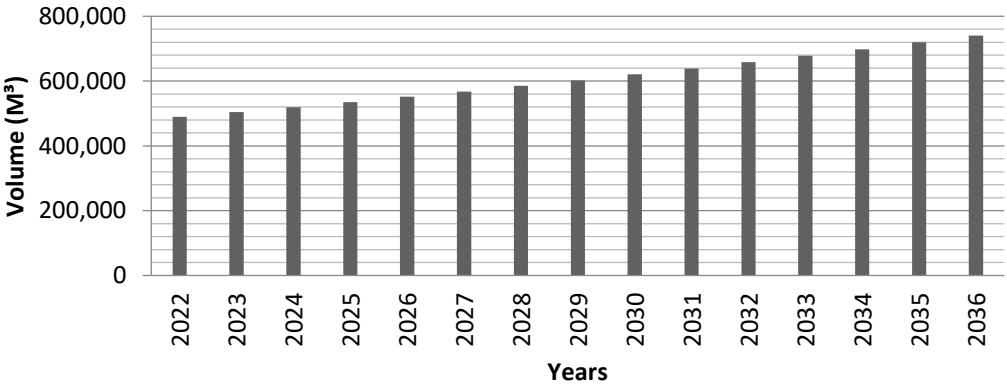


Figure 5. Amount land-filled waste at CET Boughareb
(Source: Author's estimation)

As indicated in the data treatment section, three filling scenarios were developed. The BAU scenario is considered a reference. Under this scenario, there is no diversion. 100% of the waste will be landfilled, which represents 9,110,271.62 m³. The results show that the TLC will reach saturation (calculated at 1,440,000 m³), in 2 years and 313 days of operation, instead of the 15 years estimated in the technical study (figure 6).

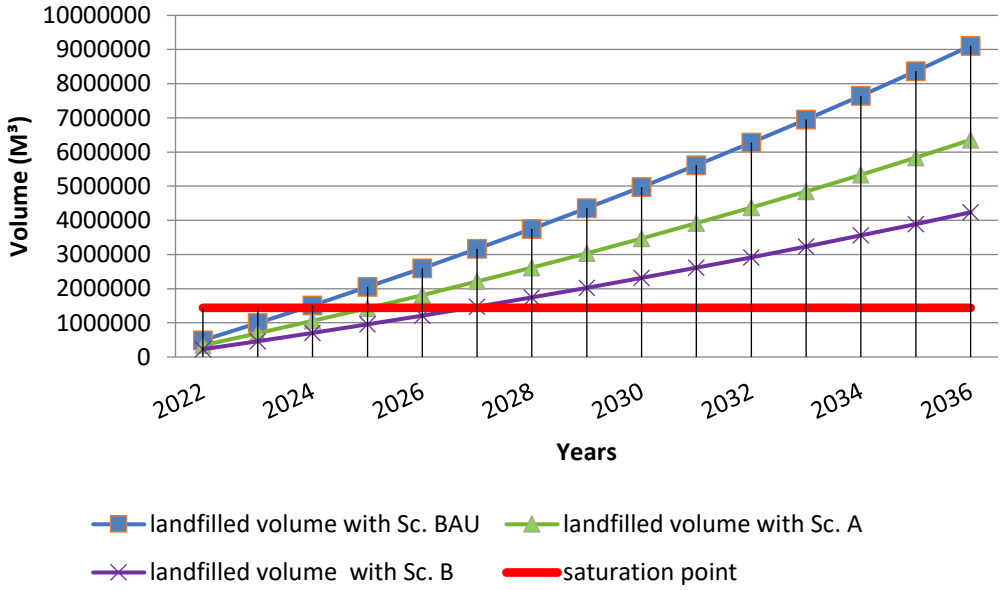


Figure 6. Filling scenarios for BougharebTLC
(Source: Author's estimation)

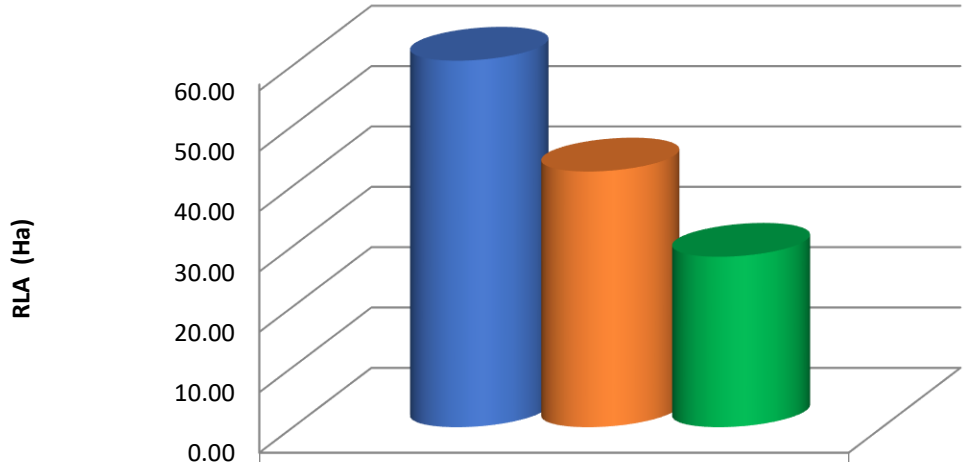
For scenario A, which is applied for a waste diversion rate of 30.24%, including only the recyclable fraction, the results indicated an operating time of 04 years and ≈ 10 days (9.90), instead of the 15 years estimated in the technical. The total amount of waste that needs to be land filled is 6,355,325.48 m³.

For scenario B the operating time obtained was 05 years and 319 days, instead of the technical study's projected 15 years. The total amount of waste that will be deposited in landfills is 4,236,276.30 m³.

The results support the positive impact of waste diversion on reducing the amount of waste entering the TLC, which helps to extend the operating life of the TLC, the scenario that includes composting has the greatest advantage, due to the important presence of organic matter in the waste streams that reach the TLC.

Landfilling is considered the most economical and acceptable method for disposing of waste, but even so, it generates toxic leachate and biogas, which are considered greenhouse gases, and comsume large land areas. Therefore, waste diversion from landfills is an important part of lowering waste management's environmental consequences and enhancing resource efficiency. The Boughareb TLC is intended to dispose household and similar waste over a 39-hectare area for 15 years. Data reveal that the BAU scenario will result in a land overconsumption of 60.74 hectares, or 21.74 hectares overrun. The functioning of the TLC under scenario A will also result in a 3.37 ha request land area (RLA) excess. The only scenario that matches the TLC technical

study's estimations is scenario B, which requests for waste diversion for composting, land consumption under scenario B is estimated at 28.24 ha (figure 7).



	Total
RLA (Ha)/ Sc.BAU	60.74
RLA (Ha)/ Sc. A	42.37
RLA (Ha)/ Sc. B	28.24

Figure 7. Required land filling area
(Source: Author's estimation)

Because household waste and similar generation will increase, significantly larger land areas will need to be used for landfills. Waste disposal will necessitate a vast amount of land. The wilaya of Constantine extends over 224,549 hectares. In 2015, the land cover was: 61.69% for agriculture; 10.04% for built-up area; 9.81% for forest; 13.12% for grassland; 5.06% for water surfaces and 5.06% for barren land (Gana et al., 2017). Barren land is composed mostly of areas of exposed soil or areas with very little vegetation cover and includes bare rocks, quarries, and gravel pits. Their surface was estimated in 2015 at about 11,358 ha. They are the most suitable lands for building landfills. According to the results of this study and the land availability, the increased creation of household waste and similar in Constantine will necessitate the usage of a significantly larger area for waste disposal. The land demand will be so important that there will be a shortage of land required for land filling area. As a result, future crises will arise owing to the scarcity of land space, a valuable natural resource.

CONCLUSION

In Constantine, the elimination of household and similar waste is done either in controlled dumps, in wild dumps or in the technical landfill centre, despite the guarantees that the TLC present in terms of environmental protection, they consume large areas of non-recoverable land considering the enormous quantities of waste produced each year. The present study shows that landfilling waste without any recovery form is affecting massively not just the technical landfill centre's lifespan, but also the required land area, furthermore the results attest the significant impact of waste diversion on the Boughareb TLC in Constantine, Algeria. In a business as usual (BAU) scenario where the diversion rate is 0%, the TLC will consume 60.74 hectares instead of 39 hectares and will not even reach the estimated lifespan in the engineering study. The TLC will be

closed in 2 years and 313 days. While by applying waste diversion the land consumption will decrease and the lifespan of the TLC will increase considerably: by diverting for recycling only, it will consume 42.37 hectares and lifespan will increase by 1 year and 60 days, but by diverting for composting, the required land area will be under the estimated area, the TLC will need only 28.24 hectares and it's lifespan will increase by 3 years and 6 days.

Algeria's waste land filling rate will definitely lead to a waste and land crisis in the near future. This is due to a number of factors, including a lack of efficient household and similar waste recovery, the dominance of landfill as the only waste disposal option, and the absence of selective waste collection. This situation could have negative consequences such as: a land problem that will have an influence on future development projects, a decline in land and property values, and a land use changing of areas surrounding the TLC, this land use changing is a result ofanthropic factors which transform the natural landscape (Kerekes and Alexe, 2019). Therefor, there is a need to integrate existing and future landfills into the general city-level spatial planning framework for a coherent development planning process (Dada, 2020).

AKNOWLEGMENTS

The authors would like to fully acknowledge the help given by the National waste agency (AND) and the Wilaya's Public Management Establishment of Technical Landfill Centre - Constantine (EPWG CET) for all the information provided to undertake this work.

REFERENCES

Ajayi, S. & Oyedele, L. (2017). Policy imperatives for diverting construction waste from landfill: Experts' recommendations for UK policy expansion. *Journal of Cleaner Production*, 147, 57-65.

Akhtar, A., Ahmad, A., Qureshi, M. & Shahraz, S. (2017). Households willingness to pay for improved solid waste management. *Global Journal of Environmental Science and Management*, 3(2), 143-152. doi:10.22034/gjesm.2017.03.02.003

AND. (2019). Caractérisation des déchets ménagers et assimilés. campagne nationale 2018 / 2019. Retrieved March 3, 2021, from https://and.dz/site/wp-content/uploads/caract%C3%A9risation2019.pdf.

AND. (2021). *Rapport sur l'État de la Gestion des Déchets en Algérie.* Agence Nationale des Déchets. Retrieved July 15, 2021, from http://and.dz/site/wp-content/uploads/rapport%20DMA2.pdf.

Assamoi, B. & Lawryshyn, Y. (2012). The environmental comparison of landfilling vs. incineration of MSW accounting for waste diversion. *Waste Management*, 32(5), 1019-1030.

Carević, I., Sibinović, M., Manojlović, S., Batoćanin, N., Petrović, A., & Srejić, T. (2021). Geological Approach for Landfill Site Selection: A Case Study of Vršac Municipality, Serbia. *Sustainability*, 13(14), 1-15. doi:10.3390/su13147810

Dada, O. (2020). Environmental and health hazards of residents domiciled around Africa's largest landfill. *Journal of Environmental Planning and Management*, 64(9), 1642-1667. doi:10.1080/09640568.2020.1835621

EEA. (2009). *Diverting waste from landfill, effectiveness of waste-management policies in the European union.* Luxembourg: Office for Official Publications of the European Communities.

Eludoyin, O. & Gafar, M. (2020). Effects of urban waste on heavy metals concentration in Carica Papaya Linn and soil in Eneka Dumpsite, Port Harcourt, Rivers State, Nigeria. *Analele Universităţii din Oradea, Seria Geografie*, 30(2), 131-140. doi:10.30892/auog.302102-840

Gana, M., Benderradji, M., Saint-Gerand, T. & Alatou, D. (2017). Monitoring Land Use/Land Cover Dynamics in the Province of Constantine, Algeria using Remote Sensing and GIS. *Indian Journal of Science and Technology*, 10(41), 1-9. doi:10.17485/ijst/2017/v10i41/115586

Ghosh, P., Gupta, A. & Thakur, I. (2015). Combined chemical and toxicological evaluation of leachate from municipal solid waste landfill sites of Delhi, India. *Environmental Science and Pollution Research International*, 22(12), 9148-9158. doi:10.1007/s11356-015-4077-7

Kerekes, A. & Alexe, M. (2019). Evaluating Urban Sprawl and Land-Use Change Using Remote Sensing, GIS Techniques and Historical Maps. Case Study: The City of Dej, Romania. *Analele Universităţii din Oradea, Seria Geografie*, 29(2), 52-63. doi:10.30892/auog.292106-799

Laner, D., Fellner, J. & Brunner, P. (2012). Site-specific criteria for the completion of landfill aftercare. *Waste Management & Research*, 30(9), 88–99. doi:10.1177/0734242X12453610

Linc, R., Dincă, I., Tătar, C., Staşac, M., Nistor, S., & Bucur, L. (2017). The household independent cellars of oradea hills, Romania: a chance to continuity through the human and environmental capital. *Analele Universităţii din Oradea, Seria Geografie, 27*(2), 141-152.

ME. (2018). *Centre d'enfouissement technique (CET) classe II : Etude, Réalisation, Exploitation*. Manuel Technique (Deuxième Edition). Retrieved September 15, 2022 from https://www.me.gov.dz/fr/telechargement/centre-denfouissement-technique-cet-classe-ii/.

Mueller, W. (2013). The effectiveness of recycling policy options: waste diversion or just diversions? *Waste management*, 33(3), 508-518. doi:10.1016/j.wasman.2012.12.007

ONS. (2011). *Démographie algérienne. Algérie*: Office National des statistiques: Retrieved February 4, 2022 from https://www.ons.dz/spip.php?rubrique182.

ONS. (2014). *Démographie algérienne. Algérie*: Office National des statistiques: Retrieved February 5, 2022 from https://www.ons.dz/spip.php?rubrique182.

ONS. (2016). *Démographie algérienne. Algérie*: Office National des statistiques: Retrieved February 4, 2022 from https://www.ons.dz/spip.php?rubrique182.

ONS. (2018). *Démographie algérienne. Algérie*: Office National des statistiques: Retrieved February 4, 2022 from https://www.ons.dz/spip.php?rubrique182.

ONS. (2019). *Population et Démographie.* Alger: Office National des Statistiques. Retrieved February 4, 2022 from https://www.ons.dz/spip.php?rubrique13.

Reza, B., Soltani, A., Ruparathna, R., Sadiq, R., & Hewage, K. (2013). Environmental and economic aspects of production and utilization of RDF as alternative fuel in cement plants: A case study of Metro Vancouver Waste Management. *Resources, Conservation and Recycling* 81: 105-114.

Scharff, H. (2014). Landfill reduction experience in the Netherlands. *Waste management* 34(11): 2218-2224. doi:10.1016/j.wasman.2014.05.019

Smith, K. (2015). *Report: L.A. County must expedite recycling to meet landfill reduction goals. San Gabriel Valley Tribune.* Retrieved August 29, 2021, from www.sgvtribune.com/2015/07/13/report-la-county-must-expediterecycling- to-meet-landfill-reduction-goals/.

Swep-net. (2014). *Rapport sur la gestion des déchets solides en Algérie.*Retrieved March 3, 2020, from https://www.resourcerecovery.net/sites/default/files/algerie_ra_fr_web_0.pdf.

Torkayesh, A., Behnam, M., & Mehdi, R. (2021). Sustainable waste disposal technology selection: The stratified best-worst multi-criteria decision-making method. *Waste Management*, 122, 100-112. doi:10.1016/j.wasman.2020.12.040

Uding Rangga, J., Syed Ismail, S., Rasdi, I., Karuppiah, K., & Ikmal Irozi, M. (2019). Environmental Impact, Health Risk, and Management Cost of Landfilling Practice: A Case Study in Klang, Selangor, Malaysia. *Journal of Waste Management and Disposal*, 2(1), 1-12.

Vaverková, M., Adamcová, D., Zloch, J., Radziemska, M., Boas Berg, A., Voběrková, S., & Maxianová, A. (2018). Impact of Municipal Solid Waste Landfill on Environment – A Case Study. *Journal of Ecological Engineering*, 19(4), 55-68. doi:10.12911/22998993/89664

Wilson, D., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, C. & Simonett, O. (2015). *Global Waste Management Outlook.* United Nations Environment Programme.

Submitted:	Revised:	Accepted	Published online
December 16, 2021	February 28, 2022	March 3, 2022	October 20, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **2/2022**, pp. 85-100
ISSN **1221-1273**, E-ISSN **2065-3409** **DOI** 10.30892/auog.322102-885

PADIŞ - A GEOMORPHOMETRIC APPROACH

Lucian BLAGA*
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: blagalucian2012@gmail.com

Grigore Vasile HERMAN
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: grigoreherman@yahoo.com

Citation: Blaga, L. & Herman, G.V. (2022). Padiș – A Geomorphometric approach. *Analele Universităţii din Oradea, Seria Geografie*, 32(2), 85-100. https://doi.org/10.30892/auog.322102-885

Abstract: This study presents a unitary morphometric analysis for one of the most spectacular karst sectors in Romania: the closed basin Padiș – Cetățile Ponorului. 2 DEMs was used for this purpose, one derived from the interpolation of level curves and altimetry quotas from topographic maps, on scale 1 : 25000, and the second (generated from LiDAR data) was taken over from the National Agency for Cadastre and Land Registration (ANCPI). We have processed 6 morphometric parameters comparatively (hypsometry, slope, aspect and 3 types of curvatures : profil, plan and general curvature) to highlight the metric features of the relief in the studied area as accurately as possible. The results show that the surface relief in Padiș is mature, with an average altitude of 1268 m, in which prevail the slopes with moderate tilt (6 - 17°), predominantly sunny and semi-sunny. The relation between the general curvature values and the hydrogeologic features of the area explains the distribution of the sectors with underground water loss and also the disorganized distribution of the surface hydrographic network.

Key words: Padiș, morphometry, slope, aspect, curvatures

* * * * * *

INTRODUCTION

Padiș, one of the most spectacular sectors of the Apuseni Mountains, is probably the most known area from these mountains, knowledge offered by the numerous research studies done here and also by its widespread publicity online. A simple typing of the word ”Padiș” in Google Search Engine offers 29 600 results in 0.69 seconds.

Concerning the scientific knowledge of the karst in Padiș, it is noticeable a concentration of the research on three directions of interconnected approaches. The first one is lithostratigraphic and structural with studies that target the knowledge and effective mapping of the deposits in the area (Bleahu, 1957a; Bleahu, 1964; Patrulius et al., 1971; Ianovici et al., 1976; Lupu, D., 1975; Bordea and Bordea, 1982; Bleahu et al., 1985; Mantea, 1985). The second research direction is hydrogeological, focusing on the dynamics and geochemistry of the karst streams from the area. The studies of Viehmann (1966a,b), Vălenaș et al. (1982), Orășeanu et al. (1991), Orășeanu (1996, 2010)

* Corresponding Author

are important here. The third direction, predominantly geomorphological, is focused on the Padiș karst morphology with complex and well-documented studies that track the carbonation and dissolution mechanisms, the establishment of the present karst types, the assessment of the karst dynamics (Bleahu, 1957b; Bleahu, 1974; Viehmann et al., 1980; Viehmann, 1991; Vălenaș et al., 1977; Vălenaș, 1984; Cocean, 1985, 1990, 1992, 1993). Also included here are the studies that present the discoveries of new endokarst forms, most of them with very well-made maps (Vălenaș, 1977 – 1978, 1982; Damm, 1992; Damm and Moreh, 2001; Damm et al., 2004 – 2005).

Besides these, there are other studies that integrate the features of this mountainous area in presentations accessible for the wider audience (Bleahu and Bordea, 1967, 1974, 1981; Gaceu et al., 2012; Gaceu et al., 2013), that emphasize the touristic promotion of Padiș.

Morphometrically, the current studies are either punctual, meaning that for each karst unit a topographic survey was done, or the morphometric data were taken from Bleahu & Bordea's studies and completed with data from topographic maps. Here we also have to mention the morphometric processing that refers to Bătrâna Mountains (Badea et al., 2006) and Indrieș's (2010), that focuses on Padiș – Scărișoara Mountains.

Our study aims to present a unitary quantitative approach of Padiș – Cetățile Ponorului endorheic basin. Our main objective is the accurate obtaining of the basic morphometric parameters that characterize the area, based on good and very good quality of entry data.

STUDY AREA

The name "Padiș – Cetățile Ponorului Endorheic Basin" does not leave any questions regarding the limits of the analysed area. In accordance with the reality in the field and out of respect for the aforementioned researchers, the limits of this area located in the central-northern part of Bihor Mountains (figure 1), were mapped in a classical way (on georeferenced topographic maps, scale 1: 25000) on the alignments of interfluves described very well by Bleahu and Bordea (1981), so we will not discuss them.

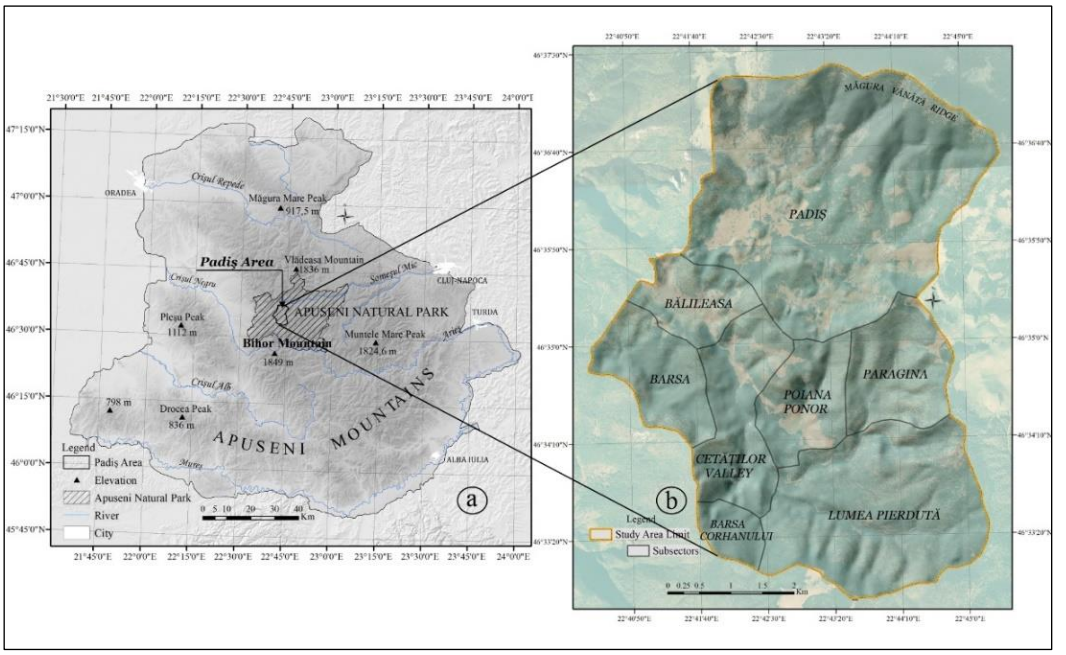


Figure 1. a) Study area location in Apuseni Mountains; b) Study Area with subsectors
(Source: Authors)

The surface that resulted after the delimitation covers 3593 ha (the above mentioned authors give the value of 36 km^2).

The endorheic character (noticed by Bleahu as early as 1953 – 1954, in ”Minutes of the meetints of the Geologic Committee”, published in 1957) and the division of the basin in 8 subsectors (map 1), are largely determined by the double alternation of layers of impermeable, non-karstificable rocks with layers of soluble rocks (limestone and dolomite).

The vegetation is coniferous (mainly spruce), broadleaf forests (beech) and secondary grassland. Inversions of vegetation often occur (the spruce is present on the plateau and especially on the bottom of humid sinkholes and the beech and the associated vegetation climb up the slopes), due to the persistent thermal inversion. The ecological management is provided by Apuseni Natural Park, as the studied area belongs to it.

MATERIALS AND METHODS

In this study we used 2 digital elevation models (DEMs) for the morphometric processing. The first one, called DEM_TOPO, was obtained through the interpolation of the elevation features (contour lines and altimetry quota corresponding to the most important peaks) digitized from the topographic maps 1:25000 (L-34-058-A-b; L-34-058-A-d; L-34-058-B-a; L-34-058-B-c), using Topo to Raster method, based on ANUDEM (Australian National University's Digital Elevation Model) locally adaptive elevation gridding procedure developed by Hutchinson (1989). The vertical accuracy of the entry data is 10 m (ensured by the 10 m equidistance between the contour lines), but for interpolation we selected a cell size of 15 m to reduce the so-called ”terracing” effect. The second elevation model, called DEM_LiDAR, was taken from ANCPI (National Agency for Cadastre and Land Registration), that offers an elevation model processed from LiDAR data, obtained during the Laki II project, that covers totally or partially 6 counties from Romania (Bihor, Arad, Alba, Hunedoara, Mureș, Harghita). The absolute vertical precision is 10 cm and the horizontal one is 30 cm. The data downloaded from Geoportal ANCPI have the resolution of 1m, and for the DEM extraction, after the mosaicking procedure of the grid-type rasters, a resampling was done at a resolution of 10 m. We mention the fact that for the extraction of both DEMs, it was used a buffer of 30 m to the limit – digitized polygon to ensure the best environment to run the used algorithms (sliding 3 x 3 or 5 x 5 cells window on raster). As a consequence, the surface of the study area for which we will do all the quantitatve reports is 3675 ha, the difference of 82 ha compared to the mapped limit being irrelevant from statistical point of view.

The morphometric parameters used in this study are part of the primary attributes category (Wilson and Gallant, 2000): hypsometry, slope, aspect and 3 types of curvatures (profil, plan and general curvature). To obtain them we tested comparatively 2 methods implemented in SAGA (System for Automated Geoscientific Analyses): Zevenbergen and Thorne’s (1987), with 9 polynominal parameters, and Florinsky’s (2009), with 10 polynominal parameters. For the testing, we used curvatures due to their sensitive behaviour. We mostly aimed at standard deviation and standard error to have acceptable values and the distribution of values at the cell level to offer a reasonable possibility of grouping them in territory. The results have shown that for the elevation data stored in DEM_TOPO, the behaviour of the algorithms derived from the 2 approaches is almost identical, but for DEM_LiDAR, meaning for data with very good resolution, it was noticed that Florinsky’s method is more suitable (figure 2) for our objective because it offers a better spatial uniformity of the values with a positive effect in the setting of the classes. As a result, all the morphometric processing in this study is based on Florinsky’s method.

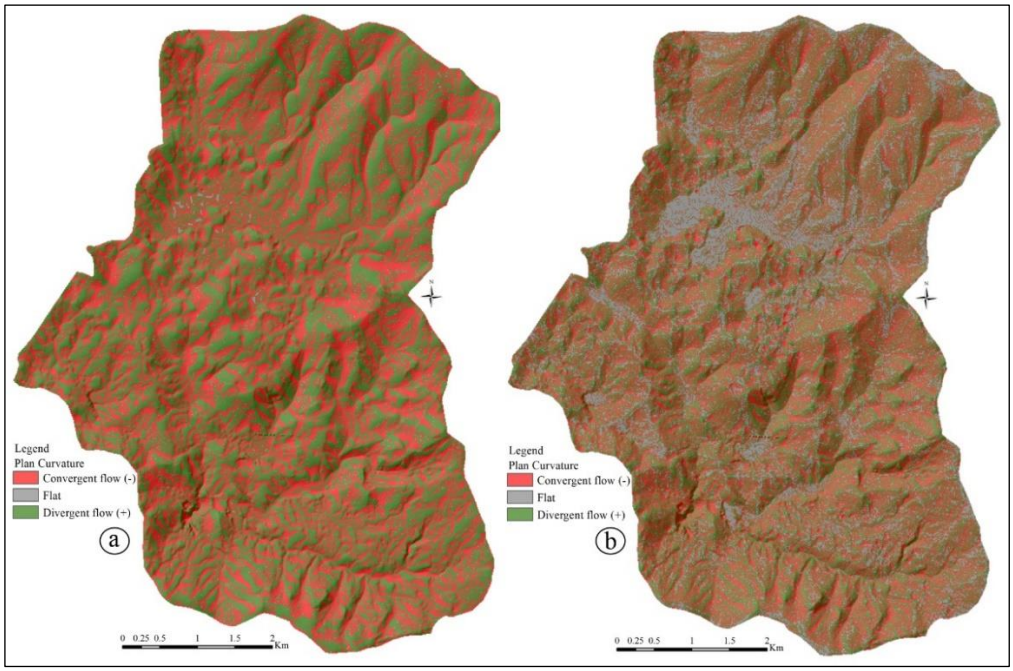


Figure 2. Plan Curvature from DEM_LiDAR obtained through: a) Florinsky method; b) Zevenbergen and Thorne method
(Source: Authors)

RESULTS AND DISCUSSION

Hypsometry

For the maximum and minimum altitude we kept the values from the topographic maps: 1641 m, in the NE corner of the sector, and 936 m in SV (Cetățile Ponorului). The average elevation for Padiș is 1268 m (value extracted from DEM_LiDAR).

Overall (figure 3), the altitude decreases in NW – SE direction and from W to E (towards Cetățile Ponorului and Barsa). Regarding the distribution of altitude ranges (table 1, figure 4), it is noticeable that 78 % of the analysed surface is between 936 m and 1350 m. The 1350 – 1450 m level has a ratio of only 14 %, and the highest level, with a ratio of 8 %, corresponds to the alignment of ridges that borders the plateau.

Table 1. The distribution of the Padiș area by altitude ranges
(Source: Authors)

	Altitude Ranges.					
	936 - 1150 m	1150.01 - 1250 m	1250. 01 - 1350 m	1350.01 - 1450 m	1450.01 - 1643 m	Total Area (ha)
Area from DEM_TOPO (ha)	632.50	1053.16	1194.84	507.76	287.28	3675.5
Area from DEM_LiDAR (ha)	603.72	1040.47	1211.26	521.05	298.92	3675.5

The explanation of this distribution of altitude values is given by the arrangement of the lithology in alternating strips, with strata that incline in the general direction NW - SE, which also

influenced the direction of the underground drainage, with an obvious effect in accentuating the karst modeling for the SW part of the basin.

The comparative analysis of the altimetric intervals in the 2 DEMs (figure 4) shows an almost perfect similarity in terms of their spatial distribution. However, there is a 1% difference between the first and the second altimetric interval, an aspect that is best observed if you follow the passage from the Bălileasa uvala to the Cetăților Valley (figure 3).

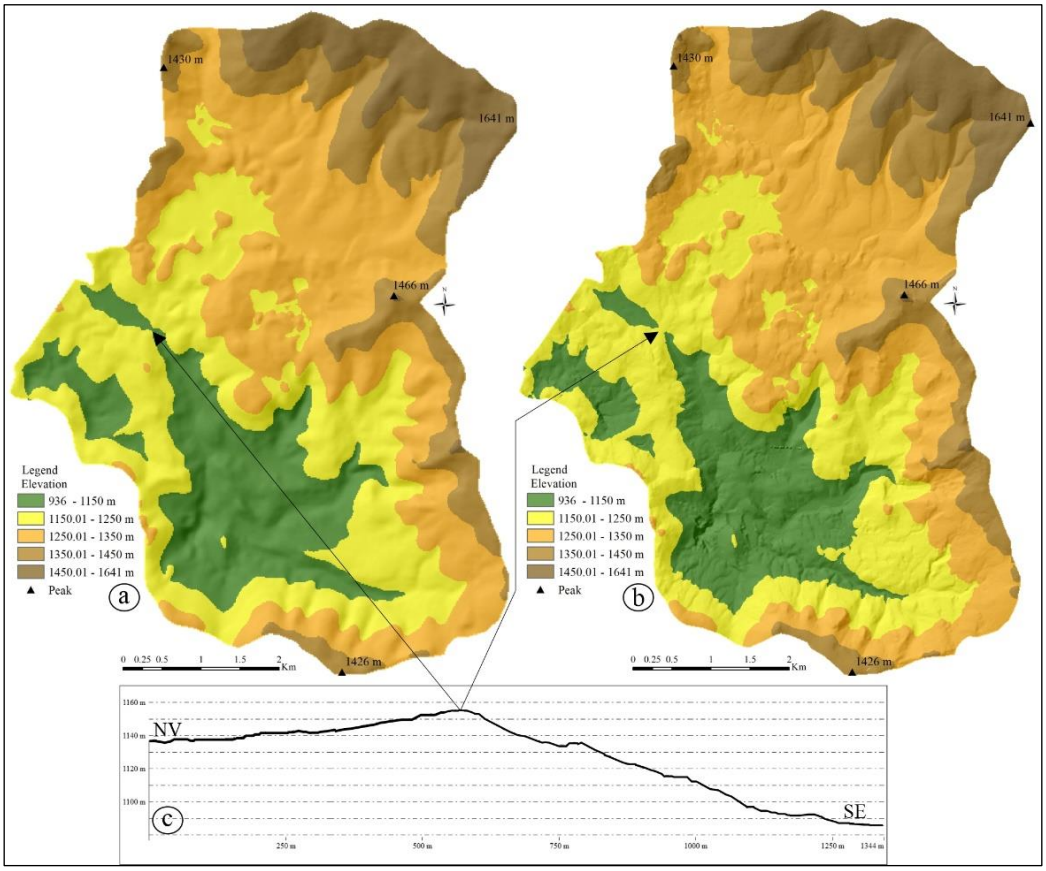


Figure 3. Hypsometry: a) Hypsometric raster based on DEM_TOPO. b) Hypsometric raster based on DEM_LiDAR. c) Longitudinal profile through the crossing sector between Bălileasa and Cetăților Valley (Source: Authors)

Table 2. Tabulated Area between surfaces of altitude ranges derived from DEM_TOPO and surfaces of altitude ranges derived from DEM_LiDAR (expressed in hectares)
(Source: Authors)

		936 - 1150 m	1150 - 1250 m	1250 - 1350 m	1350 - 1450 m	1450 - 1643 m
DEM_TOPO	936 - 1150 m	590.16	41.51	0	0	0
	1150 - 1250 m	14.14	978.27	58.96	0	0
	1250 - 1350 m	0	18.90	1142.40	31.24	0
	1350 - 1450 m	0	0	7.24	486.24	13.72
	1450 - 1643 m	0	0	0	2.07	283.50

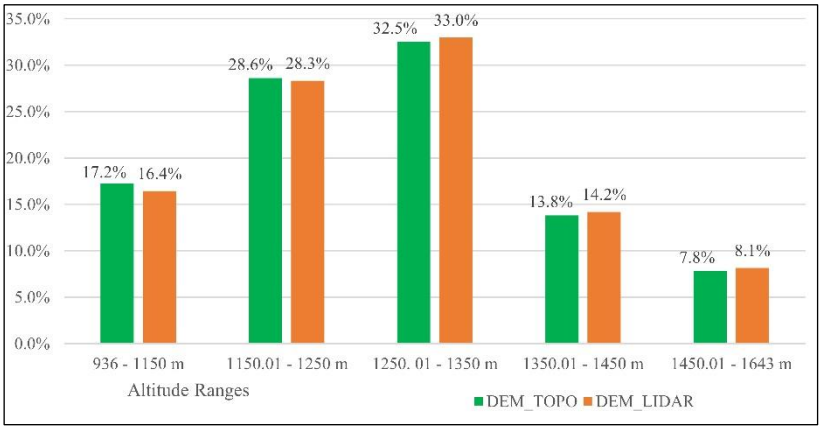


Figure 4. The percentage distribution of the area by altitude intervals
(Source: Authors)

For the rest of the altitude ranges, the differences in occupied surface and migrations from one hypsometric range to another are insignificant (table 2).

Slope

The slope classes and their spatial distribution (figure 5) express very well the plateau character of the northern compartment (Padiș Plateau), the quasi-horizontality of Bălileasa and the more rugged relief in the central and south-western part of the basin. Almost half (49 %) of the surface has a moderate slope, with values between 6 and 17° (table 3, figure 6), a very important fact for the achievement of a good infiltration of the surface water.

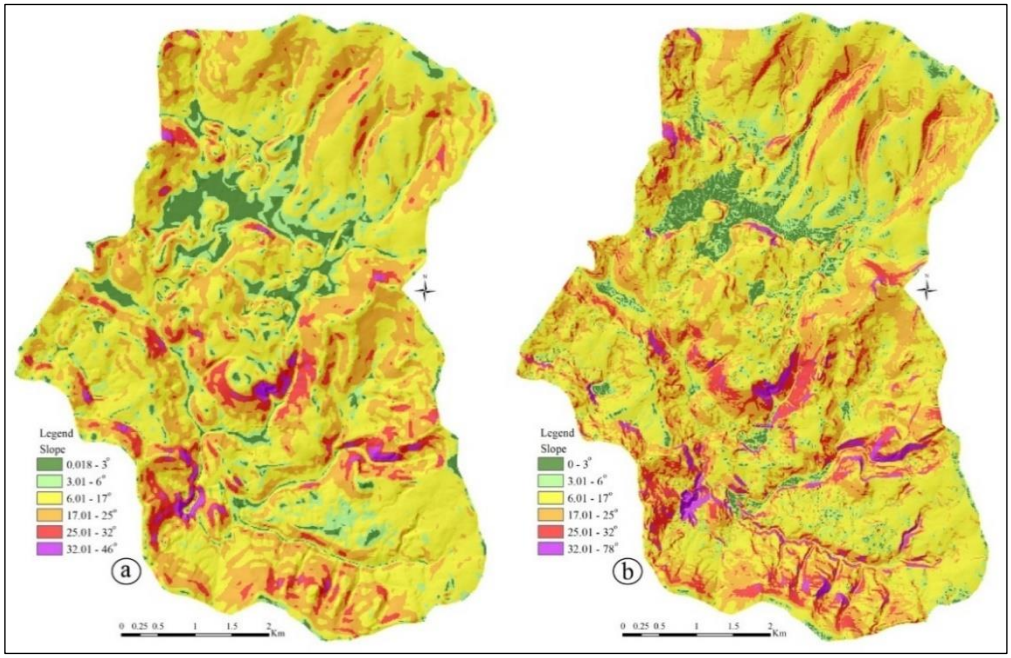


Figure 5. Slope based on: a) DEM_TOPO ; b) DEM_LiDAR
(Source: Authors)

The horizontal / quasi-horizontal and slightly tilted terrains represent 12 – 15 % of the total analysed surface, and the class over 32° covers 1 – 2.5 % of Padiș surface. The slope values that mark the petrographic and erosional abrupts (over 45°) are found in Cetățile Ponorului, Izbucul Ponorului, the right slope of Ursului valley towards the spring, the left slope of Seci (Glăvoiul) valley and in Pietrele Boghii. Only the slope raster derived from LiDAR has stored values over 70° tilt, while for the slope obtained from DEM_TOPO, the values stop at 46°.

Table 3. The distribution of the Padiș area by slope classes
(Source: Authors)

	Slope Classes						
	0 - 3°	3 - 6°	6 - 17°	17 -25°	25 - 32°	32 - 45/78°	Total Area
Area from DEM_TOPO (ha)	215.66	322.70	1815.93	1048.88	230.94	41.42	3675.5
Area from DEM_LiDAR (ha)	167.83	275.53	1796.78	1028.42	315.36	91.50	3675.5

As can be seen from figures 6, the only slope class where almost the same percentage weight is kept on both sets of results derived from DEM_TOPO and DEM_LiDAR, is the one of 6 - 17°. For the rest of the classes, the differences are between 1 and 3 % and are clearly conditioned by the greater variety of cell-level input data from DEM_LIDAR.

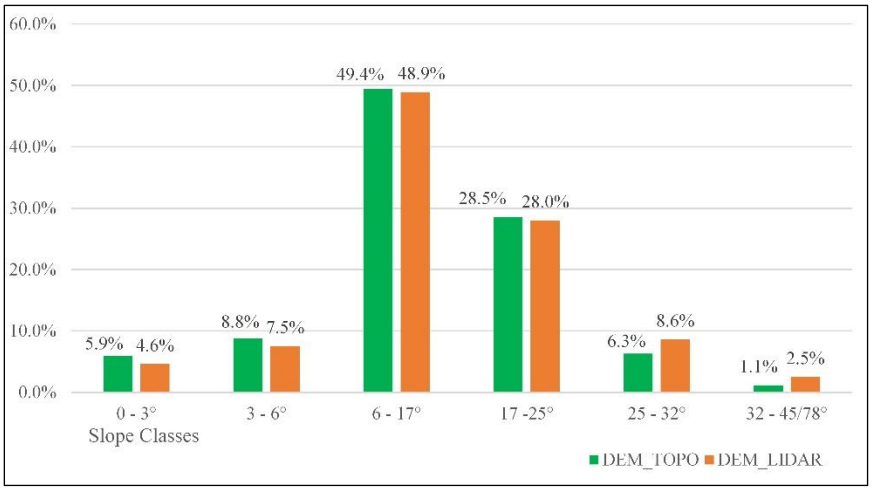


Figure 6. The percentage distribution of the area by slope classes
(Source: Authors)

Actually, if we analyse the spatial correspondence between the classes of the 2 rasters, we notice significant differences. For example, for the class 3 - 6° from DEM_TOPO, only 87 ha are kept in the same class for the data derived from DEM_LiDAR, and the rest migrate maily to the class 6 - 17° (table 4). For the class 25 - 32°, only 93 ha are kept in the same class as the slope raster derived from DEM_LiDAR. We draw attention that we talk about migrations of the surfaces of the rasters from one class to another, that is we should not confound the information from frigure 6 with that from table 4.

Table 4. Tabulated Area between slope classes areas derived from DEM_TOPO and slope classes areas derived from DEM_LiDAR (expressed in hectares)
(Source: Authors)

		0 - 3°	3 - 6°	6 - 17°	17 -25°	25 - 32°	32 - 45/78°
DEM_TOPO	0 - 3°	78.06	58.62	64.06	8.14	2.48	0.90
	3 - 6°	47.65	87.44	163.99	18.27	3.86	0.69
	6 - 17°	36.14	123.51	1224.33	359.01	55.24	16.55
	17 -25°	1.17	6.28	322.39	542.65	149.02	23.86
	25 - 32°	0.14	0.90	18.62	91.10	93.17	27.52
	32 - 45/78°	0.00	0.21	2.00	7.24	13.10	20.07

Aspect

In this study, the aspect rasters were classified to obtain the 4 standard classes (shady slopes, semi-shady slopes, semi-sunny slopes, sunny slopes), to which we add the horizontal terrains (figure 7). We mention that the rasters derived from any GIS soft for the aspect parameter (slope azimuth) highlight only the perfectly horizontal terrains (mathematically). If we want to highlight these terrains on aspect maps, with a correspondence with the horizontal terrains on slope maps, some processing is required presented by Blaga et al. (2014).

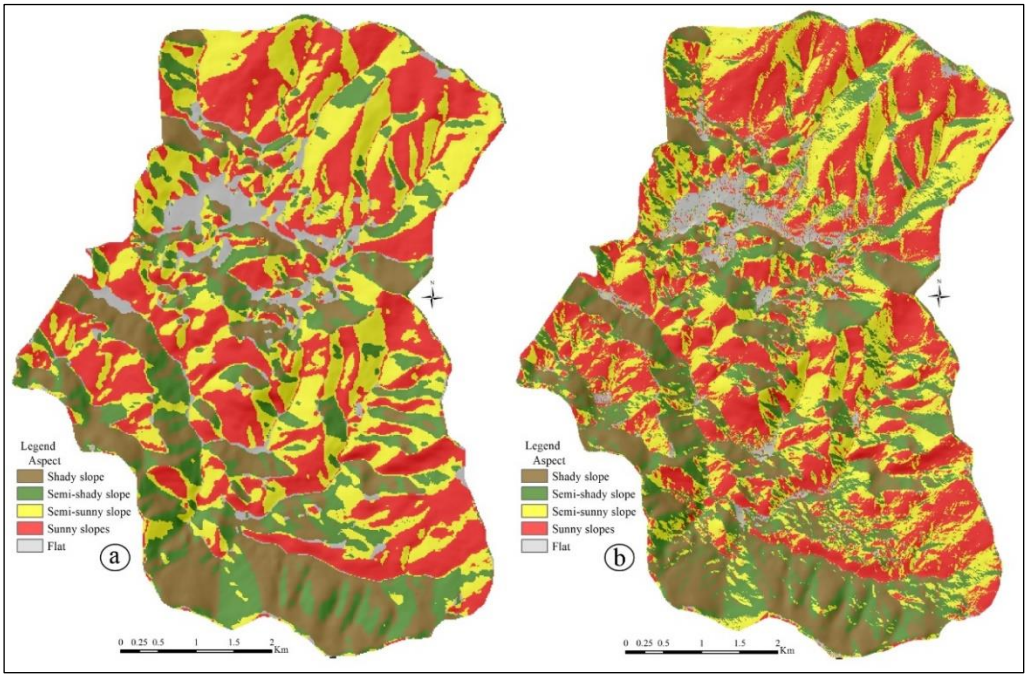


Figure 7. Aspect based on: a) DEM_TOPO; b) DEM_LiDAR
(Source: Authors)

The largest percentage of the total area of the basin belongs to sunny slopes (33%), followed by semi-sunny slopes with 28% (figure 6). The shady and semi-shady slopes together cover less than 1300 ha (table 5), being distributed spatially, mainly in the southern half of the area.

Table 5. The distribution of the Padiș area by sspect classes
(Source: Authors)

	Slope Aspect Classes					
	Shady slopes	Semi-shady slopes	Semi-sunny slopes	Sunny slopes	Flat	Total Area
Area from DEM_TOPO (ha)	595.91	670.12	1018.85	1174.89	215.66	3675.4
Area from DEM_LiDAR (ha)	583.46	689.63	1040.07	1194.43	167.83	3675.4

The comparative analysis of the surfaces related to the aspect slope classes derived from the 2 DEMs (figure 8), indicates an almost perfect quantitative correspondence, and it is normal to be so, because no matter how much information variety the LiDAR data bring, the slope azimuth can only be one for a hillslope (if the processing is done correctly).

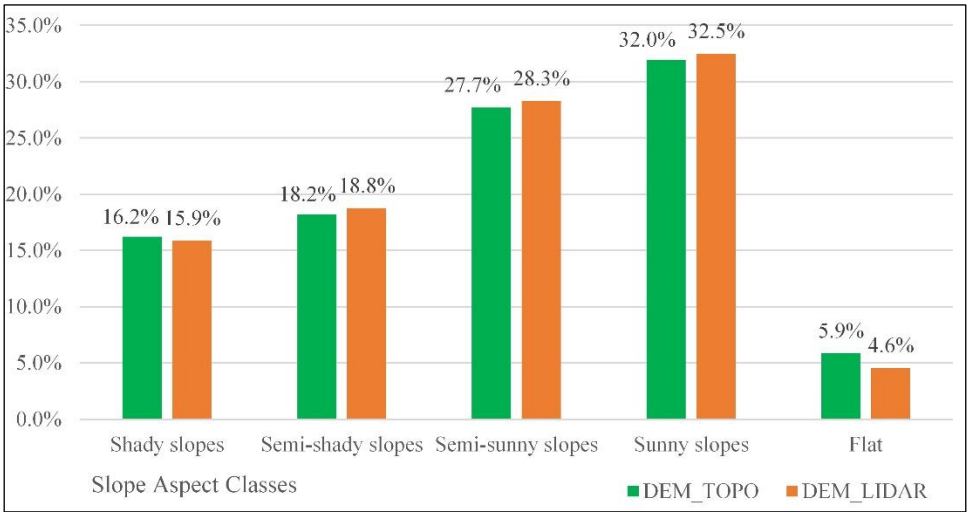


Figure 8. The percentage distribution of the area by slope aspect classes
(Source: Authors)

Land Surface Curvatures

Since 2012, the year of the publication of a study related to the significance of the curvatures (Blaga, 2012) up to now, the confusions related to their interpretation and implementation in GIS softs have still been present, although in this period a lot of well-documented articles on this topic have been published, as the one written by Minár, Evans and Jenčo in 2020. As the above mentioned authors say, there is a problem with the LiDAR data (they indirectly make this reference, meaning that they recommend smoothing and generalization of DEMs), related to the wide variety of Z (altitude) data at cell level and the implementation of the method of calculation in the GIS softs. Without going into details, (without forgetting our objective) we mention that this was the main reason why we chose Florinsky's algorithmization. **Profile Curvature**

It expresses the changing rate of the slope on the versant profile direction, along the flow alignments, perpendicular to the level curves, respectively. Morphologically, it indicates the convex (positive values in SAGA) and concave (negative values in SAGA) character of the slopes in the vertical plane (from the interfluves to the adjacent channels). From the point of view of runoff and

erosion/deposition, it indicates sectors with high (convex areas) or low (concave areas) potential for accelerating runoff or decelerating runoff on slopes, and implicitly for intensifying erosion/deposition. The tolerance range for horizontal lands is ± 0.0001.

At the level of the entire basin, a balance is observed in the distribution and percentage of convex and concave areas (figure 9), with a slight increase for convex surfaces, which varies from 41 ha for the profile curvature from DEM_TOPO, to 161 ha for the profile curvature derived from DEM_LiDAR (table 6).

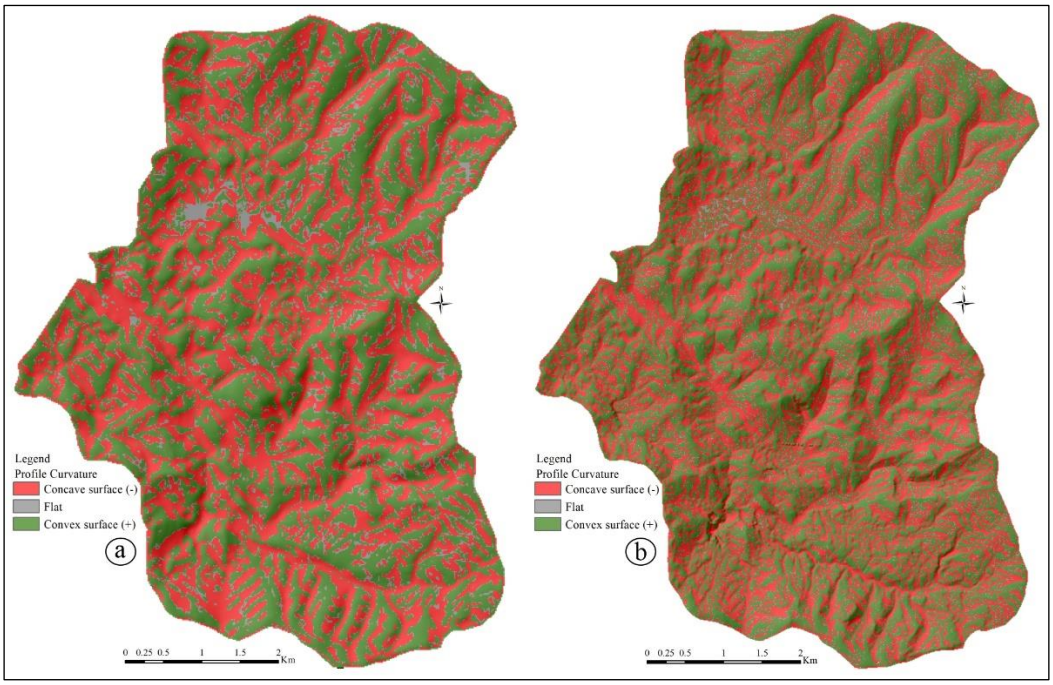


Figure 9. Profile Curvature based on: a) DEM_TOPO; b) DEM_LiDAR
(Source: Authors)

Table 6. The distribution of the Padiș area by profile curvature classes.
(Source: Authors)

	Profile Curvature Classes			
	Convex Area (+)	Concave Area (-)	Flat	Total Area
Area from DEM_TOPO (ha)	1694.30	1652.60	328.64	3675.5
Area from DEM_LiDAR (ha)	1817.13	1655.35	202.94	3675.4

Plan Curvature

In summary, it expresses the rate of change of the slope in a direction parallel to the isohypses, that is, it shows us the convex or concave character of the surfaces in this direction. It is essential in modeling runoff on slopes, because it indicates its convergent or divergent character, a fact already demonstrated by existing studies (Mitasova et al., 1995; Mitasova et al., 1996; Mitas and Mitasova, 1998), with the specification that in the mentioned studies the plan curvature is replaced by the

tangential curvature that has the same significance. The analysis of the spatial and quantitative ditribution of the sectors with convergent and divergent runoff from the study area (figure 10, table 7) shows a balance similar to the one revealed for the values of the profile curvature.

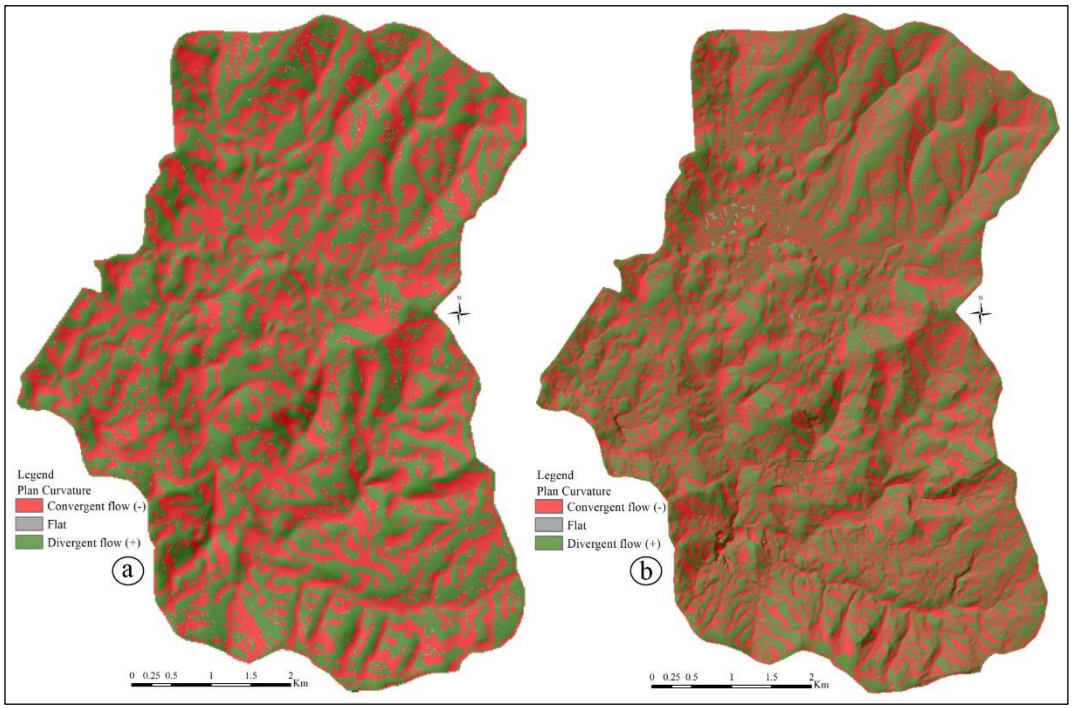


Figure 10. Plan Curvature based on: a) DEM_TOPO; b) DEM_LiDAR
(Source: Authors)

The sectors with convergent runoff cover 46 % (46.84 % / 46.02 % - DEM_TOPO / DEM_Lidar) of the total area, and those with divergent runoff cover 51 – 52 % of the entire area of Padiș plateau.

Table 6. The distribution of the Padiș area by plan curvature classes
(Source: Authors)

	Plan Curvature Classes			
	Convergent flow (-)	Divergent flow (+)	Flat	Total Area
Area from DEM_TOPO (ha)	1721.77	1884.85	68.92	3675.5
Area from DEM_LiDAR (ha)	1691.61	1931.90	51.91	3675.4

At the level of horizontal surfaces, despite the fact that the same tolerance range was kept (± 0.0001), it is noticeable a significant decrease compared to the data from the profile curvature, a fact that can be explained by the method of calculation.

General Curvature

Regardless of the algorithmization, it expresses the convex, concave or horizontal character of the forms of relief, in the sense that by the positive values (in SAGA) are identified the convex

forms (slopes, interfluves, peaks) and by the negative ones (in SAGA) the concave forms (slopes, channels, depressions). The horizontal terrains have the same interpretation presented for the other 2 types of curvatures.

The convex surfaces represent 50 % of the territory, according to the processed data from DEM_TOPO, and 52 % from the data derived from DEM_LiDAR (figure 10, table 7), and the concave surfaces cover 47.5 % and 45.4 % respectively of the entire area. These percentages show us the maturity state of the relief in Padiș regarded as a whole and related to the scale of cyclical time.

Table 7. The distribution of the Padiș area by general curvature classes
(Source: Authors)

	General Curvature Classes			
	Convergent flow (-)	Divergent flow (+)	Flat	Total Area
Area from DEM_TOPO (ha)	1834.13	1748.03	93.38	3675.5
Area from DEM_LiDAR (ha)	1912.58	1671.35	91.49	3675.4

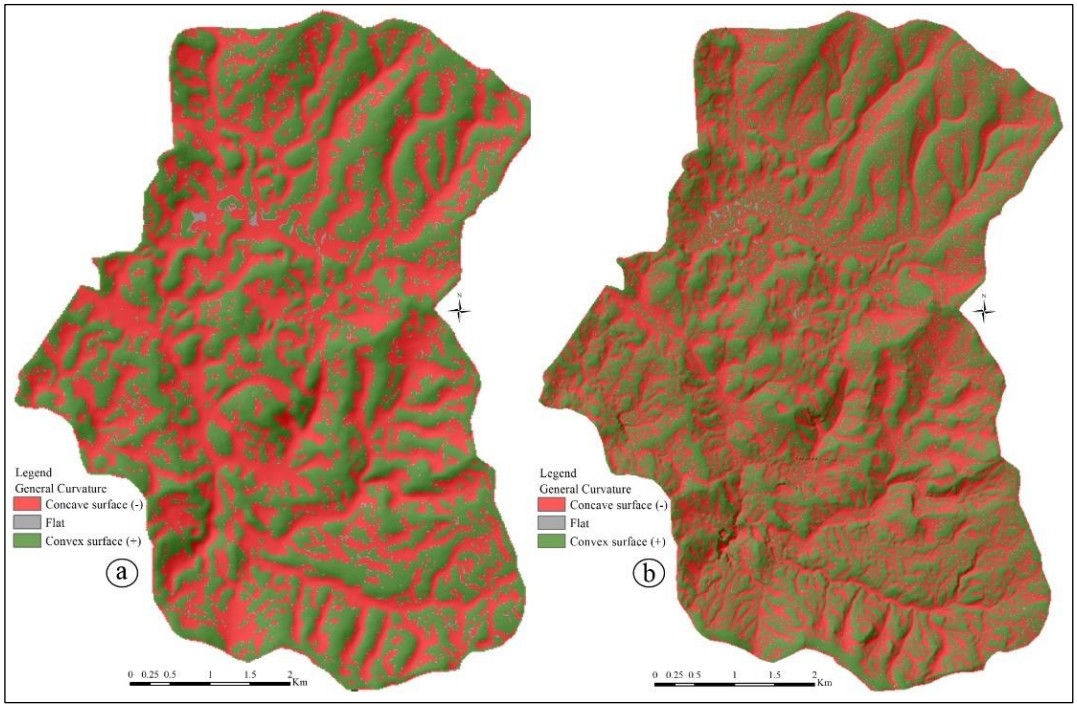


Figure 10. General Curvature based on: a) DEM_TOPO; b) DEM_LiDAR
(Source: Authors)

The information that can be extracted by relating the general curvature to the other geographical and geological territorial components can be more valuable than the specification of an evolution stage for the karst geomorphosystems from an area.

In figure 11 we presented together the hydrogeological features of the territory, the general curvature derived from DEM_TOPO and a hillshade generated from DEM_LiDAR. The hydrogeological map was drawn by Orășeanu (1996) for Bihor – Vlădeasa Mountains. We have only georeferenced the sector corresponding to Padiș with 9 control points taken from topographic maps 1: 25000.

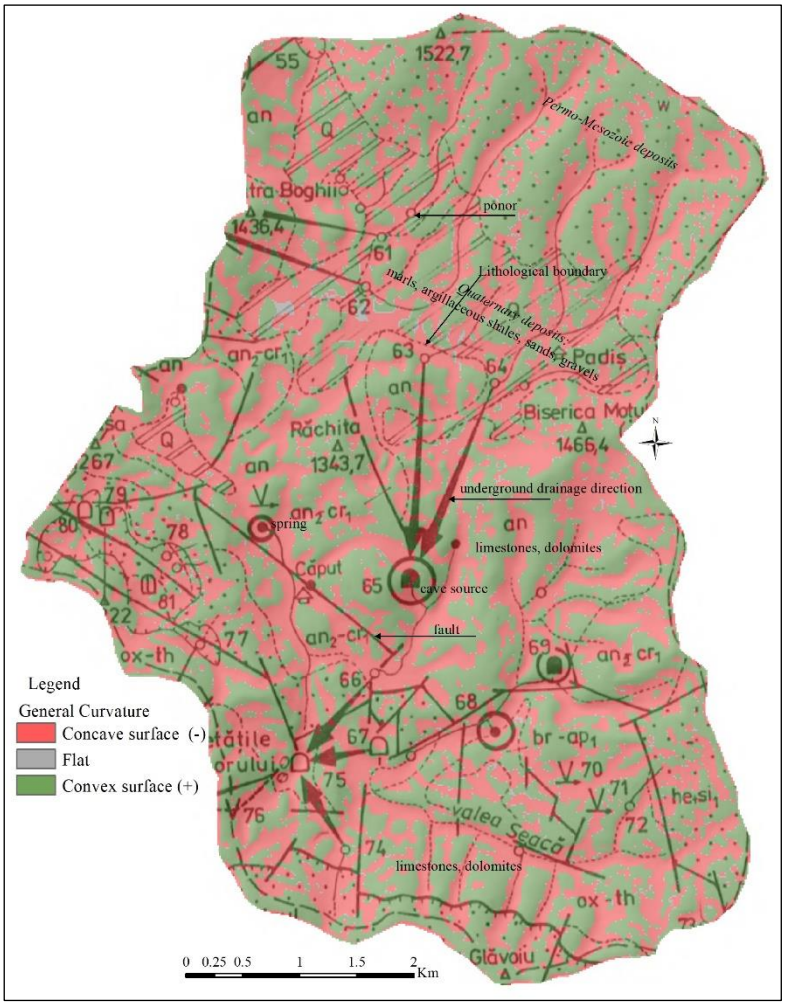


Figure 11. The hydrogeological features (Orășeanu, 1996) combined with the General Curvature in Padiș (Source: Authors)

If we follow closely the lithologic contact between Quaternary deposits (marls, argillaceous shales, sands, gravels) and karstificable rocks (limestones, dolomites) it is noticeable that there is a good correspondence with the alignment of the concave sectors from the area. In addition, if we look at the location of ponors with higher density on Padiș plateau, we can notice that they are located in the sectors with negative sign for the general curvature. Actually, this concave sinuous strip located at the contact between limestone and Quaternary sedimentary deposits corresponds to the alignment of underground water loss because the water loss takes place not only in ponors, but also diffusely. The same correspondence can be seen if we follow the location of the fault lines or the surface drainage network.

CONCLUSIONS

In this study we have done a unitary morphometric analysis of Padiș – Cetățile Ponorului basin using 6 primary morphometric parameters, essential for such a study.

The results show that we are in a mountainous sector, with a predominantly karst plateau morphology in the northern half, situated at an average altitude of 1268 m, in which prevail the surfaces with a moderate tilt (6 - 17°). All the types of curvature used express the maturity character of the surface relief, but this aspect could be caused by the direction of the main shaping agent (water) in the underground. Anyway, even the shaping stage of some local sectors, such as Cetățile Ponorului, in which the exokarst starts to combine with the endokarst, offers the same clues.

We believe that the potential of curvature parameters in relation to other morphological and geological features has not yet been fully exploited, and consequently, the future studies can highlight these aspects in more detail.

REFERENCES

Badea, L., Buza, M., Niculescu, G., Sandu, M., Schreiber, W., Șerban, M., & Kadar, A. (2006). *Unităţile de relief ale României, III, Munţii Apuseni şi Podişul Transilvaniei [The relief units of Romania, III, the Apuseni Mountains and the Transylvanian Plateau]*, Editura Ars Docendi, București.

Blaga, L. (2012). Aspects regarding the significance of the curvature types and values in the studies of geomorphometry assisted by GIS. *Analele Universităţii din Oradea, Seria Geografie, 2012*, 327-337.

Blaga, L., Josan, N., & Ilieș, D. C. (2014). *Relieful şi amenajarea teritoriului [The relief and development of the territory]*, Editura Universităţii din Oradea.

Bleahu, M. & Bordea, S. (1967). *Munţii Apuseni. Bihor-Vlădeasa [Apuseni Mountains. Bihor-Vladeasa]*, Editura Uniunii de Cultură Fizică şi Sport, Bucureşti.

Bleahu, M. & Bordea, S. (1974). *Munţii Bihor-Vlădeasa*. Ghid turistic *[Bihor-Vlădeasa Mountains. Tourist Guide]*, Editura pemtru Turism, București.

Bleahu, M. & Bordea, S. (1981). *Munţii Bihor-Vlădeasa [Bihor-Vlădeasa Mountains]*, Editura Sport-Turism, Bucureşti.

Bleahu, M., (1957a). Cercetări geologice în regiunea Padiş-Cetăţile Ponorului *[Geological research in the Padiş-Cetăţile Ponorului region], D.S. Com. Geol*., vol. XII.

Bleahu, M. (1957b). Captarea carstică şi importanţa ei pentru evoluţia morfologică a regiunilor carstice *[Karst capture and its importance for the morphological evolution of karst regions], Probl. de geogr.", V*.

Bleahu, M., Bordea, S., Bordea, J., Mantea, Gh., Popescu, A., Marinescu, Fl., Cioflica, F., & Ștefan, A. (1985). Harta geologică a României, scara 1:50.000, foaia Pietroasa. IGR, Bucureşti *[Geological map of Romania, scale 1:50,000, Pietroasa Sheet. IGR, Bucharest]*.

Bleahu, M. (1964). Formaţiuni periglaciare în carstul din Munţii Bihorului *[Periglacial formations in the karst of the Bihor Mountains], Lucrările Institutului Speologic Em. Racoviţă, 3*, 215-228.

Bleahu, M. (1974). *Morfologia carstică: condiţionarea geologică şi geografică a procesului de carstificare [Karst morphology: the geological and geographical conditioning of the karstification process]*, Editura Ştiinţifică.

Bleahu, M., & Bordea, S. (1974). Munţii Bihor-Vlădeasa: ghid turistic *[Bihor-Vlădeasa Mountains: tourist guide]*, Editura pentru Turism, București.

Bordea, S., & Bordea, J. (1982). Contributions to the knowledge of the Permian formations in the western part of the Bihor Mountains. Dări de seamă ale sedintelor. Institutul de geologie si geofizică. 4. Stratigrafie, 69(4), 29-38.

Cocean, P. (1985). Les surfaces de nivellement karstique des monts Apuseni *[Karst leveling surfaces of the Apuseni Mountains]*. Travaux de L'Institut de Spéologie „Émile Racovitza, 24, 97-104.

Cocean, P. (1990). Tipuri genetice de peşteri şi avene din carstul Munţilor Apuseni [Genetic types of caves and avens from the karst of the Apuseni Mountains]. *Studia Univ. Babeş-Bolyai. Geographi*a, 35(2), 19-29.

Cocean, P. (1992). Les traits generales de la karstification dans Ies Monts Apuseni *[General features of karstification in the Apuseni Mountains], Studia Univ. Babes-Bolyai. Geographia*, 37(1-2), 39-48.

Cocean, P. (1993). Tipuri genetice de acvifere carstice din Munţii Apuseni [Genetic types of caves and avens from the karst of the Apuseni Mountains]. *Studia Univ. Babeş-Bolyai, Geographia*, 38(I), 57-61.

Cocean, P., (1984). Dispunerea altitudinală a peşterilor din Munţii Apuseni *[The altitudinal arrangement of the caves in the Apuseni Mountains], S.C.G.G.G*., XXXI, Bucureşti.

Damm, P. E. & Moreh, K. (2001). Explorări speologice în partea central-estică a Munţilor Bihor *[Speleological explorations in the central-eastern part of the Bihor Mountains]*. *Speomond*, 6, 10-12.

Damm, P. E. (1992). Avenul V5 - sistemul carstic Vărăşoaia - Izbucul Boga *[Avenul V5 - the Vărăşoaia - Izbucul Boga karst system]*. *Nymphaea*, 22, 29-35.

Damm, P. E., Zih, J., Zih-Perenyi, K. & Pop, C. (2004-2005). Avenul V5. Istoria unui record național de adîncime *[Avenue V5. History of a National Depth Record]*. *Speomond*, nr. 9-10, 3-7.

Florinsky, I. V. (2009). Computation of the third-order partial derivatives from a digital elevation model. *International Journal of Geographical Information Science*, *23*(2), 213–231. https://doi.org/10.1080/13658810802527499

Gaceu, O., Blaga, L., Ungureanu, M., Ilieș, D. C., & Dehoorne, O. (2012). The Karst Plateau of Padiș in Bihor Mountains-one of the most spectacular tourist sites in Romania. Description and development possibilities and promotion of the „Moțului Church" tourist circuit. *GeoJournal of Tourism & Geosites*, *9*(1), 92-110.

Gaceu, O., Ungureanu, M. & Ilieș, D.C. (2013). *Padiș-o oază turistică în inima Munților Apuseni [Padiș a tourist oasis in the heart of the Apuseni Mountains]*, Editura Universității din Oradea.

Geoportal ANCPI. Available online: https://geoportal.ancpi.ro/portal/apps/webappviewer/index.html?id=3f34ee5af71c400396dda574f0d53274 (accessed 15- 02- 2022).

Hutchinson, M. F. (1989). A new procedure for gridding elevation and stream line data with automatic removal of spurious pits. *Journal of hydrology*, *106*(3-4), 211-232.

Ianovici, V., Borcos, M., Bleahu, M., Patrulius, D., Lupu, M., Dimitrescu, R., & Savu, H. (1976). *Geologia Muntilor Apuseni [Geology of the Western Mountains]*, Editura Academiei Republicii Socialiste România.

Indrieș, A. C. (2010). *Munții Padiș-Scărișoara: studiu de geografie regional [Padiș-Scărișoara Mountains: regional geography study]*, Editura Universității din Oradea.

Indrieș, A.C. & Indrieș A.A. (1991). *Platoul carstic Padiș [Padiș karst plateau]*, Editura Primus, Oradea.

Lupu, D. (1975). *Contribuţii la studiul faunei senoniene de rudişti din Munţii Apuseni [Contributions to the study of the Senonian fauna of Rudists from the Apuseni Mountains]*, RTD, 23 p., Universitatea Bucureşti.

Mantea, G. (1985). *Geological studies in the upper basin of the Someşul Cald Valley and the Valea Seacă Valley region (Bihor-Vlădeasa Mountains)*, Anuarul I.G.G., 65, pp 5-89, București.

Minár, J., Evans, I. S., & Jenčo, M. (2020). A comprehensive system of definitions of land surface (topographic) curvatures, with implications for their application in geoscience modelling and prediction. *Earth-Science Reviews*, *211*, 103414.

Mitas, L., & Mitasova, H. (1998). Distributed soil erosion simulation for effective erosion prevention. *Water resources research*, *34*(3), 505-516.

Mitasova, H., Hofierka, J., Zlocha, M., & Iverson, L. R. (1996). Modelling topographic potential for erosion and deposition using GIS. *International journal of geographical information systems*, *10*(5), 629-641.

Mitasova, H., Mitas, L., Brown, W. M., Gerdes, D. P., Kosinovsky, I., & Baker, T. (1995). Modelling spatially and temporally distributed phenomena: new methods and tools for GRASS GIS. *International journal of geographical information systems*, *9*(4), 433-446.

Orășeanu, I. (1996). Contribution to the hydrogeology of the karst areas of the Bihor-Vlădeasa Mountains. *Theor Appl Karstol*, *9*, 185-214.

Orășeanu, I. (2010). Bihor Vlădeasa Mountains. *Karst hydrogeology of Romania,* Editura Belvedere, Oradea, 217-244.

Orășeanu, I., Gașpar E., Pop, I. & Tănase, T. (1991). Tracers experiments in the karst area of Bihor Mountains (Romania). *Theoretical and Applied Karstology* 4, 159-172.

Patrulius, D., Bleahu, M., Popescu, E. & Bordea, S. (1971). The Triassic Formation of the Apuseni Mountains and the East Carpathians Bend. *Guidebook to excursions*, *8*, 1-86.

Vălenaș, L. (1977-1978). Explorarea reţelei subterane din Groapa de la Barsa (M. Bihor) *[Exploring the underground network in Groapa de la Barsa (M. Bihor)]*. *Bul. CSER*, București, 170-211.

Vălenaș, L. (1982). Explorarea Reţelei Lumea Pierdută (Munţii Bihor) *[Exploring the Lost World Network*

(Bihor Mountains)], Bul. Inform. F.R.T.A.-C.C.S.S., 6, 167-175.

Vălenaş, L. (1984). Studiul complex al carstului din zona Izvorul Ursului-Pîrîul Sec (Munții Bihor) *[Complex study of the karst in the Izvorul Ursului-Pîrîul Sec area (Bihor Mountains)]*. Crisia, 14, 559-580.

Vălenaş, L., Bleahu, M., Brijan, P. & Halasi, G. (1977). Inventarul speologic al Munţilor Bihor *[The speleological inventory of the Bihor Mountains]*. *Nymphaea*, 5, 209-335.

Vălenaş, L., Halasi, G. & Czako, L. (1982). La morphologie et la hidrologie des conduits submerge du bassin de la Gârda Seacă (Monts Bihor) *[The morphology and hydrology of the submerged conduits of the Gârda Seacă basin (Bihor Mountains)]*. *Nymphaea*, 10, 195-205.

Viehmann, I. (1966a). Colorările cu fluoresceină în cunoaşterea hidrografiei carstului *[Staining with fluorescein in the knowledge of karst hydrography]*. *Hidrotehnica, Gospodărirea apelor. Meteorologia,* 11(1), 37-42.

Viehmann, I. (1966b). Colorările cu fluoresceină în cunoaşterea hidrografiei carstului *[Staining with fluorescein in the knowledge of karst hydrography]*. *Hidrotehnica, Gospodărirea apelor. Meteorologia,* 11(2), 92-96.

Viehmann, I. (1991). *Carst în Munţii Apuseni şi Rodnei: studiu comparativ cu consideraţii geomorfologice şi stratigrafice [Karst in the Apuseni and Rodnei Mountains: comparative study with geomorphological and stratigraphic considerations].* Teză de doctorat (Doctoral dissertation).

Viehmann, I., Cristea, E., Serban, M., Cuc, O. & Ghitea, S. (1980). La morphologie du complexe karstique „Cetăţile Ponorului" (Les Monts Apuseni, Roumanie) *[The morphology of the karstic complex „Cetăţile Ponorului" (Apuseni Mountains, Romania)]*. *Trav. Inst. Speol. „Emile Racovitza"*, 19, 261-274.

Zevenbergen, L. W. & Thorne, C. R. (1987). Quantitative analysis of land surface topography. *Earth Surface Processes and Landforms, 12*(1), 47–56. https://doi.org/10.1002/ESP.3290120107.

Submitted:	Revised:	Accepted:	Published online:
September 27, 2021	April 15, 2022	October 20, 2022	December 21, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **2/2022**, pp. 101-113
ISSN **1221-1273**, E-ISSN **2065-3409** **DOI** 10.30892/auog.322103-888

COVID-19 AND MICE EVENTS: UNPACKING THE FACTORS MEDIATING THE RETURN OF IN-PERSON EVENTS IN SOUTH AFRICA

Refiloe Julia LEKGAU
School of Tourism & Hospitality, College of Business and Economics,
University of Johannesburg, South Africa, email: rlekgau@uj.ac.za

Tembi Maloney TICHAAWA*
School of Tourism & Hospitality, College of Business and Economics,
University of Johannesburg, South Africa, email: tembit@uj.ac.za

Citation: Lekgau, R.J., & Tichaawa, T.M. (2022). Covid-19 and Mice Events: Unpacking the factors mediating the return of in-person events in South Africa. *Analele Universităţii din Oradea, Seria Geografie, 32*(2), 101-113. https://doi.org/10.30892/auog.322103-888

Abstract: The shift to virtual events by the MICE sector was one of the first strategies adopted by the sector in response to the restrictions imposed because of the COVID-19 pandemic. This study examines the factors mediating the return of in-person MICE events in South Africa. Utilising a qualitative research design, interviews with MICE event planners, professional associations, and governing authorities reveal that live events are perceived to have greater potential to attain local economic development benefits and MICE event legacies. Additionally, the limitations of virtual events had a subsequent effect on networking, direct selling, and other main motives for attending MICE events. The return of in-person events began with stimulating the local market and exploring more hybrid events. Overall, the study presents the resilience of in-person MICE events, examining the various steps taken to ensure its return post-COVID-19.

Key words: MICE events, virtual events, South Africa, COVID-19,

* * * * * *

INTRODUCTION

Meeting, Incentive, Conference, and Exhibition (MICE) events have undergone a drastic transformation due to the onset of COVID-19 and resultant regulations. As underscored by Janiszewska et al. (2021), the geographical expansion, nature of transmission, severity, and infectiousness of the virus had significant implications for the hosting of the MICE events. This came after the widescale cancellation of major events globally and, to a certain extent, the conceptualization of events as being 'super spreaders' of the virus (Hemmonsbey et al., 2021). Like other event typologies, the MICE sector had been one of the first forms of tourism to be prohibited and regulated following the outbreak of the pandemic (Bartis et al., 2021; Ho and Sia, 2020). As a result, the available studies on the reaction of this sector to COVID-19 have shown their transition to virtual platforms to have been a widely used strategy to adapt, survive and maintain business continuity (see for example, Anguera-Torrell et al., 2021; Dillette and Ponting, 2021; Hofstadter-Thalmann et al., 2022; Palrao et al., 2021; Seraphin, 2021). Similarly, few studies have concurred that the pandemic and the transition to virtual events constitute an opportunity for the MICE sector

to reinvent itself (Seraphin, 2021; Dillette and Ponting, 2021; Hofstadter-Thalmann et al., 2022). Indeed, these studies affirmed that resulting conditions had led to the development of innovative means to plan and host MICE events.

While virtual MICE events present new opportunities, it has been agreed upon that the recovery of the MICE sector revolves around the return to in-person events as the predominant means to host such events. This is due to the significance of the sector for tourism development and economic growth for many destinations, particularly those in developing regions such as Sub-Saharan Africa (Shereni et al., 2021). Rogerson (2015) denotes the significance and expansion of MICE sector activity to be a result of globalization and the integration of economic sectors. Indeed, this sector has been noted to facilitate and constitute a key component of the knowledge economy (ICCA, 2018; Rogerson, 2015). Regarding tourism development, scholars such as Rogerson and Rogerson (2021) and Tichaawa (2017, 2021) highlight that, prior to the pandemic, MICE tourism held a large share of international travel to the region. Accordingly, this sector has been developed and leveraged to improve tourism economies of host destinations, contribute to urban regeneration strategies and enhance (and contribute to) the destination brand (Alananzeh et al., 2019; Cassar et al., 2020; Kim et al., 2020; Weru and Njoroge, 2021). Unfortunately, despite the supported significance of the sector, it has remained a largely unexplored facet of tourism research in the region (Rogerson, 2015; Shereni et al., 2021). In fact, this continued within the context of COVID-19, whereby the effects and changes caused by the pandemic on tourism in Sub-Saharan Africa has yet to be focused on within the MICE events context.

In South Africa, the end of the national lockdown and the reopening of international tourism provided a much needed opportunity for MICE events to bounce back and begin their post-COVID-19 recovery. This is due to the fact that there is a need for (physical) contact between delegates, buyers and sellers, and other MICE stakeholders which necessitates the in-person hosting of such events (Dimitrovski and Seocanac, 2018). South Africa is recognized as one of the leading MICE destinations, regionally and internationally (Weru and Njoroge, 2021) and has, in 2022, resumed its hosting of two African premier events: Meetings Africa in February and Africa's Travel Indaba in May. These events were hosted in compliance with the country's 50% venue capacity regulations. In July 2022, all remaining lockdown regulations were lifted so from this time, the MICE events sector could fully resume their operations. While the sector and literature become focused on MICE event recovery, the purpose of the current study is to examine the factors that mediate the return of in-person events in the country, taking into consideration the role of MICE events in tourism and economic development as well as the regulations that had been in place at the time. In this regard, the theoretical significance of the study is twofold: (i) firstly, the study reveals factors that could shape the next phase in the development of the MICE events sector in South Africa; and (ii) secondly, this study could provide valuable insight for the MICE sector for further consideration when dealing with exogenous shocks or disruptions, as it critically unpacks the phases undertaken for the MICE sector to adapt and return to in-person mediums. These insights could be helpful in enhancing the resilience and flexibility of the sector in the future.

SOUTH AFRICA'S MICE SECTOR'S RESPONSE TO COVID-19

While the South African government's response to COVID-19 began in March 2020, with the implementation of the national lockdown, the MICE sector (along with other typologies of events) had already cancelled and postponed their events much earlier (Hemmonsbey et al., 2021; Lekgau and Tichaawa, 2021). The national COVID-19 response had been followed by the adoption of the Alert Level strategy to manage the reopening of certain sectors while accounting for the state of the virus in the country; the level of infections and transmission rates at the time, health facilities capacities and socio-economic impacts of the restrictions (Bama and Nyikana, 2021; GSA, 2021; Kotze, 2021; Vermeulen-Miltz et al., 2022). Since the MICE sector was classified within 'gatherings' under the Disaster Management Act, the sector was particularly vulnerable to

regulations pertaining to the number of people permitted at gatherings and international borders (Bartis et al., 2020; TBCSA, 2020). Accordingly, the hosting of in-person events during the pandemic was subject to the respective implemented alert level. Table 1 below illustrates the various alert levels set within the nation from 2020 and 2022 and the subsequent implications to the hosting of in-person MICE events.

Table 1. Alert levels and implications for the MICE sector

(Source: Government of South Africa, 2021)

Alert Level	**Dates placed**	**MICE events implications**
Alert level 5	26 March to 30 April 2020	MICE events prohibited & international borders closed.
Alert level 4	1 to 31 May 2020	MICE events prohibited & international borders closed.
Alert level 3	1 June to 17 August 2020	MICE events prohibited & international borders closed.
Alert level 2	18 August to 20 September 2020	Limited to a maximum of 250 persons for indoor venues and 500 persons for outdoor venues or 50% of the capacity of the venue should it be small. International travel permitted in certain airports, outside hours of curfew. A negative COVID-19 test must be produced not more than 72 hours before the date of arrival.
Alert level 1	21 September to 28 December 2020	Limited to a maximum of 250 persons or less for indoor venues and 500 persons or less for outdoor venues or 50% of the capacity of the venue should it be small.
Adjusted alert level 3	29 December 2020 until 28 February 2021	Limited to a maximum of 50 persons or less for indoor venues and 100 persons or less for outdoor venues or 50% of the capacity of the venue should it be small
Adjusted alert level 1	1 March 2021 to 30 May 2021	Limited to a maximum of 100 persons or less for indoor venues and 250 persons or less for outdoor venues or 50% of the capacity of the venue should it be small
Adjusted alert level 2	31 May to 15 June 2021	Limited to a maximum of 250 persons or less for indoor venues and 500 persons or less for outdoor venues or 50% of the capacity of the venue should it be small
Adjusted alert level 3	16 June 2021 to 27 June 2021	Limited to a maximum of 50 persons or less for indoor venues and 100 persons or less for outdoor venues and if the venue is too small, then not more than 50 percent of the capacity of the venue may be used.
Adjusted alert level 4	28 June to 25 July 2021	MICE events are prohibited until 11 July 2021, after which this will be reviewed.
Adjusted alert level 3	26 July to 12 September 2021	50 persons or less for indoor venues and 100 persons or less for outdoor venues or 50% of the capacity of the venue should it be small
Adjusted alert level 2	13 to 30 September 2021	Events subject to a limitation of a maximum of 250 persons or less for indoor venues and 500 persons or less for outdoor venues or 50% of the capacity of the venue should it be small
Adjusted alert level 1	From 1 October 2021	Events are allowed but limited to 1000 persons or less for indoor venues and 2000 persons or less for outdoor venues or 50% of the capacity of the venue should it be small. International travel permitted in certain airports. A vaccination certificate and/or a negative COVID-19 test must be produced not more than 72 hours before the date of arrival.

As shown in the table above, the regulations placed on the MICE sector limited the full reopening of the MICE sector as these events had not been permitted in line with the restrictions on the number of people in outdoor and indoor venues. Evidently, the sector had to adjust its MICE offerings accordingly and focused strongly on virtual events. This resulted in numerous calls for industry and government collaborations for the planning of tourism recovery, particularly in the months following the initial implementation of the national lockdown (Bama and Nyikana, 2021; Rogerson and Baum, 2020; SAT, 2020). The collaborations that emerged led to the development of the tourism recovery plan, which delineated recovery into three main phases: Protective Interventions, Managed Re-opening and Continuous Interventions (SAT, 2020). However, it is crucial to note that the recovery plan sought to design focused-MICE event strategies and activities in the second phase and implement them in the third phase. Further, the plan recognized that the uncertainty in the hosting of MICE events, particularly large-scale (also indicated in the table above), necessitated developing a MICE sector-specific plan. After appealing for the reopening of MICE events, there were several demonstrations of self-regulations. In fact, the different segments of the MICE sector formed the South Africa Events Council - an industry-wide coalition to address the collective challenges of the sector, provide a unified voice and showcase the value of MICE events (AXXO, 2021). These acts of self-regulation led to the development of a comprehensive set of safety protocols for the MICE operators, which include the re-opening guidelines and the industry protocols (Event Council Industry, 2020; TBCSA, 2020). These protocols regulated the hosting of in-person COVID-19-compliant MICE events, and were strongly leveraged in order to demonstrate to the government the safety and expert organisation of MICE events and its differentiation from other events within the 'gatherings' categorization.

The above discussion unpacked the efforts of various MICE stakeholders in lobbying for the return of in-person MICE events, and the current study continues this research theme by exploring the factors that contributed to the return of such events. The following section details the methodological procedures adopted in this research.

METHODOLOGY

The study utilized a qualitative research approach. A qualitative research approach was deemed suitable as it allowed for the in-depth exploration of the subject matter (Leavy, 2017). Accordingly, semi-structured interviews were conducted with 19 representatives of the MICE sector. As underlined by Bartis et al. (2021), the MICE sector of South Africa is represented by three broad segments, which include governing authorities (or decision makers), the supply side, and the support services. These stakeholders play an important role in developing, growing, and executing MICE events in South Africa. As such, it became paramount to understand the views and expert opinions of representatives from these stakeholder groups. The representatives from these stakeholder segments were purposively selected based on their expert knowledge and involvement in MICE tourism recovery in South Africa. Further, owing to the different roles played by these three major subsectors of MICE tourism, the study gathered views from each of the three segments. Specifically, the study included representatives from the Southern African Association for the Conference Industry (SAACI), the Society for Incentive Travel Excellence (SITE), AAXO, the Professional Conference Organisers (PCO) Alliance; MICE event planners, MICE event suppliers (venue, audio-visual suppliers, exhibitions stands), and finally, representatives from the National Department of Tourism and the South African National Convention Bureau.

The interviews were held virtually via MS Teams and Zoom which allowed for eased convenience in terms of meeting time and venue. The interviews, on average, lasted between 30 and 60 minutes. The interview protocol focused on exploring the changes in hosting MICE events during COVID-19, the use of virtual events, the gradual reopening of the sector, and its implication on how such events are hosted. The semi-structured nature of the protocols allowed for further probing of the participants' answers to gather a deeper understanding of the current workings of the MICE

tourism environment. With their permission obtained, the interviews had been recorded and transcribed verbatim. Thereafter, the transcriptions were loaded onto Atlas.ti version 9, which allowed for the coding (and grouping) of the data, in which three major group codes were then generated.

FINDINGS AND DISCUSSION

Limitations of virtual events

Interviews with various MICE professionals averred virtual events to have been a temporary solution to the restrictions that strained the operations of the MICE sector. While the value of these forms of events were acknowledged and praised, the study participants then underscored that the rapid rise of virtual MICE events was followed by 'virtual fatigue', which affects the levels of engagement in these events. Encapsulating such views, one participant stated:

> In other settings, there needs to be some sort of physical component... because we are seeing that engagement levels are dropping. I just had my team meetings this morning where at some point I said, 'just switch on your cameras, and stand up'. Because nobody is saying anything. It has been proven that engagement levels are dropping. While some of the objectives are being achieved, you also need to look at outcomes. If you're looking at outputs and outcomes, it is not achieving exactly what you need.

The respondents explained that this phenomenon was due to the prolonged period of remote working, as well as the frequent hosting of online MICE events. Bailenson (2021) explains that this fatigue from virtual meetings is caused by limited mobility, increased cognitive load and extra amounts of close-up eye gaze. Participants strongly contended that in-person events were more effective in garnering positive engagement, interactions and experiences compared to their virtual counterparts. See, for instance:

> When you are in a venue, you are there with the atmosphere and with the people around you and the networking opportunities. And now when you are logging in from your laptop at home, I think while the clients want their reach to be more, the reality is that people have become hesitant to sit behind their laptops for nine hours in a day. They would maybe watch the first hour, and then they would walk away or continue with the day.

Additionally, the respondents then questioned the viability of virtual events, in the long term, considering the role of MICE events in facilitating knowledge creation and sharing, networking and collaborations. In fact, some respondents agreed that the limited return on investment in some virtual events was due particularity to this limitation:

> We have seen conference organisers suddenly moving to a virtual space. I have been involved in one or two events, which have been virtual. And the virtual spaces got very little return. I mean it's just like watching a television screen - there is a bit of interaction, but people, as humans, aren't built like that, we are built to engage face-to-face.

However, the above should be considered within the context that the use of virtual events in South Africa is relatively new, particularly at the time of the study. As such, the current study concurs with the contention of Dillette and Ponting (2021) as well as Hofstadter-Thalmann et al. (2022), in that the focus on virtual events going forward will be on ensuring that the platform, content, and program supports and embeds this interactive character (on the side of delegates) within MICE events.

Some respondents underscored the social nature of events, similar to the view of Seraphin (2020) on the anthropological needs tied to events, in that people want to come together for such occasions. Indeed, the respondents concurred that this was another limitation of virtual events. Overwhelmingly, the respondents put forth that the major appeal of in-person events was tied to the fact that these events are grounded on human interactions. Some responses in this regard include the following:

> Long term, we would much prefer to be doing physical events. And some people ask 'what if it is so good that it replaces the physical events'. That is never going to happen with our industry. I mean, it might happen with pharmaceuticals, some of the medical professions might prefer to keep it virtual. But for us, the reality is that tourism is a social industry, and people like to connect. When you're in hospitality, you're in it for the love of people. And people want to see people.

> A lot of companies still want that human contact. And we, as South Africans, like to be there and say, 'Hello, we're glad to see you'. We like that human contact. I don't think it will last. When we are clear and we can move around again like normal, I think we'll go back to full capacity venues.

Interestingly, some studies have argued that continued innovation (facilitated by training and content redesign) holds future opportunities for facilitating interactions with event attendees (Dillette and Ponting, 2021; Simons, 2019; Sox et al., 2017). However, the above results corroborate previous findings on the significance of networking and forming professional relationships in the decision to attend MICE events (Cassar et al., 2020; Lee et al., 2010; Kim et al., 2020; Oppermann and Chon, 1997). In fact, Kim et al. (2020) averred that the need to expand social contacts in MICE events had been a strong determinant of conference attendance requiring much consideration from organisers on ways to develop and structure the program to facilitate networking opportunities.

Furthermore, considering the factors determining MICE event attendance, the respondents highlighted the importance of the travel component involved in this sector. As attendees are noted to derive different social values from virtual and in-person events, some respondents highlighted the travel to the hosting destination to allow for more immersive experiences at the event when compared to virtual events. This arises from the difficulty recently identified in balancing home and work responsibilities prevalent in remote working (Chetty and Motala, 2021), which subsequently feeds into the nature of virtual event hosting and attending.

Impact of live events

Underscored by the respondents is the role of in-person events in tourism growth, destination development, and local economic development. Accordingly, many of the respondents pointed to the role of in-person MICE events for promoting and developing the South African destination brand. Indeed, representatives of SAT (specifically the SANBC) had noted this role to have led to the establishment of the sector, as well as the strategic targeting of events supported. Speaking to the opportunities provided by MICE events for local businesses, entrepreneurs, and individuals, one representative of SANCB highlighted:

> With the events that we go after, it's not about the numbers for us. We supported, for example, an event of 100 delegates that focus on rural educators, providing training. For us that is much more valuable because of the macro economic impact that it will have. So compared to 2000 people getting together that will have minimum impact in terms of the priority areas for our country, we look at the priority sectors for the country, and then we overlay it with events with these macroeconomic legacy potentials. Just another example, there is an international

> clown congress and it is 6000 people that meet every three years, and it rotates around the world. So that event I kept on saying to my boss, 'but it's 6000 people'. And she said 'how is that event going to help us in terms of investment and entrepreneurial opportunities?' And those are the filters that we use to decide what events we do and attract to South Africa.

The non-tourism benefits of MICE events, unfortunately, remains a relatively unexplored facet of MICE tourism. The ICCA (2018) report explained that MICE events draw in leading experts, specialists and practitioners in their respective fields to strengthen the internal capacities of a nation. Similarly, Jago and Deery (2010) add that MICE events contribute towards the professional development within the hosting city by creating access for local professionals to experts in their field. Accordingly, the quote above illustrates the support provided by the SANBC to MICE events based on their ability to provide macro-economic benefits, as opposed to only the size of the event. As such, many respondents had pointed to the ability of in-person events to greatly strengthen the attainment of these legacies linked to MICE events. Such findings concur with that of ICCA (2018), which reported that face-to-face collaborations, facilitated by events, greatly enhance the knowledge economy. Asongu and Kauda (2020) have gone on to expand on the significance of the knowledge economy in opening economic opportunities in Sub-Saharan Africa. Evidently, hosting these events can provide opportunities for local entrepreneurs, businesses and the greater society within the hosting city. The value of offering accessibility to industry experts and information creation and dissemination has been frequently cited in interviews as an important reason to fast-track the return of in-person events.

Moreover, many of the respondents concur that virtual events resulted in some lost opportunities owing to a focus on the presentation of information. Some representatives of the MICE planners agreed that virtual events largely served the purpose of providing content, with one stating '*And we just gave them the academic content, that is what is been presented to them. That's the only part of the conference that we are effectively keeping - it is academic content'*. It is important to note that the quote was stated during the period where MICE event planners had been testing and learning to host such events online, and consequently experienced some difficulty in ensuring that the platform facilitated and allowed for networking and user engagement. However, it is also important to note that the type of experience gained from virtual events is dependent on several factors, such as connectivity and accessibility to devices. While much of the country had shifted to remote working during 2020 and 2021, some respondents pointed out that not all parts of the country had stable network coverage, which was further affected by loadshedding. These, unfortunately, are factors beyond the control of MICE event planners but which can affect the delegates' overall experience of an event. This is due to the fact that connectivity, or the lack thereof, affects accessibility to the event, engagement, as well as the presenters' ability to share their content. Resultantly, event planners found these concerns to be easier to manage when the event is held in person. Specifically, they accrued this to the venue's ability to provide backup generators, staff onsite to assist attendees, and prior experience in hosting in-person events.

Finally, the impact of live events has also been related to the tourism impact of in-person events. The onset of COVID-19 saw many events cancelled and postponed to a later date. Many of the respondents described the significant disturbance to the multiplier effect of the tourism industry. For instance, one respondent underlined the following:

> If you think about it with one conference, who all gets affected? From the moment that delegate arrives in the country, there [is] the person who picks them up at the airport, that brings them to the hotel. Then they book in at the hotel, and there is the hotel employees, the housekeepers, the waiters, [and] the front of office staff. Then they go to the conference, and there is everybody that's on site at the conference. Then they go on a tour, and there's a tour guide that takes them on a tour…

Subsequently, the halt of in-person events meant that *'...so the whole value chain gets impacted. Now all of a sudden, we've taken all of that away*'. Accordingly, in-person events serve a crucial role in realising the tourism impact of MICE events, as relating to increased visitor arrivals, direct and indirect employment opportunities and the interlinkages with tourism and leisure businesses. In planning for recovery, the SANCB underscored that while it had developed a strategy to develop virtual events (Lekgau and Tichaawa, 2021), this was done in order to promote the South African MICE destination brand so as to ensure further intentions to host such events in the country, in person. Accordingly, the organisation then posited for the focus to remain related to '*getting bums in beds*' so as to support the recovery of tourism in the country.

Restarting in-person events

The recovery of the MICE sector mirrors that of the wider tourism industry, particularly in its approach. The SAT (2020) reported that cultivating and sustaining local demand is the first step towards tourism recovery. Interestingly, there were some debates regarding the relevance of this approach for the MICE sector, with several respondents contending that the sector in South Africa was dependent on international markets, while others emphasised that the local demand exists, as has been demonstrated by the leisure travel activity after local borders and travel had been opened. One respondent offered the following:

> As soon as we lifted the regulations and the restrictions, our leisure business was booming, and still is. And you would think by now that maybe people have run out of money but actually, people are still travelling for leisure. You know, they're obviously travelling locally. And it's the same in all markets, whether it's in South Africa, or in Nigeria, or in, in any of the European countries - domestic leisure business is still happening. So the way we see it, we all start with the local, which is within countries, and then Africa will be the next source that will supported others, as we've seen already. And then lastly, it will be the international key source markets.

Further, it is crucial to consider the way in which the pandemic had been unfolding in other countries and the subsequent uncertainty that still permeated through the travel industry - focusing on local demand became a vital means to restart the MICE industry. This was owed to fluctuation in COVID-19 cases that determined the government's responses, which, more often than not, meant more stringent regulations on travel and gatherings.

While the above discussions detail some of the factors mediating the return of in-person events, the respondents aver that this return began with the use of hybrid events. Some respondents went on to explain that these events were a crucial means to restarting the hosting of in-person events while complying with the COVID-19 regulations. The quote below illustrates this sentiment:

> In the case of South Africa, although we can now have meetings up to 100 people, it's still very much virtual most of the time, and then a little bit of hybrid that is starting to come by. And with your hybrid events, it will be a mix of some people in person at the venue and most of them attend virtually.

The COVID-19 regulations that had the most significant impact on the operations of the MICE industry had been the closure of international borders and the restrictions on the number of people permitted at gatherings. While the regulations on the number of people at gatherings have been altered with the adjustment of alert levels, where more people were gradually permitted to attend events, the restrictions on the events sector of South Africa lasted the longest, particularly the regulations on gatherings. Indeed, it was only in July 2022 that all COVID-19 regulations were

eased. As such, the stringent regulations on the MICE sector led to the implementation of hybrid events (the mixture of virtual and in-person components into an event) becoming a prominent means for the return and recovery of the MICE sector.

Accordingly, hybrid events are viewed to combine the strengths of both virtual and in-person events while minimizing each of the medium's limitations. For example:

> Clients are seeing a bigger return on investment now, and they want the best of both worlds. They know face to face works because there are certain things that cannot be done online, there are certain connections that cannot be made online. It's an exhausting process, that face to face, that human need, the empathy, those physical cues that we get when we are in a same room with a person or sitting across the table from somebody. You don't get those physical cues online and so you need to have a face to face. And maybe the interaction in the hybrid [event], those people that come online virtually during that showtime will be there. They might not be able to seal the deal, but maybe there could be follow-up meetings and sessions that could happen face to face from the hybrid [event]. So it's making sure that we will be able to deliver on those needs, so that we can bring both audiences together and allow them to engage with both audiences within the capacity that they have. But at the same time, exhibitors need a lot of training to manage the virtual space as well.

Hybrid events allow for the facilitation of the social component of MICE events, which had been identified as missing in virtual events. Therefore, in terms of attendee engagement and experience, hybrid events remain one of the best available options. Largely, the quote above suggests that virtual events comprise a means to transition back to MICE events being hosted fully in person. It is important to note that there still remains some barriers before this can be achieved, which include travel and gathering restrictions which still remain techniques used to minimize the spread of the pandemic, until widespread immunity is achieved against the virus. As such, these events still allow for the return of the hosting of in-person MICE events. Furthermore, emerging studies have noted that the pandemic has caused a major shift in travel behaviours, specifically relating to an increased perception of risk (Agyeiwaah et al., 2021; Matiza and Slabbert, 2021; Rogerson and Rogerson, 2021; Yang et al., 2021). For a nation such as South Africa, which is a long-haul destination, hybrid events become valuable in generating confidence in participating in travel to future MICE events. Furthermore, beyond COVID-19 regulations, it is important to consider the role of the public image in the determination of whether or not to attend MICE events. Since 2020, the manner in which the pandemic had been managed at a national level, as well as the unfortunate July 2021 riots, have been noted to have negatively affected the destination image of South Africa. Accordingly, hybrid events prove useful beyond managing the COVID-19 restrictions on the sector.

In fact, some respondents have noted the potential of this medium for hosting events, owing to the wider reach provided for by the virtual component. For instance, one MICE planner mentioned the following:

> I think it's definitely going to be hybrid going forward. So one incredible opportunity that has come out of this is that it has open people's eyes and mind to how we can actually make the world even smaller. Therefore, for argument's sake, if we are hosting an association, and there are 500 delegates from all over the world, normally it would be we'd spend a fortune on getting an international speaker to fly into Cape Town, and to be there for the full duration. Now, budgets allowing, because budget doesn't always allow that, so automatically, your opportunity is now 'okay, who can we afford, who could we bring in'. We are now able to have a hybrid event where that specific international speaker could be sitting in Sweden, or could be sitting in any part of the world, and it is as if he is sitting right in the venue.

Accordingly, this provides greater flexibility for both attendees and participants in the MICE events. The virtual component therefore provides a broader array of options on how to host such events. In fact, some respondents noted that adoption of virtual events, as well as the new condition to operate in (as caused by the virus), may result in the generation of various formats of hybrid events. For example, one respondent postulated:

> This is just me seeing how things will pan out. The physical events will become the premium version - where less people will go to, you pay a premium, you are also going to get the premium. Where you are going to sit in front of your computer and still participate in business events, you're going to probably pay less, but you're also going to get less.

Indeed, the market for MICE events has changed and may continue to change in light of the effects of COVID-19 on the economic sectors of societies. The above postulation is only one of the ways in which the MICE events might return. However, most of the respondents hold the view that in-person formats are best suited to the MICE sector owing to the fundamental reasons these events are hosted.

Lastly, while there remains questions around the various ways hybrid events will be utilized going forward, many of the respondents indicated that while the demand for such events had been understandably low, the government market segment was identified to have driven the restart of MICE tourism:

> The areas where it's recovering first, or maybe the segments that are really recovering first, is [the] government [market]. Interesting enough, we've seen some groups coming through from governments. But it's also because their financial year is ending now in March. So they are kind of finishing up whatever is sitting on their budget. And, of course, you've got new budget being released now. And so they've got to start the activity at the same time.

Such views were shared by several respondents involved in MICE planning. This suggests that this segment is targeted for the restart of the industry. Interestingly, some other respondents highlighted that their engagement with the restart of MICE activity may aid in the industry's lobbying efforts to demonstrate the safety of attending such events, as well as the deliberate and expert planning involved that minimise the risk of COVID-19 spread. Notably, while the government had been identified as the immediate market showing signs of recovery, the respondents had further emphasised the significance of MICE events to industry associations:

> You need to look at it from the associations because it's where the demand is coming from. The association still need to be financially viable. Conferences and meetings is [still] a huge part of their revenue. And it drives and creates income for the association. So if you take, for example, a large Congress, the International cardiology Congress, 15,000 people normally converge every four years to a destination. Their business model is based on getting an income every four years for 50,000 people. So these fundamental shifts taking place, that is not key at the moment on how these business models need to change, to make associations more sustainable in the future, and how meetings and conferences will be used as income generators and revenue spreaders for them.

An earlier study had found that the bidding activities of the SANCB continued during 2020 and 2021, and primarily, the association market segment had been one to book their events in South Africa in the near future (Lekgau and Tichaawa, 2021a). This thereby suggests that the return of in-person association events may occur in the medium-term. Understandably, the corporate market may

take the longest to return to in-person formats owing to the economic downturn resulting from COVID-19.

CONCLUSION

The stringent regulations implemented in response to COVID-19 severely hampered the operations of the MICE sector of South Africa. Resultantly, the return of in-person MICE events in South Africa has been strongly lobbied for by the MICE sector stakeholders. The current study aimed to unpack the factors that mediate the return of such events, particularly focusing on those factors outside of the COVID-19 policy considerations. The study shows that the MICE sector contended that virtual events had been instrumental in ensuring the continuity of the events industry up until the COVID-19 regulations permitted the return of such in-person events. The results suggest the limitations of virtual events, the impact of live events (on local economic development and tourism), as well as the inherently social nature of MICE events are factors essentially leading the transition back to an in-person dominant MICE event sector. Arguably, some of these factors, such as the realization of both tourism and non-tourism benefits, are vital for economic and tourism recovery. Further, the results shown in the study reveal the various stages (and subsequent debates) of the bounce back of in-person events, beginning with generating local demand to hybrid events and various new options developed for MICE events.

Largely, the results of the study concur with the contention of Shereni et al. (2021) on the eventual return of in-person MICE events and their resilience to disturbances and crises. As one of the most regulated tourism sectors, the MICE sector has faced many challenges on its path to reopening and recovery. By providing a critical identification and analysis of this path, the current study offers value in informing plans and strategies when crises occur. Moreover, while the study focused on the context of South Africa, the lessons learned could be adapted to other developing MICE destinations in Sub-Saharan Africa, as this sector has been identified as a critical economic sector to develop, and therefore its resilience and sustainability should be continuously enhanced.

REFERENCES

Agyeiwaah, E., Adam, I., Dayour, F., & Baiden, F. B. (2021). Perceived impacts of COVID-19 on risk perceptions, emotions, and travel intentions: evidence from Macau higher educational institutions. *Tourism Recreation Research*, 46(2), 195-211.

Alananzeh, O., Al-Badarneh, M., Al-Mkhadmeh, A., & Jawabreh, O. (2019). Factors influencing MICE tourism stakeholders' decision making: The case of Aqaba in Jordan. *Journal of Convention & Event Tourism*, 20(1), 24-43.

Anguera-Torrell, O., Aznar-Alarcon, J. P., & Vives-Perez, J. (2021). COVID-19: Hotel industry response to the pandemic evolution and to the public sector economic measures. *Tourism Recreation Research*, 46(2), 148-157.

Asongu, S. A. & Kuada, J. (2020). *Building Knowledge Economies in Africa: An Introduction*. Working Papers of the African Governance and Development Institute. 20/002, African Governance and Development Institute.

Association of African Exhibition Organisers (AXXO). (2021). *SA Events Council – looking back at a year of change*. Available at: https://www.aaxo.co.za/sa-events-council-looking-back-at-a-year-of-change/ [Accessed 28 November 2021].

Bailenson, J. N. (2021). Nonverbal Overload: A Theoretical Argument for the Causes of Zoom Fatigue. *Technology, Mind, and Behavior*, 1(3), 1-6. doi.org/10.1037/tmb0000030

Bama, H. K. N., & Nyikana, S. (2021). The effects of COVID-19 on future domestic travel intentions in South Africa: A stakeholder perspective. *African Journal on Hospitality, Tourism and Leisure*, 10(1), 179-193.

Bartis, H., Hufkie, B., & Moraladi, M. (2021). The Economic Impact of the COVID-19 Pandemic on the Business Events Sub-sector in South Africa: Mitigation Strategies and Innovations. *African Journal of Hospitality, Tourism and Leisure*, 10(1), 102-111.

Cassar, J., Whitfield, J., & Chapman, A. (2020). Contemporary factors influencing association conference attendance. *Journal of Convention & Event Tourism*, 21(1), 57-90.

Chetty, K., & Motala, S. (2021) Working from anywhere: is South Africa ready? *HSRC Review*, 19(1), 14-16.

Dillette, A., & Ponting, S.S. (2021). Diffusing innovation in times of disasters: Considerations for event management professionals. *Journal of Convention & Event Tourism*, 22(3), 197-220.

Dimitrovski, D., & Seocanac, M. (2018). Travel fairs attendance with the reference to political instability: Belgrade Travel Fair. *Hotel and Tourism Management*, 6(1), 7-17.

Events Council Industry. (2020). *Global economic Significance of Business Events*. Washington, DC: The Council.

Government of South Africa. (2021). *Coronavirus COVID-19 Alert levels*. Available at: https://www.gov.za/covid-19/about/coronavirus-covid-19-alert-level-1 [Accessed 01 March 2022].

Hemmonsbey, J., Tichaawa, T., & Knott, B. (2021). Strategic conceptualisation of the South African sport tourism sector's response to the COVID 19 pandemic. *African Journal of Hospitality, Tourism and Leisure*, 10(1), 54-68.

Ho, J. M., & Sia, J. K. M. (2020). Embracing an uncertain future: COVID-19 and MICE in Malaysia. *Local Development & Society*, 1(2), 190-204

Hofstadter-Thalmannm E., Rotgans, J. I., Perez, N. A., & Nordquist, J. (2022). Effective learning in virtual conferences: The application of five principles of learning. *Journal of European CME*, 11(1), 2019435.

International Congress and Convention Association (ICCA). (2018). *A Modern History of International Association Meetings – Update 1963 - 2017*. Amsterdam: ICCA.

Jago, L., & Deery, M. (2010). Delivering innovation, knowledge and performance: The role of business events. Available at: https://www.businesseventscouncil.org.au/files/BE_Innov_Report_Mar10.pdf [Accessed 01 July 2020].

Janiszewska, D., Hannevik Lien, V., Kloskowski, D., Ossowska, L., Dragin-Jensen, C., Strzelecka, M., & Kwiatkowski, G. (2021). Effects of COVID-19 Infection Control Measures on the Festival and Event Sector in Poland and Norway. *Sustainability*, 13(23), 13265.

Kim, B. H., Kim, S. & Oh, M. (2020). Determinants of convention attendees' willingness to pay for additional programs. *Journal of Convention & Event Tourism*, 21(2), 155-176.

Kotze, K. (2020). Responding to COVID-19: Emergency laws and the return to government in South Africa. *Javnost − The Public*, 27(4), 393-406.

Leavy, P. (2017). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*. Guilford Publications, New York, US.

Lee, M. Y., Yeung, S., & Dewald, B. (2010). An Exploratory Study Examining the Determinants of Attendance Motivations as Perceived by Attendees at Hong Kong Exhibitions. *Journal of Convention & Event Tourism*, 11(3), 195-208.

Lekgau, R. J., & Tichaawa, T. M. (2021). Adaptive strategies employed by the MICE sector in response to COVID-19. *Geo Journal of Tourism and Geosites*, 38(4), 1203-1210.

Lekgau, R. J., & Tichaawa, T. M. (2021). MICE Tourism Policy and Strategy Responses in Managing the Impact of COVID-19 Pandemic. *African Journal of Hospitality, Tourism and Leisure*, 10(6), 1997-2012.

Matiza, T., & Slabbert, E. (2021). Tourism is too dangerous! Perceived risk and the subjective safety of tourism activity in the era of COVID-19. *GeoJournal of Tourism and Geosites*, 36(2), 580-588.

Oppermann, M., & Chon, K. S. (1997). Convention participation decision-making process. *Annals of Tourism Research*, 24(1), 178-191.

Palrão, T., Rodrigues, R. I., & Estêvão, J. V. (2021). The role of the public sector in the aftermath of the COVID-19 pandemic crisis: The case of Portuguese events' industry. *Journal of Convention & Event Tourism*, 1-22.

Rogerson, C. M. (2015). The uneven geography of business tourism in South Africa. *South African Geographical Journal*, 97(2), 183-202.

Rogerson, C. M. (2015). Unpacking business tourism mobilities in sub-Saharan Africa. *Current Issues in Tourism*, 18(1), 44-56.

Rogerson, C. M., & Baum, T. (2020). COVID-19 and African tourism research agendas. *Development Southern Africa*, 37(5), 727-741.

Rogerson, C. M., & Rogerson, J. M. (2021). COVID-19 and changing tourism demand: Research review and policy implications for South Africa. *African Journal on Hospitality, Tourism and Leisure*, 10(1), 1-21.

Seraphin, H. (2021). COVID-19: An opportunity to review existing grounded theories in event studies. *Journal of Convention & Event Tourism*, 22(1), 3-35.

Shereni, N. C., Ncube, F. N.. & Mazhande, P. (2021). Exhibitors' preferences at trade fairs: The case of Zimbabwe International Trade Fair (ZITF). *Journal of Convention & Event Tourism*, 22(5), 363-383.

Simons, I. (2019). Events and online interactions: The construction of hybrid event communities. *Leisure Studies*, 38(2), 145-159.

South African Tourism (SAT). (2020). Tourism Recovery Plan. Available at: https://www.tourism.gov.za/AboutNDT/Documents/Tourism%20Recovery%20Plan.pdf [Accessed 25 August 2020]

Sox, C. B., Kine, S. F., Crews, T. B., Strick, S. K., & Campbell, J. M. (2017). Virtual and Hybrid Meetings: Gaining Generational Insight from Industry Experts. *International Journal of Hospitality & Tourism Administration*, 18(2), 133-170.

Tichaawa, T. M. (2017). Business tourism in Africa: The case of Cameroon. *Tourism Review International*, 21, 181-192.

Tichaawa, T. M. (2021). Informal business tourism in Cameroon. *Geojournal of Tourism and Geosites*, 38(4), 1289-1298.

Tourism Business Council of South Africa (TBCSA). (2020). TBCSA Presents Calculated, Driven and Gradual Re-Opening of Tourism to Parliament's Tourism Portfolio Committee. Available at: https://tbcsa.travel/tbcsa-presents-calculated-driven-and-gradual-re-opening-of-tourism-to-parliaments-tourism-portfolio-committee/ [Accessed 12 June 2020].

Vermeulen-Miltz, E., Clifford-Holmes, J. K., Snow, B., & Lombard, A.T. (2022). Exploring the Impacts of COVID-19 on Coastal Tourism to Inform Recovery Strategies in Nelson Mandela Bay, South Africa. *Systems*, 10, 1 -18.

Weru, J. N. & Njoroge, J. M. (2021), Investigating the influence of business events experiences on international visitors' perceived destination image: The case of Kenya. *Journal of Convention & Event Tourism*, 22(5), 384-406.

Yang, T-T., Ruan, W-Q., Zhang, S-N., & Li, Y-Q. (2021). The influence of the COVID-19 pandemic on tourism demand for destinations: an analysis of spatial heterogeneity from a multi-scale perspective. *Asia Pacific Journal of Tourism Research*, 26(7), 793-810.

Submitted:	Revised:	Accepted	Published online
October 21, 2021	February 28, 2022	March 3, 2022	December 21, 2022

Analele Universității din Oradea, Seria Geografie **XXXII**, no. **2/2022**, pp. 114-125
ISSN **1221-1273**, E-ISSN **2065-3409** **DOI** 10.30892/auog.322104-890

GROUNDWATER QUALITY ASSESSMENT: A CASE STUDY OF THE TELEGHMA PLAIN, ALGERIA

Mouna DEKAKRA*
Laboratory of Mobilization and Management of Water Resources, Institute of Earth Sciences, University of Batna 2, 53, road of Constantine, Fesdis, Batna 05078, Algeria, e-mail: m.dekakra@univ-batna2.dz

Mohamed Redha MENANI
Laboratory of Mobilization and Management of Water Resources, Institute of Earth Sciences, University of Batna 2, 53, road of Constantine, Fesdis, Batna 05078, Algeria, e-mail: redha.menani@univ-batna2.dz

Abdelhamid KHEDIDJA
Laboratory of Mobilization and Management of Water Resources, Institute of Earth Sciences, University of Batna2, 53, road of Constantine, Fesdis, Batna 05078, Algeria, e-mail: khedi73@yahoo.fr

Citation: Dekakra, M., Menani, M.R., Khedidja, A. (2022). Groundwater quality assessment: A case study of the Teleghma plain, Algeria. *Analele Universității din Oradea, Seria Geografie*, 32(2), 114-125. https://doi.org/10.30892/auog.322104-890

Abstract: The Teleghma plain is located in northeastern Algeria, in the upper valley of Oued Rhumel. It is characterised by a semi-arid climate with average annual precipitation of 300 mm/ year. The shallow aquifer of Mio-Plio-Quaternary is powered mainly by carbonate formations of the Eocene surrounding the région. The uncontrolled use of groundwater for irrigation has caused water stress in the area which has threatened the degradation of water quality. On the other hand, the intense use of chemical fertilisers for agriculture aims has caused groundwater pollution by nitrates where concentrations exceeded the standard limit recommended by the world health organisation.

Key words: Groundwater, Hydrology, water, Pollution, Nitrate, Agriculture

* * * * * *

INTRODUCTION

In recent decades, the sharp increase in population in the Mediterranean regions, the rise in the standard of living, the development of irrigated agriculture, and new activities (especially tourism) have radically changed the uses of the land and the water, which make it more difficult to meet water needs in the future because many aquifers are already overexploited and water surfaces are in danger (Cudennen et al., 2007).

Pollution of water by nitrate nitrogen is well known in developed countries as a consequence of excessive fertilisation of industrial crops; on the other hand, the high levels of nitrates in developing countries are relatively due to agricultural activity (Collin and Salem, 1989). Natural processes appearing in aquifers and anthropogenic activities determine the quality of groundwater (Iqbal et al., 2017).

* Corresponding Author

Today, agriculture in the Teleghma region is an essential activity for more than 72,728 inhabitants (NSO, 2008), this irrigated agriculture has caused water stress due to the overexploitation of aquifers, in particular, that of the Mio-Plio- Quaternary. The results of chemical analyses confirm the pollution of groundwater by nitrates in most of the Teleghma plain. The objective of this article is to appraise the degree of risk of contamination of groundwater in the Telghema region by nitrogenous forms, in particular nitrates, where the concentrations have greatly exceeded the standards recommended by the WHO, especially in areas marked by a wide variety of crops and which irrationally use nitrogen fertilisers (Khedidja and Boudoukha, 2019).

STUDY METHODS

Sample collecting

The campaign of water sampling took place during the recharge period marked by low water availability, where 47 samples was collected for analysis. The samples concerned for analysis are the ones taken from points located on the edge of the bed of the main wadi (Wadi Seguin); these samples were taken and stored following collection and preservation standards (polyethylene bottles, preservation in a cooler, rapid transfer, storage in a refrigerator at four degrees celsius, analysis within two days). Measurements (Temperature, pH, and conductivity) were carried out in situ with a multi-parameter device. The chemical analyses were carried out in a laboratory; the laboratory analyses concern NO3- and major elements (Na+, K+, Mg2+, Ca2+, SO4 2-, HCO3-, Cl-). Cations were measured by several methods, by titration for chlorides and by measurement of alkalinity and spectrophotometry for nitrogenous elements, meanwhile major ions were measured by atomic absorption spectrophotometry (Michener and Lajtha, 2007; Rodier, 2009). The preciseness of the chemical analysis was verified by the ionic charge balance method. The ionic balance is within the thresholds of ± 5% (Domenico and Schwartz, 1998). The statistical processing of the physicochemical data was carried out using XLSTAT 2007.1 software (table1).

Table 1. Statistical characteristics of the physico-chemical parameters of the groundwater of Teleghma

Paremeters	Units	Minimum	Maximum	Average	SD	CV (%)
T	C	8.40	19	15.13	2.45	16.60
pH		6.55	8.70	7.11	0.46	6.70
EC	µs/cm	460	2530	1199.12	462.83	39.40
Ca++	mg/l	56.12	188.38	106.02	31.19	30.1
Mg++	mg/l	10.69	78.96	33.93	15.29	46
Na+	mg/l	10	295	88.17	69.98	81.10
K+	mg/l	0	32	3.02	6.61	223
HCO+++	mg/l	158.6	860	270.95	78	29.40
SO4--	mg/l	20	860	119.64	163.54	139.60
Cl-	mg/l	35.5	319.5	152.26	77.20	51.80
NO3-	mg/l	10	178.97	67.84	45.75	68.90
SAR	%	0.19	2.94	1.35	0.85	63.28
Pl	%	27.98	75.88	42.38	12.61	29.75
KR	%	0.11	1.12	0.32	0.22	70.45

Natural context

The Teleghma Plain is part of the North African Neritic Unit (figure 1). It belongs to a transition zone between the marly facies of the Tellian nappes to the north of the plain and the marly and marl-limestone series to the south (Vila, 1977). The Mio-Plio-Quaternary formations (clays, marls, scree, limestone crusts, and alluvium) extend over the entire plain, the parts of which in relief are marked by traces of tectonic accidents generally faults in the NW-SE direction. The whole is eroded, sometimes causing the appearance of Eocene limestones which outcrops in several places in the plain, such as at Koudiat Timetlas.

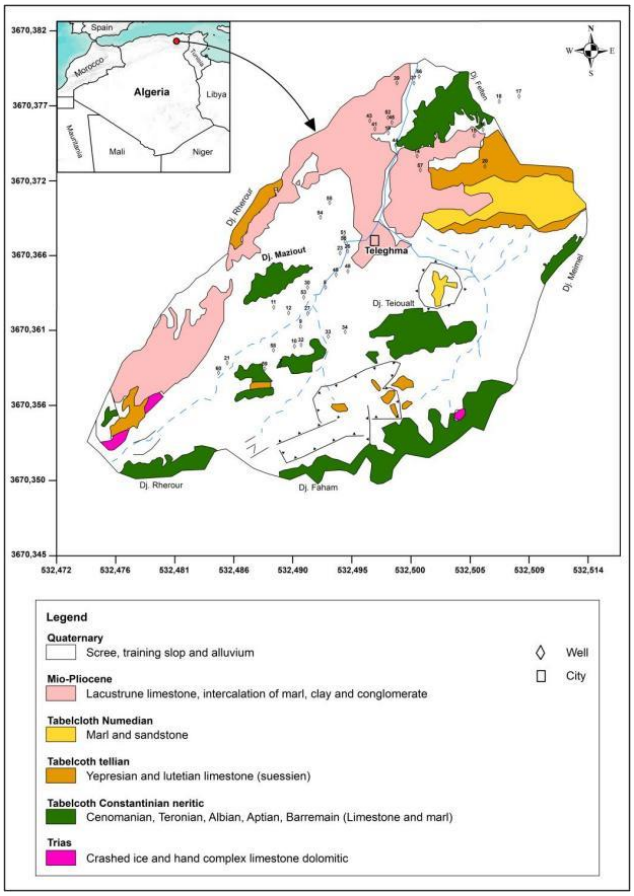


Figure 1. Geological map of plain of Teleghma according to Vila JM
(Source: GGC, 1973; Vila, 1977)

The average annual precipitation recorded at the climatic station of Teleghma reached 331 mm/ year over a period of 34 years (1976-77 to 2010-11) (National Water Resources Agencyof Constantine (NWRA); National Meteorological Office of Algiers (NMO)), and testify to the low rainfall. This region characterising a semi-arid climate. The establishment of the water balance according to the Thornthwaite method and the Tixeron-Berkaloff relations allowed us to quantify actual evapotranspiration about 315 mm with infiltration of 11 mm and runoff of 13 mm.

The Teleghma plain is characterised by the presence of three aquifers which are the shallow aquifer of the Mio-Plio-Quaternary where is composed of limestones and fossiliferous conglomerates, the Eocene aquifer which consists of phosphate limestones with strongly fissured flint, and the Cretaceous aquifer (Albien-Aptian) composed of compact and fissured limestones, and dolomites (Durozoy, 1960; Vila, 1977; General geophysics campaign, 1973; Farah, 1991). In this study, we are interested in the first aquifer of the Moi- plio- quaternary.

The piezometric state of the Mio-Plio-Quaternary aquifer was studied by carrying out one campaign; took place during the high water period (May 2015). The piezometry of the aquifer is marked by a regular shape coincident the closed configuration of the basin (figure 2), with:

• An inflow limit from the carbonate massifs surrounding the plain.
• An outflow limit, through a thin alluvial sill where Oued Seguin flows, which drains the aquifer to the outside of the basin.

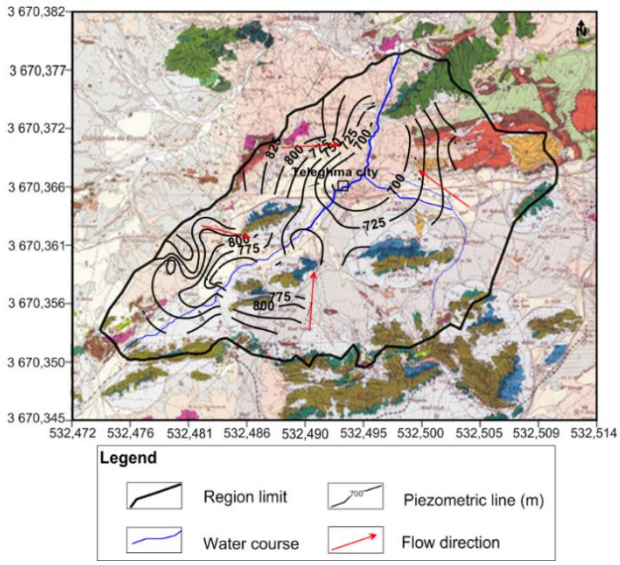


Figure 2. Piezometric map of Teleghma's aquifer

The surface aquifer is fed mainly by effective precipitation and the adjacent formations characterising the carbonate massifs of the Cretaceous. The flow is mainly from the south to the north.

This plain is fed mainly by rainfall and underground inflows from the carbonated massive surrounding region. This groundwater is exploited by more than 300 boreholes, with an average flow of 750 m3 / day, used mainly for the irrigation of cereals and market gardening (mainly garlic and potato; 639,700 quintals of garlic harvested during season 2019-2020) National agricultural land Office (NALO) for a cultivated area of around 4,447 ha (Chamber of agriculture of Teleghma (CAT)). where agriculture is the main source of income in the region.

Agricultural activity

Agricultural activity in the plain of Teleghma is mainly focused on cereal and vegetable crops. These different agricultural activities require the use of chemical fertilisers to improve yields (figure 3). These chemical fertilisers differ depending on the type of crop practiced (table 2).

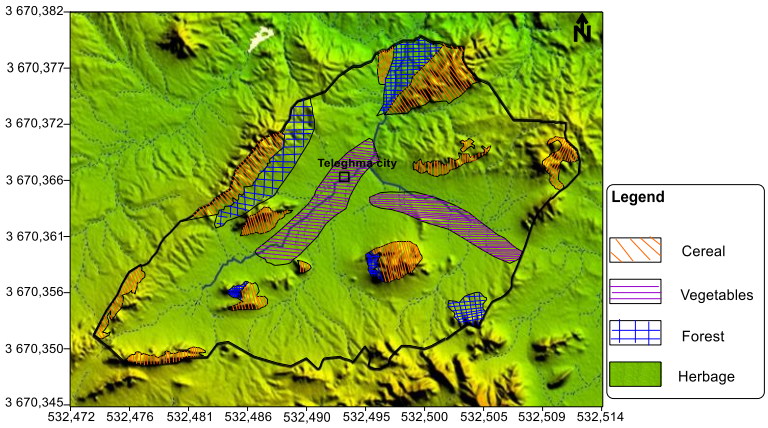


Figure 3. Distribution of Agricultural activities

Table 2. Types of chemical fertilisers used in the Teleghma plain (CAT)

Type of chemical fertiliser	Trade name	Properties
Root Liquid	FERTIACTYL GZB	13 % N, 5% K_2O
Leaf liquid	FERTILEADER 954	9% N, 5% K_2O,
	FERTILEADER 469	4% N,6% P_2O, 9% K_2O
	FERTILEADER Magical	12% CaO, 4% MgO
	FERTILEADER Alpha	6% N, 12% P, 4.2% B
	FERTILEADER Start	3% N, 4% MgO, 30% P
	FERTILEADER Bore	5.7% B
	FERTILEADER Arbo	3% N, 18% K_2O

Chemical fertilisers are defined as organic and inorganic matter added to the soil to enrich certain elements (primarily nitrogen, phosphorus, and potassium) for plant growth (Beaton et al., 2003).

However, chemical fertilisers cause several problems for soil, plants, and water, its losses are considered to be the main constituent of water pollution (Norse, 2005), where groundwater has been polluted with nitrates due to the form, dose, and timing of chemical fertiliser application (Diaw et al., 2016). Excessive application of chemical fertilisers causes augmentation of acidification of soil as well as widespread eutrophication of lakes with high concentrations of nutrients in groundwater (Cui et al., 2014) (there is a cumulation of superfluous N and P in the soil of intensively cultivated areas which is a source of water pollution) (Smith and Sciliano, 2015). The pollution of groundwater by nitrates, due to the use of chemical fertilisers, is characterised by very high concentrations of nitrates which are directly related to heavy fertilisation (Pawar and Shaikh, 1995).

RESULTS AND DISCUSSION

Water quality

The representation of water points on Piper's diagram shows a tendency to the magnesium pole and calcium pole in the under triangle of cations, while the anions show a dominance of bicarbonate for certain points and a tendency to the calcium sulfate for other points (figure 4).

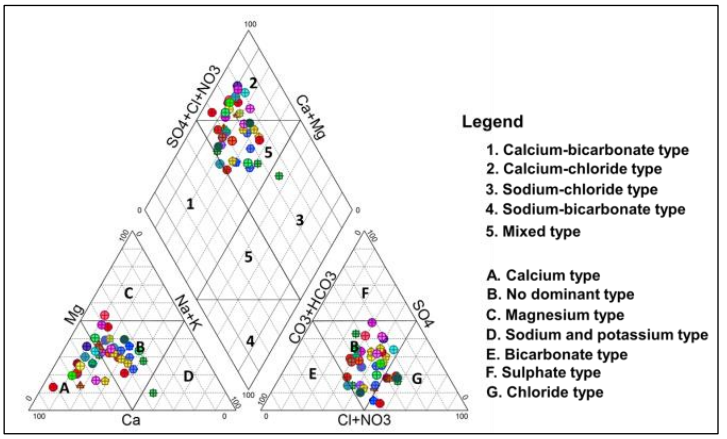


Figure 4. Piper diagram of the water samples

According to the primary distribution of the chemical facies of the plain's waters (figure 5), it appears that the impact of the evaporitic formations is well noticeable in the domination of the cations of sulfate and chloride and by the anions of calcium and anions of magnesium.

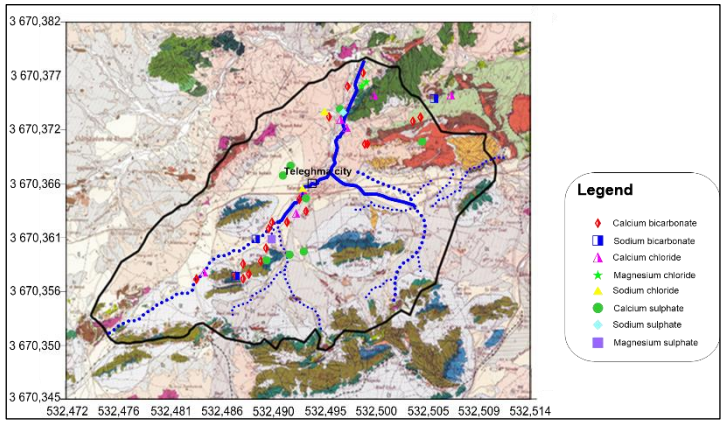


Figure 5. Spatial distribution of chemical facies in Telaghma plain

The analys of the spatial distribution of chemical facies of water from the plain Telghma depending on the electrical conductivity according to the flow axis (figure 6), allowed us to reveal that the calcium bicarbonate facies appearing in the northeast and southwest zone became sodium bicarbonate in the center of the study site from values of electrical conductivity greater than 1500 µS cm-1, resulting in the effect of evaporation as well as the acceleration of the dissolution phenomenon and the exchange effect between basic alkali metals and alkaline earth metals (Khedidja and Boudoukha, 2019).

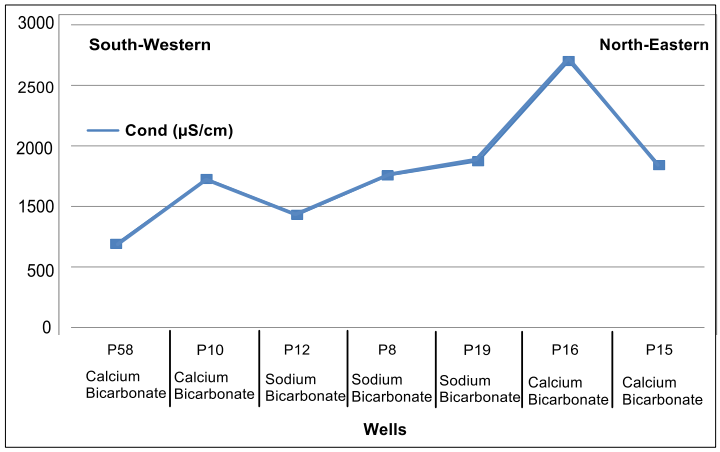


Figure 6. Spatial distribution of chemical facies of Mio-Plio-Quaternary aquifer

SALINITY INDEX

The Electrical conductivity (EC) is a useful parameter in categorising salinity hazard as well as the adequacy of water for irrigation purposes (Farah, 1991); it is defined as the rate of cations (Mg++, Ca++, K+, and Na+) and anions (SO4-, Cl-, HCO3- and CO3-) soluble in water (Natural Resource Conservation Service, 2011). The groundwater samples were classified according to Bauder et al. in 2007. The values of electrical conductivities are between 460 and 2530 µS cm-1

with a 1199.125 µS cm-1 as an average, the waters of the plain are ranged between good quality (83.33 %) and admissible quality (16.66 %) (table 3).

Table 3. Classification of water according to the EC

EC (µs/cm)	Water quality	Number of samples%
< 250	Excellent	0
251-750	Good	16.66
750-2000	Admissible	83.33
2001-3000	Doubtful	0
>3000	Unsuitable	0

According to the direction of flow, the groundwater becomes more and less loaded with salts explaining by the decrease in electrical conductivity from the southwest to the northeast of the study region resulting in the phenomenon of dissolution (figure 7).

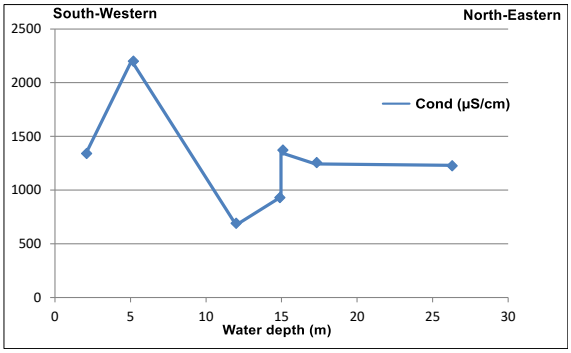


Figure 7. Spatial evolution of conductivity as the water depth

Total hardness (TH)

The hardness of water is the outcome of the divalent metallic cations existence (Mg2+ and Ca2+), it is calculated as the sum of the concentrations of these last in meq l-1 as equivalent to CaCO3 (Todd, 1980). The equation that follows expresses it:

$$TH = 2.5 \times Ca2+ + 4.1 \times Mg2+$$

This is usually classified according to United states environmental protection agency (U.S. E.P.A.) in1986 as soft (0-60 mg/l), moderately hard (60 - 120 mg/l), hard (120 - 180 mg/l), and very hard (>180 mg/l).

The range of total hardness values for water in the plain of Teleghma is ranging from 45 mg/l to 61 mg/l, with an average of 40 mg/l, which is adequate to WHO limits.

The classification of the calculated total hardness, according to Sawyer and McCarthy in 1967 shows that 12.5 % of the water samples are hard and that the rest (87.5 %) is considered very hard, which revealed that the study region has very hard water (table 4).

Table 4. Classification of water by total hardness.

Total hardness (mg/l)	Classification	Collected samples %
<70	Soft	0
70-150	Moderately hard	0
150-300	Hard	12.5
>300	Very hard	87.5

Analysis by ascending hierarchical classification

Cluster analysis is a multivariate statistical approach, applied to objects to be compiled based on their similar characteristics (Hou et al., 2017).

The cluster analysis has been used mostly and considered in the groundwater hydrochemistry of aquifers as a fine representer of spatial variations (Khanoranga and Khalid, 2019).

The method is chosen in the ascending hierarchical classification (CAH) for our case is that of Ward. According to Saporta in 1990, it constitutes the best method of hierarchical classification on Euclidean data. We used this classification for the variables Na, Ca, K, Mg, SO4, HCO3, NO3, Cl and electrical conductivity.

Analysis of this classification reveals three chemical groups (figure 8):

• The first includes the parameters Mg, SO_4, and Cl, these are waters influenced by the dissolution of evaporitic rocks, which come from the Trias which outcrops in places at the level of the limits of the Teleghma plain.

• The second group is characterised by bicarbonates and calcium, this group is the result of the dissolution of carbonate rocks at the level of the feeding zones located at the level of the Felten, Fahem, and Maziout djebels.

• The third group includes sodium, potassium, and nitrates, it would seem to be largely linked to pollution of agricultural origin by the leaching of surplus chemical fertilisers of the NPK type in the soils, as well as the return of water from the soil. irrigation to the water table. More than 70 % of the water samples analysed have a nitrate content greater than 50 mg/l (standard accepted by the WHO).

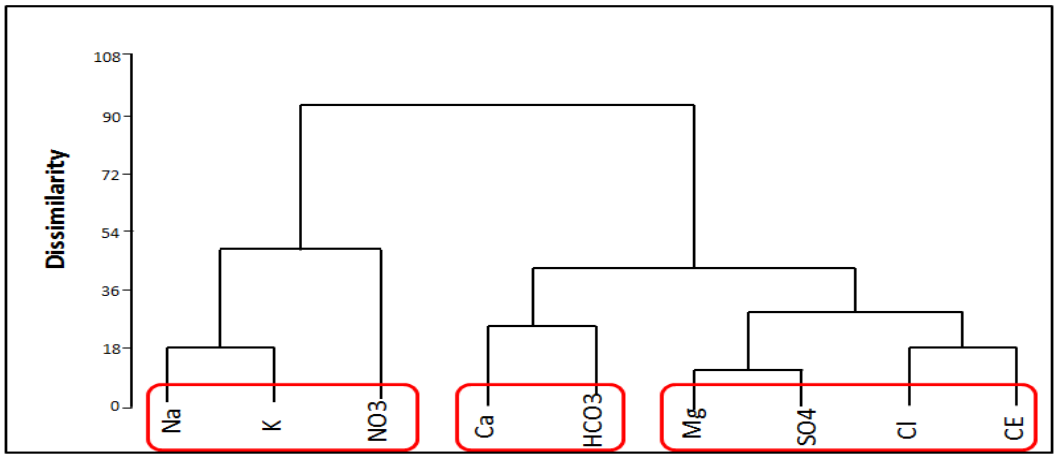


Figure 8. Hierarchical cluster analysis: dendrogram of water sample

Pollution by nitrates:

The review of the map drawn from the data sampling campaign in May 2015 (figure 9) shows that the area most vulnerable to pollution by nitrates are in the north part of the plain, mainly due to the alluvial nature of the terrain that favors immigration of nitrogenous elements to the saturated zone under the effect of the intensification of agriculture and excessive pumping with a content of 180 mg/l. Low concentrations are stored in the southwest part of the land given the high groundwater level and the clayey nature of the roof of the web, which protects groundwater against infiltration of nitrate ions. The low concentration is around 10 mg/l. Chemical analysis showed that nearly 85% of water points have values greater than 50 mg/l.

The examination of the figure of the evolution of the nitrate contents along the flow axis, allowed us to see that the very high nitrate concentrations are located at the level of the northeastern

part of the study region coincide with the preferential direction of the groundwater orientation south west-north east whose aquifer has a shallow depth (figure 10).

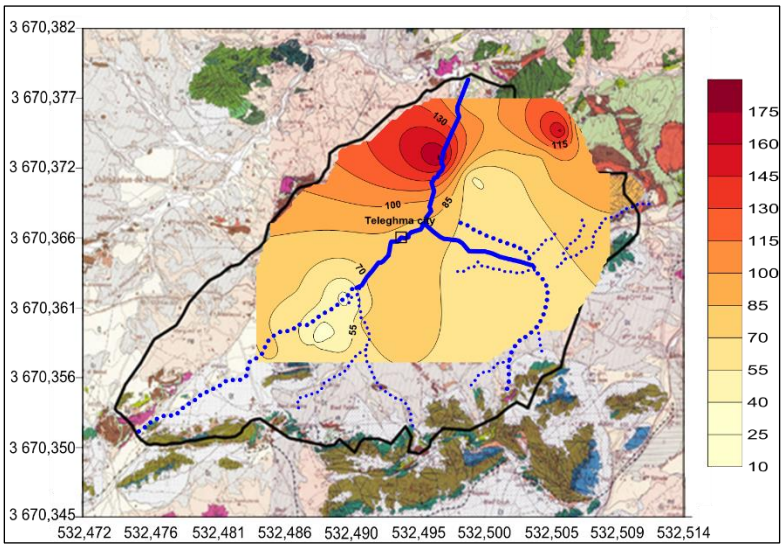


Figure 9. Map of nitrates distribution in Teleghma plain

The type of crop and its sequence are main factors in water pollution (Shepherd and Lord, 2009): the type of crop determines the type and quantity of fertilisers used (in the case of potato uses 12 Kg ha-1 of NPK fertilisers and for the case of garlic uses 6 Kg ha-1 (C.A.T), however, if the sequence of crops that need fertilisers is too long (potato for example) the risk of pollution will be greater because there will be no possibility for the soil to release the surplice nutrients.

The types and quantities of chemical fertilisers used are not directly related to the cultivated areas but rather related to the type of crop practiced and especially to the expected yield (table 5).

Table 5: Average fertilised area of the main crops grown in the plain and the quantity of chemical fertilisers used (2014 to 2019) (CAT)

Culture	Region					
	Teleghma		Oued Seguin		M'chira	
	Area (ha)	Quantity of fertiliser (Qts)	Area (ha)	Quantity of fertiliser (Qts)	Area (ha)	Quantity of fertiliser (Qts)
Potato	387	4644	113	1356	33	396
Garlic	431	3879	41	369	40	360
Onion	211	1899	17	153	17	153
Total	1029	10422	171	1878	90	909

Water pollution is becoming more and more worrying because of the increase in fertilised areas (11,900 hectares in 2015) (CAT).

On the other hand, the low solubility of the phosphate-soil reaction products formed during the application of chemical fertilisers reduces the efficiency of its use by the plants which requires the addition of additional doses of chemical fertilisers to achieve the desired volumes (Savci, 2012). The effectiveness of fertilisers can be improved by applying them more spaced out over time, thereby reducing the amounts used, to give the plants time to assimilate these nitrogenous fertilisers. (Stanford et al., 1970).

Inputs of nitrogen in organic form in the soil are by anthropogenic amendments, returned to the soil of crop residues, and/or restitution of animal waste. The constitution of the stock of mineral nitrogen in the soil is derived from synthetic fertiliser inputs in the form of ammonium nitrate and urea.

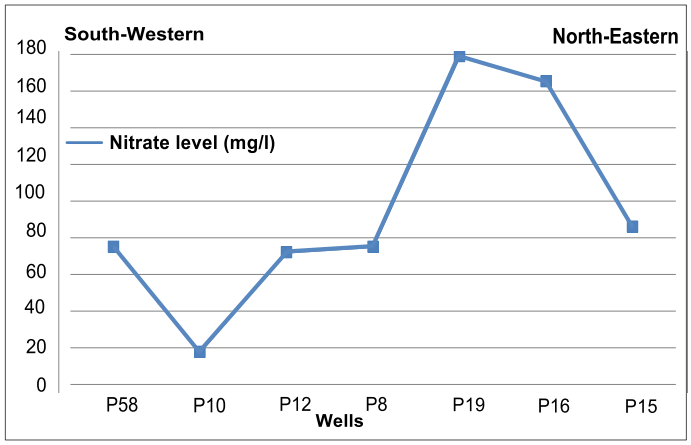


Figure 10. Spatial evolution of nitrate contents as the flow axis

This state is visible especially in the northern part of the land, this is due to the effect the intensive use of chemical fertilisers and the low vulnerability to pollution of these locations by nitrates, which allows nitrates to easily infiltrate the aquifer. Water points located at great depths located in the southwest part, where the northeast at have low nitrate contents (figure 11) due mainly to the self-purification phenomenon of the unsaturated zone (Wang and Chu, 2016), this zone is characterised by deeper piezometric levels reaching 100 m.

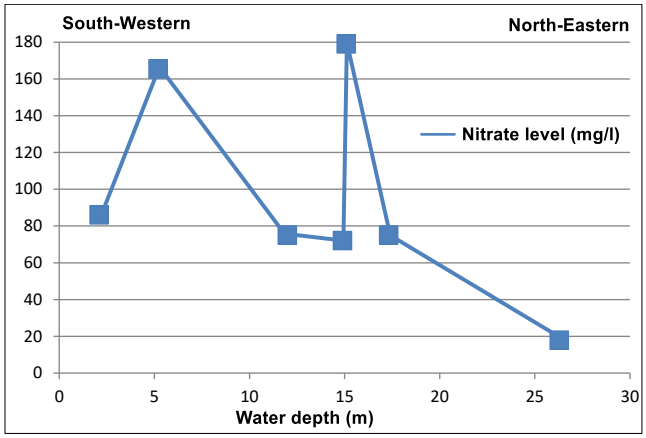


Figure 11. Relation Nitrate- water depth

CONCLUSION

The Mio-Plio-Quaternary aquifer is the most exploited aquifer in the Téleghma region. The depth of the water level is fifty meters but has experienced drawdowns that can reach twenty meters, due to its overexploitation.

The concentrations of major elements reveal fairly homogeneous hydro-chemical facies (three main facies: calcium bicarbonate, calcium chloride, and calcium sulfate which testify,

according to their distribution, to the geological nature of the region. influence of the evaporite formations of the Triassic is indicated by sulfate domination.

The pollution by nitrates of the groundwater of the plain mainly results from the heavy application of chemical fertilisers in agriculture. The problem is worrying in the northern part of the plain where vegetable crops are cultivated in particular and cereals which need nitrogen fertilisation.

Nitrate pollution can be reduced in the region through more appropriate agricultural practices such as:

- Crop rotation, which consists of cultivating successively different crops on the same land, to preserve the soil's production capacity and to cultivate crops that require less fertiliser to reduce pollution (Eghball et al., 2000).

- provide strips of grass between fields and streams, and the use of plants that create an intermediate layer to trap nitrates (according to Eghball et al. these strips of grass can reduce concentrations of nitrates by twenty-one percent).

REFERENCES

Beaton J.D., Tisdale S.L., Nelson W.L., & Havlin J.L. (2003). *Soil Fertility and Fertilisers: An introduction to Nutrient management*. Pearson Education Inc. New Jersey.

Chamber of agriculture of Teleghma. (2018). Archives. Mila. Algeria. Available online at: https://www.demo.cnagri.dz/ (accessed on 21 June 2022).

Collin J.J., & Salem G. (1989). *Pollutions des eaux souterraines par les nitrates dans les banlieues non assainies des pays en développement : le cas de Pikine (Sénégal)* [Nitrate groundwater pollution in developing countries suburbs without sanitation the case of pikine (Senegal)]. Proceedings for international symposium on integrated solutions forwater pollution problems, Portugal. Note technique SGN/JE no 89/27.

Cudennen C., Leduc C., & Koutsoyiannis D. (2007). Dryland hydrology in Mediterranean regions. *Journal of Hydrological Sciences, 25*(6), 1077-1087. https://doi.org/10.1623/hysj.52.6.1077

Cui Z., Dou Z., Chen X., Ju X., & Zhang F. (2014). Managing agricultural nutrients for food security in china: past, present, and futur. *Journal of Agronomy, 106*(1), 191-198. https://doi.org/10.2134/agronj2013.0381

Diaw E.B., Lo M.L., Wade M., Nado S., Diallo A., & Sissoko G. (2016). Modélisation numérique du transport de solutés : prévision des risques de contamination de la nappe des Niayes (Sénégal) par les pesticides [Numerical modelling of solute transport: prediction of contamination risks of the Niayes aquifer (Senegal) by pesticides]. *Journal of Innovation and Applied Studies*, (17), 1358-1372.

Domenico P.A., & Schwartz F.W. (1998). *Physical and Chemical Hydrogeology*. John Wiley and Sons Inc. New York.

Durozoy G. (1960). *Les Ressources en eau des massifs calcaires crétacés de la région de Constantine: étude d'hydrogéologie appliquée* [Water resources of the Cretaceous limestone massifs of the Constantine region, applied hydrogeology study]. Directorate of Hydraulics and Rural Equipment. Department of Scientific Studies. Algeria. notice PPN08370146X.

Eghball B., Gilley J.E., Kramer L.A., & Moorman T.B. (2000). Narrow grass hedge effects on phosphorus and nitrogen in fertiliser application. *Journal of Soil and water conservation, 55*(2), 172-176.

Farah A.S. (1991). *Etude du comportement hydrochimique d'un oued en zone mediterraneenne semi-aride d'afrique du nord et de ses causes naturelles et anthropiques : l'oued rhumel, constantinois, Algerie* [Study of the behaviour of a wadi in the semi-arid Mediterranean zone of North Africa and its natural and anthropogenic causes. wadi Rhumel. Algeria]. Doctoral Dissertation. Orleans University. France.

General Geophysics Campain. (1973). *Etude par prospection géophysique sur les hautes plaine de Sétif* [Geophysical survey of the Settifian High Plains]. Hydraulic departement of the wilaya of Mila. Algeria.

XLSTAT (by Addinsoft). Access 27.09.2021, available at: https://www.xlstat.com/en/download.

Iqbal N., Khan N.A., Ferrante A., Trivellini A., Francini A., & Khan M. (2017). Ethylene Role in Plant Growth, Development and Senescence: Interaction with Other Phytohor. *Journal of Frontier in Plant Science*, (8), 1-19. https://doi.org/10.3389/fpls.2017.00475

Hou J., Qiu C., Shen Y., Li H., & Bao X. (2017). Engineering of Saccharomyces cerevisiae for the efficient co-utilization of glucose and xylose. *Journal of FEMS Yeast Research, 17*(4), 1-11. https://doi.org/10.1093/femsyr/fox034

Khanoranga A., & Khalid S. (2019). An assessment of groundwater quality for irrigation and drinking purposes around brick kilns in three districts of Balochistan province, Pakistan, through water quality index and multivariate statistical approaches. *Journal of Geochemical Exploration*, (197), 14-26. https://doi.org/10.1016/j.gexplo.2018.11.007

Khedidja A., & Boudoukha A. (2019). Quality assessment of shallow groundwater for irrigation purposes in Tadjenanet – Chelghoum Laid area (Eastern Algeria). *Journal of River Basin Management, 19*(2), 1-18. https://doi.org/10.1080/15715124.2019.1628031

Michener R., & Lajthaeds K. (2007). *Stable isotopes in ecology and Environmental Science*. Blackwell. Oxford.

National agricultural land Office. (2018). Archives. Algeria. Available online at: https://www.g-fras.org/en/world-wide-extension-study/africa/northern-africa/algeria.html (accessed on 22 June 2022).

National Meteorological Office. (2018). Archives. Algeria. Available online at: https://www.aps.dz/en/algeria/tag/National%20Meteorological%20Office (accessed on 25 June 2022).

National statistics office. (2008). Archives. Algeria. Available online at: https://www.ons.dz/ (accessed on 29 June 2022).

National Water Resources Agency. (2008). Archives. Algeria. Available online at: https://www.ona-dz.org/ (accessed on 23 June 2022).

Natural Resource Conservation Service. United States Department of Agriculture. (2011). *Environmental Technical Note* No. MT-1 (Rev. 2).

Norse D. (2005). Non-point pollution from crop production: global, regional and national issues. *Journal of Pedosphere, 15*(4), 499-508.

Pawar N.J., & Shaikh I.J. (1995). Nitrate pollution of groundwaters from shallow basaltic aquifers, Deccan trap Trap Hydrologic Province, India. *Journal of Environmental Geology*, (25), 197-204. https://doi.org/10.1007/BF00768549

Rodier J. (2009). *Analyses d'eau* [Water analysis]. Dunod. Malfoff. France.

Savci S. (2012). An agricultural pollutant: chemical fertiliser. *Journal of Environmental science and development, 3*(1), 77-80. https://doi.org/10.1007/BF00768549

Sawyer C., & McCarthy P. (1967). *Chemistry of Sanitary Engineers*. McGraw Hill. New York.

Shepherd M.A., & lord E.L. (2009). Nitrate leaching from a sandy soil: the effect of previous crop and post-harvest soil management in an arable rotation. *Journal of Agricultural Science, 127*(2), 215-229. https://doi.org/10.1017/S002185960007800X

Smith L., & Sciliano G. (2015). A comprehensive review of constraint to improved management of fertilisers in china and mitigation of diffuse water pollution from agriculture. *Journal of Agriculture, ecosystems, and environment*, (209), 15-20. https://doi.org/10.1016/j.agee.2015.02.016

Stanford G., England C.B., & Taylor A.W. (1970). *Fertiliser use and water quality*. Agricultural Research Service. U.S. Department of Agriculture.

Todd D.K. (1980). *Groundwater hydrology*.Wiley. New York.

Vila J.M. (1977). *Carte géologique de l'Est algérien 1/20 000 avec notice explicative détaillée* [Geological map of eastern Algeria 1/20 000 with detailed explanatory note]. Service of gelogical maps. Algeria, P-Q_3-4 Constantine.

Vila J.M. (1977). *Carte géologique de l'Est algérien 1/20 000 avec notice explicative détaillée* [Geological map of eastern Algeria 1/20 000 with detailed explanatory note]. Service of gelogical maps. Algeria, 0_3-4 Sétif.

Wang J., & Chu L. (2016). Biological nitrate removal from water and wastewater by solid-phase denitrification process. *Journal of Biotechnology Advances, 34*(6), 1103–1112. https://doi.org/10.1016/j.biotechadv.2016.07.001

Submitted:	Revised:	Accepted:	Published online:
March 15, 2022	October 20, 2022	November 4, 2022	December 22, 2022

Analele Universității din Oradea, Seria Geografie **XXXII**, no. **2/2022**, pp. 126-136
ISSN **1221-1273**, E-ISSN **2065-3409** **DOI** 10.30892/auog.322105-891

EXAMINATION OF AMBULANCE ARRIVAL TIMES BY GEOINFORMATICS TOOLS – EXAMPLE OF BORSOD-ABAÚJ-ZEMPLÉN COUNTY (HUNGARY)

Dániel ECSEGI
University of Debrecen, Faculty of Science and Technology, Doctoral School of Earth Sciences,
Egyetem square 1, 4032 Debrecen, Hungary, e-mail: ecsegidani@gmail.com

Gábor KOZMA*
University of Debrecen, Faculty of Science and Technology, Department of Social Geography and Regional Planning,
Egyetem square 1, 4032 Debrecen, Hungary, e-mail: kozma.gabor@science.unideb.hu

Citation: Ecsegi, D, Kozma, G. (2022). Examination of ambulance arrival times by geoinformatic tools – Example of Borsod-Abaúj-Zemplén County (Hungary). *Analele Universității din Oradea, Seria Geografie*, 32(2), 125-135. https://doi.org/10.30892/auog.322105-891

Abstract: An essential part of the health system is the ambulance service, whose main task is to provide patients with high quality care. In the spirit of the above, the aim of the study is to explore the spatial characteristics of the ambulance service in a Hungarian territorial unit, Borsod-Abaúj-Zemplén county. The main findings of the study are:
- The geographical location of ambulance stations in the county is strongly influenced by geography and demographic characteristics.
- The designation of the coverage areas of ambulance station is fundamentally consistent with the access time to the respective ambulance stations.
- The accessibility of each settlement from the ambulance station and the time needed to travel the ambulance station - location - hospital route differ for the speed allowed by the Highway Code and for the speed of 60 km/h

Key words: ambulance stations, ambulances, Borsod-Abaúj-Zemplén county, access time

* * * * * *

INTRODUCTION

Due to the deteriorating overall health of Hungarian society and the ageing population of the country, safe access to healthcare has become increasingly important in recent years. At the same time, patients' chances of survival significantly depend on how fast the ambulance services can get them to healthcare facilities providing the necessary care.

There is a substantial body of literature available on this topic both from Hungary and internationally (Beke, 2019; Barry et al., 2018; Égi et al., 2015; Ishikawa, 2019; Kolivand, 2020; Knyazkov et al., 2015; Yasunaga et al., 2011), at various territorial levels, with slightly differing methodologies and demographic data.

* Corresponding Author

Kemkers et al. (2010) have studied the spatial characteristics of ambulance services in Hungary. Their analysis is based on a seemingly feasible plan proposing the creation of 23 new ambulance stations, taking into account questions of cost-effectiveness and rationality. Bugya et al. (2015) have created a model that can be used to identify weaknesses and to address ad hoc situations more successfully, thus also contributing to long-term planning.

Murad (2018) presented a potential application of GIS in connection with research in the field of health geography. Using Network Analyst in ArcGIS, he investigated the accessibility of healthcare centres in the city of Jeddah in Saudi Arabia. The results showed that there are several zones in the central and northern areas of Jeddah that are considered underserved in terms of healthcare services, and therefore it would be advisable to develop health services in these parts of the city.

Estember et al. (2019) studied the current performance of public and private ambulance services in Quezon City in the Philippines. Their analysis is highly complex, with several elements taken into account in their calculations, of which location, traffic conditions and time of day were found to be prominent factors. Furthermore, the speed of the ambulances, the weather, and the readiness of the ambulances also had a significant impact on how fast patients could be reached, as did also how fast the ambulance services could react to various force majeure situations.

Wajid et al. (2020) researched the coverage provided by the ambulance network in South Delhi. For the analysis, they used data on fatal accidents in the period 2014-2016, which they grouped according to different criteria. A total of 100 locations were examined to optimally locate the current 29 stations in the area, providing the most ideal coverage possible. Their results showed that with a suitable design, as few as 11 ambulance stations could provide 100% coverage.

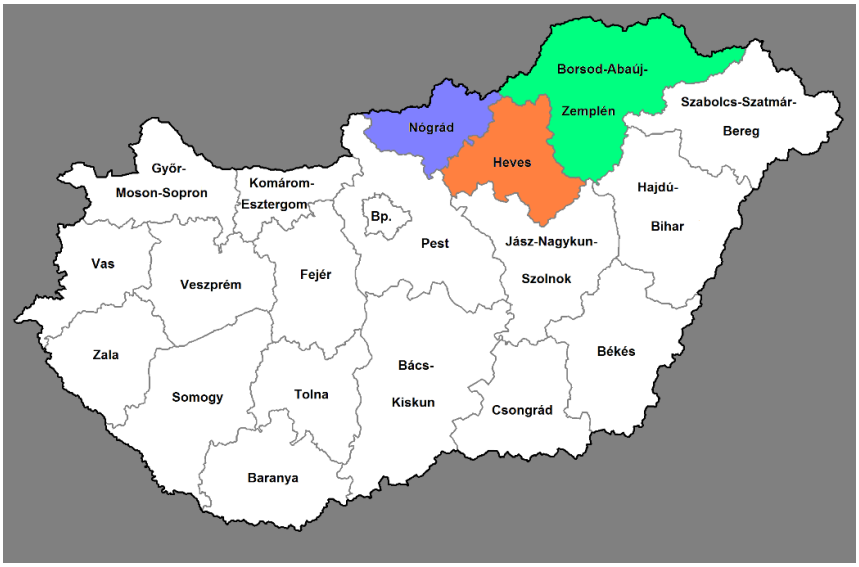


Figure 1. Geographical location of Borsod-Abaúj-Zemplén county
(Source: own work)

In the spirit of the above, the aim of the present research is to identify the location of ambulance stations in Borsod-Abaúj-Zemplén county (NUTS 3 region), in the region of Northern Hungary (NUTS 2 region) (figure 1), and to explore the contrast between the expectations formulated and the actual services provided. The county is the third largest in terms of area (7,250 km^2) and the second largest in terms of population in Hungary (according to 2011 cenzus ~680,000 inhabitants). As far as its settlement structure is concerned (Pénzes and Demeter, 2021), the northern

part of the county is characterised by a large number of small villages (Demeter and Radics, 2015), i.e. settlements with a population of less than 500 inhabitants each. This feature, combined with the mountainous topography of the region – Southern Bükk, Egri-Bükkkalja, Miskolc-Bükkkalja (Csorba, 2021) – and the resulting sparse road network, creates significant challenges in terms of optimisation and rationalization (Badar and Kozma, 2020; Molnár, 2017).

MATERIALS AND METHODS

The projection system used for the analysis is the Unified National Projection (EOV), which is represented in the ArcGIS software as "HD 1972 Egységes Orszagos Vetuleti", with EPSG (European Pertol Survey Group) code 23700. In terms of the software environment, Microsoft Excel was used to produce the charts and tables, and the software Calc from LibreOffice version 7.1 was also utilised. In addition, GIMP software version 2.10.24 was used for the subsequent modification of the maps (Makhlouf Adel et al., 2021)

The ambulance stations were shown on the map on the basis of a table provided by the National Ambulance Service (OMSZ), which not only shows the spatial location of the ambulance stations, but also the types and number of ambulances per station. The mapping of the settlements assigned to each ambulance station was also based on the data provided by OMSZ. The assignment of hospitals is based on data from the Hungarian Hospital Association and the National Hospital Directorate General (OKFŐ).

RESULTS

There are currently 21 ambulance stations operating in Borsod-Abaúj-Zemplén county (figure 2), of which 2 are type "C", 3 are type "B" and 16 are type "A" stations. The differences listed in Table 1 can be supplemented by the fact that the higher-ranking stations are equipped with ambulances providing more complex care. In contrast to the situation generally prevailing in Hungarian counties, where the highest level of service represented by type "C" ambulance stations located in the county seat, in Borsod-Abaúj-Zemplén county a station of this type also operates in Kazincbarcika, a town located about 30 km from Miskolc. The reason behind this is the fact that the chemical plant of Wanhua-Borsodchem Zrt. is located in Kazincbarcika, and because of the risk posed by this, a type "C" ambulance station was also set up in this town. Type "B" stations (Ózd, Mezőkövesd, Sátoraljaújhely) are located in towns at a greater distance from the county seat, mainly close to the county border, and their establishment is due to this geographical characteristic (providing a high level of service to areas further away from the county seat) and the large population of the settlements concerned. In addition to the ambulance stations, OMSZ also has an air ambulance base in Miskolc, which serves the whole of the North Hungary region.

Table 1. Characteristics of different types of the ambulance stations
(Data source: OMSZ)

Types of ambulance stations	Number of ambulances	Management
„C" type ambulance station	8 or more ambulances	ambulance station manager, chief nurse, garage-master
„B" type ambulance station	4-7 ambulances	ambulance station manager, technical supervisor
„A" type ambulance station	2-3 ambulances	ambulance station manager

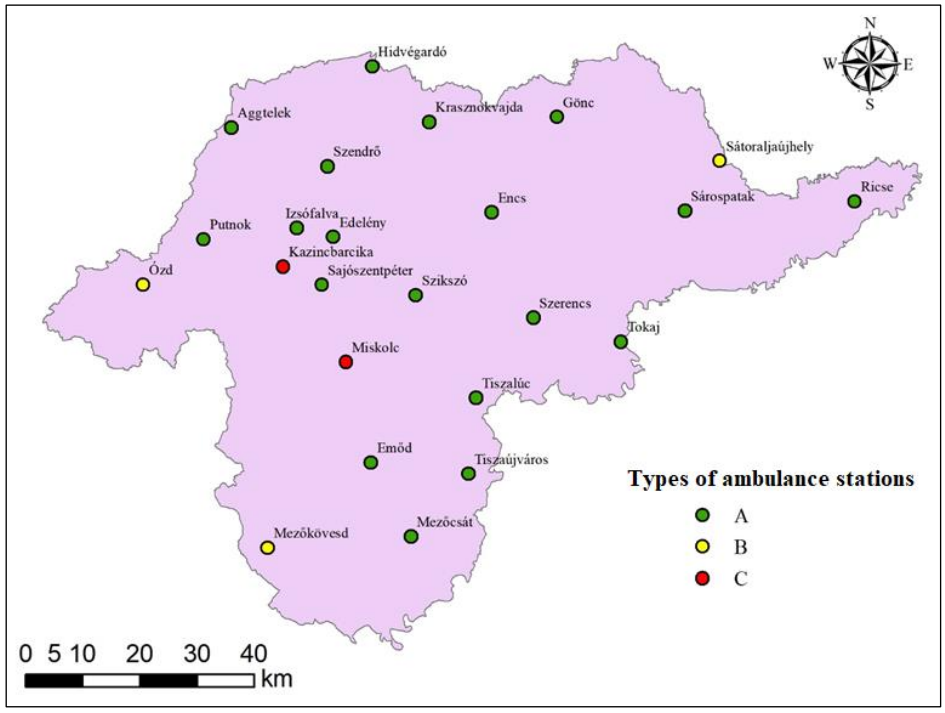


Figure 2. Geographical location of ambulance station in Borsod-Abaúj-Zemplén county
(Source: own work based on data of OMSZ)

The next stage of the research compared the official designated coverage areas of each ambulance station (figure 3) against the location of the ambulance stations that can be reached in the shortest time from each settlement (figure 4). The results showed that a total of 46 settlements were not in the coverage area of the ambulance station from which it could be reached in the shortest time. This figure represents 13.6% of the 337 settlements in the county potentially to be taken into account (there are a total of 358 settlements in the county, but we have to exclude the 21 settlements that have ambulance stations), so the two types of territorial delimitation are in fundamentally in harmony.

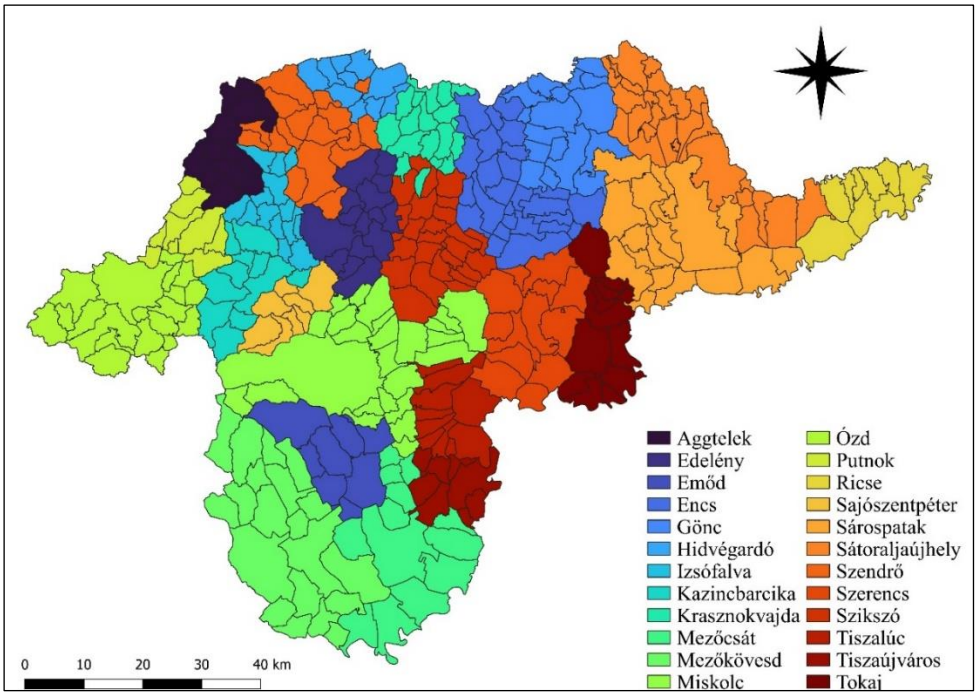


Figure 3. The official designated coverage areas of each ambulance station
(Source: own work based on data of OMSZ)

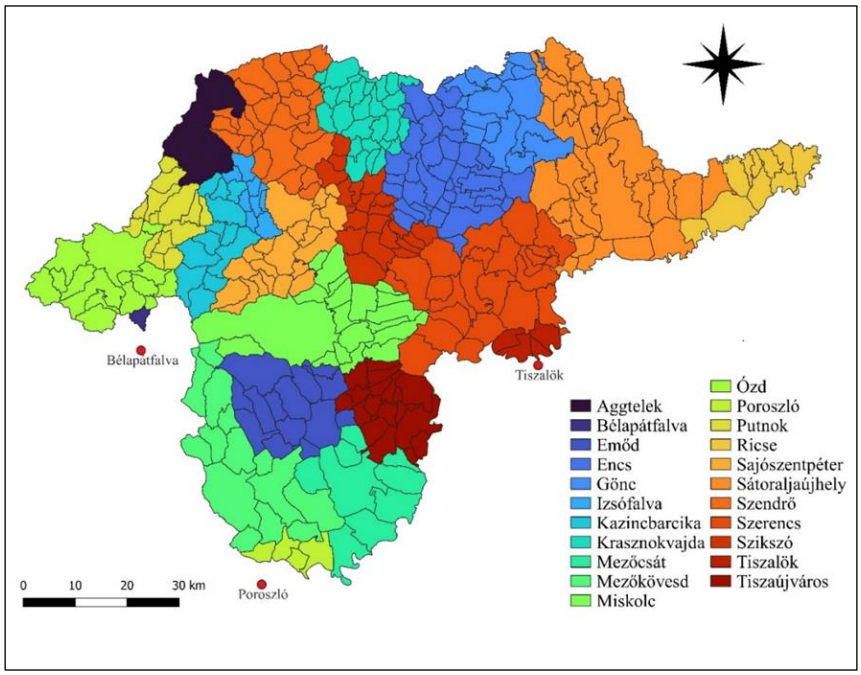


Figure 4. Coverage areas of each ambulance station designated by the shortest access time
(Source: own work based on data of OMSZ)

The highest "over-saturation" (where the number of settlements in the coverage area designated by OMSZ significantly exceeds the number of settlements that could be reached in the shortest time) can be observed in the case of Miskolc (19 settlements), followed by Mezőkövesd (7 settlements), Tokaj (6 settlements), Kazincbarcika, Mezőcsát and Ózd (5-5 settlements). Several factors are behind this phenomenon. Firstly, the majority of the settlements concerned have a type "C" or "B" ambulance station and, as a result, the official coverage area is larger than the number of settlements that can be reached most quickly from there (this is particularly the case for the two type "C" stations). On the other hand, the designation of the official coverage areas follows the county boundaries, but in some cases (e.g. Mezőkövesd and Tokaj) ambulance stations on the other side of the county line may provide faster access to certain settlements (in this case Poroszló and Tiszalök).

Nowadays, the official expectation for ambulance services is to reach the patient within 15 minutes of the emergency call. The current situation in Borsod-Abaúj-Zemplén county is very unfavourable: 81 settlements in case of a speed of 60 km/h, and 99 settlements in case of the highest possible speeds allowed by the Highway Code can be considered as uncovered (figure 5 and 6), and there are a total of 268,528 people living on the settlements in the former category. The difference between the two classifications is essentially related to the road network in the county (figure 7). On the one hand, the M3 runs along the southern/south-western half of the county, the use of which significantly improves accessibility to the areas located there. On the other hand, the northern part of the county is characterised by a network of small villages and a predominance of low-quality – or often even very poor quality roads – which do not make it possible to travel at 60 km/h.

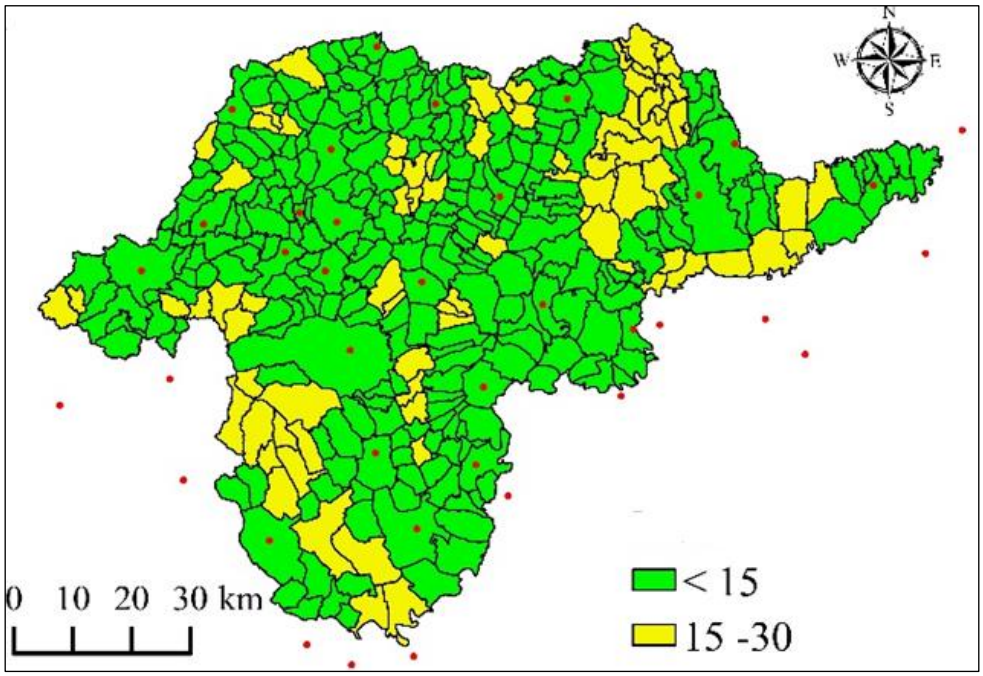


Figure 5. Access time (minutes) from an ambulance station to each settlements at a speed of 60 km/h
(Source: own work)

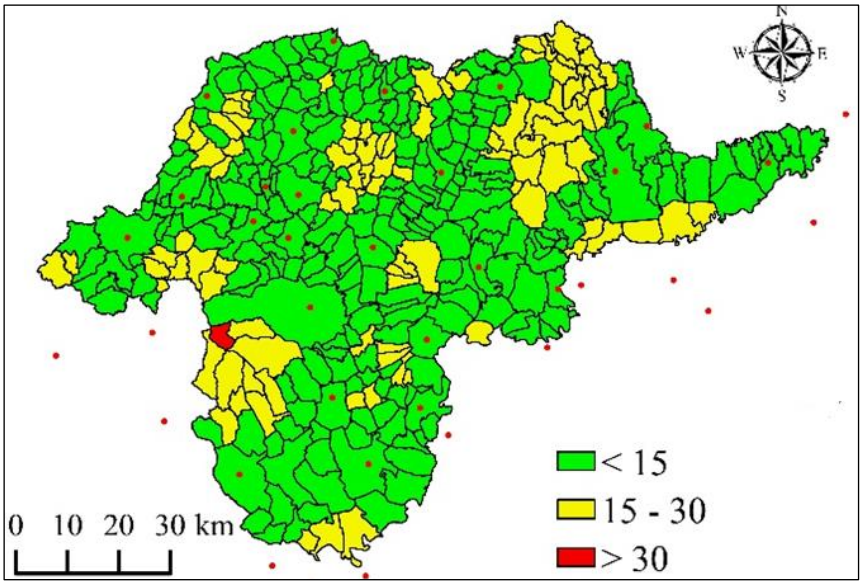


Figure 6. Access time (minutes) from an ambulance station to each municipality at the maximum speed allowed by the Highway Code
(Source: own work)

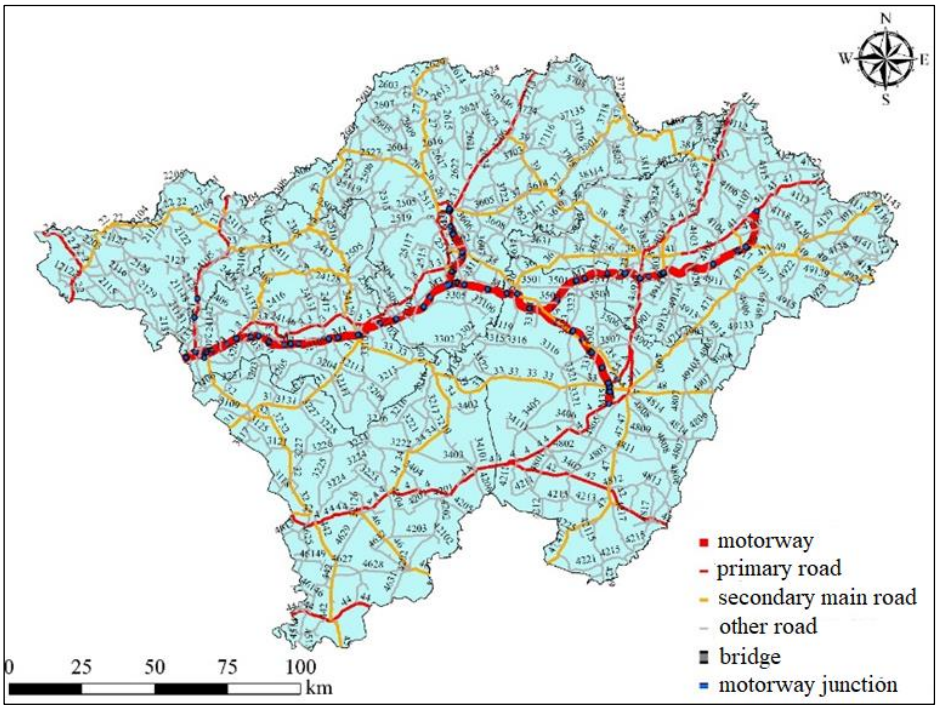


Figure 7. Road network of Borsod-Abaúj-Zemplén county and neighbouring counties
(Source: own work)

The transport of patients to hospitals is a very important task of the ambulance service and, as a consequence, the next section of the study addressed this issue. There are currently seven

hospitals operating in the county (figure 8), but the ones in Mezőkövesd and Szikszó do not have a department that would allow emergency care and were therefore not included in the study.

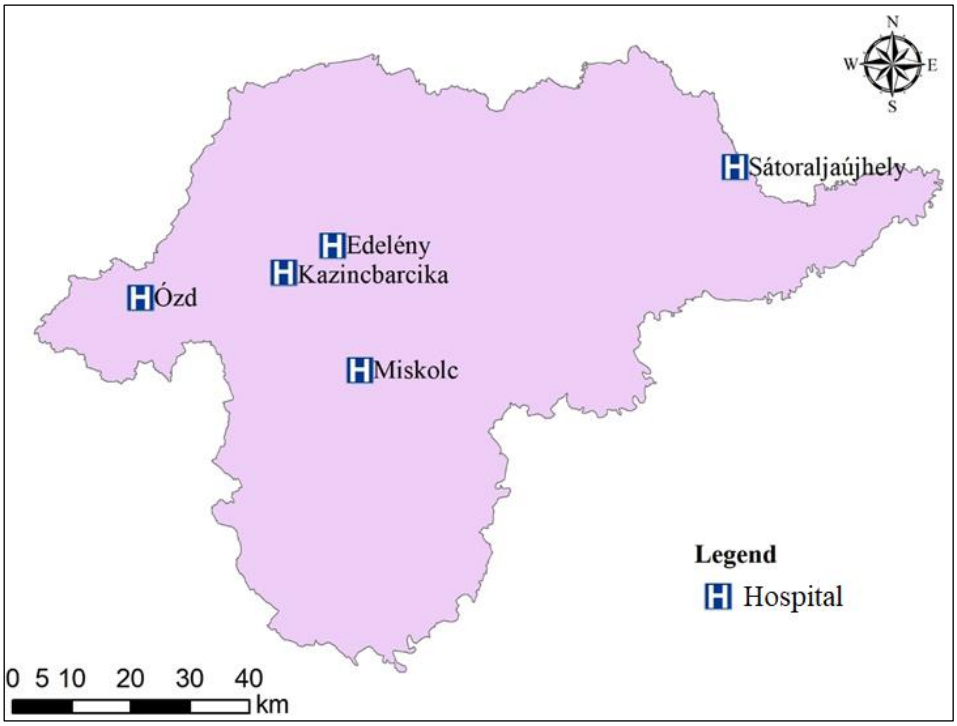


Figure 8. Hospitals that would allow emergency care in Borsod-Abaúj-Zemplén county (Source: own work)

An examination of the overall access time of each hospital (ambulance station to patient pick-up location to hospital) shows that the central and southern parts of the county are in a disadvantageous situation (figure 9 and 10). This is mainly due to the fact that these settlements are partly located far from hospitals and their accessibility is also hampered by the unfavourable topography (the Zemplén Mountains stretching in a northeast to southwest direction). The other important finding is that the total travel time to each settlement is lower in case of the speed allowed by the Highway Code (37.3 minutes) than in case of a speed of 60 km/h (39.4 minutes). This is due to the fact that connection with accessing hospitals, higher-ranking roads, such as primary and secondary arterial roads and motorways, are given priority, as they offer the possibility of travelling at higher speeds.

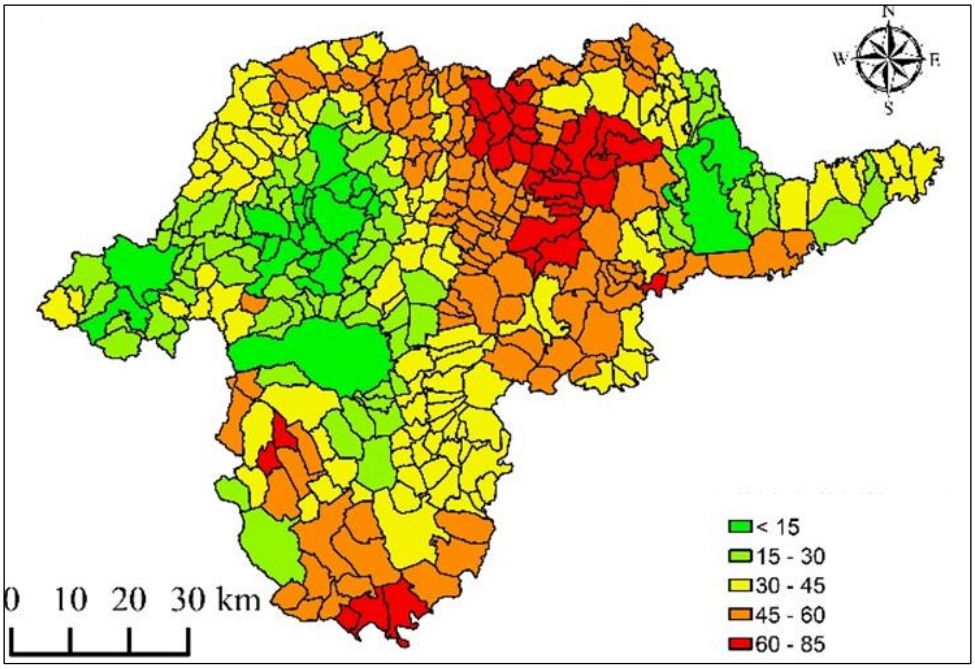


Figure 9. Total access times of nearest hospital (minutes) in case of a speed of 60 km/h
(Source: own work)

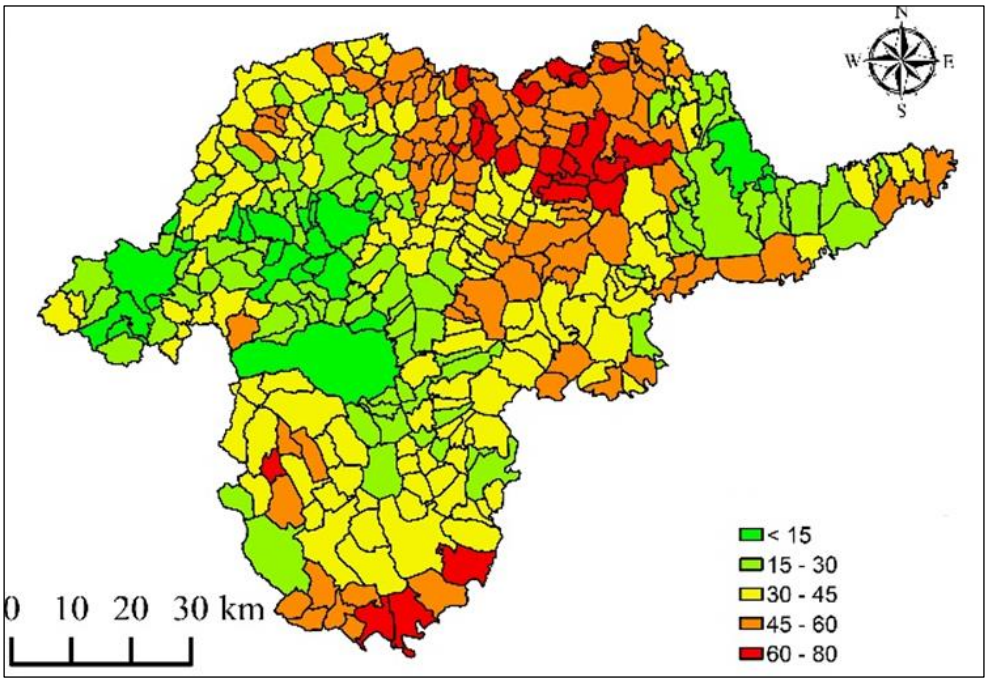


Figure 10. Total access times of nearest hospital in case of the highest possible speeds allowed by the Highway Code
(Source: own work)

CONCLUSIONS

The most important findings of the study could be summarised as follows. The geographical location of ambulance stations in the county is strongly influenced by geography and demographic characteristics. The designation of the coverage areas of ambulance station is fundamentally consistent with the access time to the respective ambulance stations, with major discrepancies observed mainly for stations providing higher-level services. The accessibility of each settlement from an ambulance station and the time required to travel the route of ambulance station to patient pick-up location to hospital differs in case a speed of 60 km/h and the highest possible speeds allowed by the Highway Code, which is primarily due to the geographical conditions and the characteristics of the road network in the county.

REFERENCES

Badar Z., & Kozma, G. (2020). The territorial characteristics of European Union subsidies for economic development used by local authorities in the Észak-Alföld (North Great Plain) region of Hungary between 2014 and 2020. *Romanian Review on Political Geography*, 22(2), 48-60. https://doi.org/10.30892/rrgp.222101-336

Barry, T., González, A., Conroy, N., Watters, P., Masterson, S., Rigby, J., & Bury, G. (2018). Mapping the potential of community first responders to increase cardiac arrest survival. *Open Heart*, 5(2), e000912. https://doi.org/10.1136/openhrt-2018-000912

Beke, S. (2019). Early treatment of acute myocardial infarction and its regional differences in Békés county. *DETUROPE–The Central European Journal of Regional Development and Tourism*, 11(1), 182-195.

Bugya, T., Trócsányi, A., Pirisi, G., & Fábián, S. Á. (2015). A magyarországi mentőellátás térbeli hatékonyságjavításának modellezése: egy lehetséges térinformatikai alkalmazás segítségével. *Területi Statisztika*, 55(4), 356-369.

Csorba, P. (2021). *Magyarország kistájai [Small landscapes of Hungary]*, Meridián Táj- és Környezetföldrajzi Alapítvány, Debrecen.

Demeter, G., & Radics, Z. (2015). A gazdasági fejlettség regionális különbségeinek vizsgálata az Osztrák-Magyar Monarchia utódállamaiban járásszintű adatok alapján [An analysis of regional differences in economic development in the successor states of the Austro-Hungarian Monarchy based on district-level data]. *Történeti Földrajzi Közlemények*, 6(2), 233-246.

Égi, C., Horváth, J., Hahn, K., Kalman, B., Betlehem, J., & Nagy, L. (2015). Improving outcomes achieved by a new stroke program in Hungary. *Cerebrovascular diseases extra*, 5(3), 132-138. https://doi.org/10.1159/000441479

Estember, R. D., Isip, I. G. A., & Misal, M. C. C. (2019). An optimization-based approach model for the improvement of the performance of Emergency Medical Service Ambulances. In *Proceedings of the International Conference on Industrial Engineering and Operations Management*.

Ishikawa, T., Mizuguchi, H., Murayama, H., Fujiwara, K., Tanikawa, T., Kobayashi, E., & Ogasawara, K. (2019). Relationship between accessibility and resources to treat acute ischemic stroke. Hokkaido, Japan: Analysis of inequality and coverage using geographic information systems. *Health policy and technology*, 8(4), 337-342. https://doi.org/10.1016/j.hlpt.2019.10001

Kemkers, R. H. C., Pirisi, G., & Trócsányi, A. (2010). A mentőellátás területi jellemzői Magyarországon. *Területi Statisztika*, 13(50), 4. 420-437.

Knyazkov, K., Derevitsky, I., Mednikov, L., & Yakovlev, A. (2015). Evaluation of dynamic ambulance routing for the transportation of patients with acute coronary syndrome in Saint-Petersburg. *Procedia Computer Science*, 66, 419-428. https://doi.org/10.1016/j.procs.2015.11.048

Kolivand, P. H., Faraji Sabokbar, H., Saberian, P., Bahmanabadi, M., Hasani-Sharamin, P., & Baratloo, A. (2020). Spatial analysis of geographic distribution and accessibility of suspected acute stroke patients transferred to acute stroke centers by emergency medical services in Tehran, Iran: a cross-sectional study. *Iranian Red Crescent Medical Journal*, 22(7), e101502. https://doi.org/10.5812/ircmj.101502

Makhlouf Adel, K., Djamel, T., & Yahyaoui, H. (2021). Integration of a GIS and HEC-HMS modeling to improve urban resilience to flood risk in Algiers, Algeria. *Analele Universităţii din Oradea, Seria Geografie*, 31(2), 100-109. https://doi.org/10.30892/auog.312102-860

Molnár, E. (2017). A félperiféria szerepe az élőmunka-igényes ágazatok globális értéktermelési hálózataiban [The role of semi-periphery in global value chains in labour-intensive sectors]. *Területi Statisztika 57*(4), 436-464.

Murad, A. (2018). Using GIS for determining variations in health access in Jeddah City, Saudi Arabia. *ISPRS International Journal of Geo-Information*, 7(7), 254. https://doi.org/10.3390/ijgi7070254

Pénzes, J., & Demeter, G. (2021). Peripheral areas and their distinctive characteristics: The case of Hungary. *Moravian Geographical Reports*, 29(3), 217-230. https://doi.org/10.2478/mgr-2021-0016

Wajid, S., Nezamuddin, N., & Unnikrishnan, A. (2020). Optimizing ambulance locations for coverage enhancement of accident sites in South Delhi. *Transportation research procedia*, 48, 280-289. https://doi.org/10.1016/j.trpro.2020.08.022

Yasunaga, H., Miyata, H., Horiguchi, H., Tanabe, S., Akahane, M., Ogawa, T., ..., & Imamura, T. (2011). Population density, call-response interval, and survival of out-of-hospital cardiac arrest. *International journal of health geographics*, 10(1), 1-9. https://doi.org/10.1186/1476-072X-10-26

Submitted:	Revised:	Accepted:	Published online:
March 17, 2022	June 15, 2022	September 04, 2022	December 22, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. 2/**2022**, pp.**137-147**
ISSN **1221-1273**, E-ISSN **2065-3409** **DOI** 10.30892/auog.31322106-893

PERSPECTIVES OVER THE ECONOMIC TRANSITION AND DEMOGRAPHIC AGING IN EASTERN EUROPE

Ionel-Calin MICLE
College Prep International, Quebec, Canada
7475 Sherbrooke St W, Montreal, Quebec H4B 1S3, Canada, e-mail: ionel.micle@prepinternational.com

Corina-Florina TĂTAR
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: corina.tatar@didactic.uoradea.ro

Marcu Simion STAȘAC
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: marcu_stasac@yahoo.com

Marius I. STUPARIU
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: marius_stupariu@yahoo.co.uk

Liviu BUCUR
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: liviubucur@yahoo.com

Vasile GRAMA
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: vasile.grama2014@gmail.com

Gyula NAGY
University of Szeged, Department of Economic and Social Geography,
2 Egyetem Street, Szeged 6722, Hungary, e-mail: geo.nagy.gyula@gmail.com

Cezar MORAR*
University of Oradea, Department of Geography, Tourism and Territorial Planning,
1 University St., 410087, Oradea, Romania, e-mail: cezar.morar@gmail.com

Citation: Micle, I.C., Tătar, C.F., Stașac, M.S., Stupariu, I.M., Bucur, L., Grama, V., Nagy, G., & Morar, C. (2022). Perspectives Over the Economic Transition and Demographic Aging in Eastern Europe. *Analele Universităţii din Oradea, Seria Geografie*, *32*(2), 136-145. https://doi.org/10.30892/auog.31322106-893

Abstract: The countries of Eastern Europe represent a particular case from the demographic and economic point of view, as their demographic transition overlapped the economic development process. This represents a major challenge for the sustainability of their health and pension systems and has resulted in reforms and measures to support economic growth and increase the birth rate. Two categories of countries from Eastern Europe were analysed,

* Corresponding Author

Romania and Poland as representatives of the ex-Communist countries that joined the European Union and the Russian Federation as representative of the former Soviet Union. The Russian Federation experienced the most profound changes after 1990, being the only country in the Eastern bloc that is close to the generational replacement threshold, the only country with a positive migration balance, but also the only country with the lowest life expectancy.

Key words: Economic transition, demographic aging, Eastern Europe

* * * * * *

INTRODUCTION

Demography is a word derived from the Greek, "*demos*" meaning people, society or citizen and "*graphie*" describing a particular subject. Demography analyses human populations and profiles them according to their specific characteristics and dynamic processes (Thomas, 2018). Demography studies the size and composition of populations according to various criteria such as age, ethnic origin, sex, marital status, level of education, spatial distribution; dynamic processes such as birth, death, migration, and the relationships between population composition and population change (Lundquist et al., 2015).

Other authors (Caselli et al., 2006) make a clear distinction between the population and the individuals, the latter being able to age more quickly or slowly, but never being able to rejuvenate, whereas a population can rejuvenate if the birth rate increases. Demography deals not only with the size and growth of the population, but also with the composition of the population (Preston et al., 2001), like the age for example, which is generally defined according to the person's birthday (Poston and Bouvier, 2010). Lately, the foci of age-related researches shifted on analysing the aging population. It is estimated that until 2050, for the first time in the human history, there will be more elderly people than children in the world (Lundquist et al., 2015). In the developed countries, people will have increased lifetime and they are likely to live longer in the future. Regarding old age, Vincent (2003) mentions that there are certain stereotypes in societies with older populations as being bound by tradition and lacking innovation, which can affect economic performance.

Most European states are undergoing an aging process. This trend is significant due to a fertility drop and a mortality increase at advanced ages. For the 27 countries of the European Union, the proportion of people aged 75 and over, almost doubled between 1980 and 2015 (from 4.8% to 9%). The differences between Central and Eastern Europe have an impact on the process of population aging and interregional relations (Botev, 2012).

Central and Eastern Europe have experienced considerable instability in mortality since the 1960s. Long periods of stagnation in life expectancy have been followed by rapid increases in life expectancy or subsequent faster declines, before more recent periods of improvement (Aburto and van Raalte, 2018).

For the south-eastern and central Europe most countries were below the median value, such as Romania, Bulgaria, Slovakia, Poland which have less than 3.5% of people aged 75 and over (Gaymu, 2017). The aging acceleration in the countries of southern Europe is due to the shrinking young population and the sustained growth of the elderly. An approach to the intersection of politics and demographic challenges in Hungary and Poland is made in the study of Petrova and Inglot (2020).

The ex-communist countries of Eastern Europe represent a special case from an economic and demographic point of view. These countries have gone through their demographic transition without ever achieving an economic development status (Hoff, 2008) and today, almost without exception, they show a negative population growth rate. Similar to "*a locomotive in the opposite direction*", it is the lowering of fertility which preceded economic development, which has difficulty in taking hold.

Today, the former satellites of the USSR (e.g. Poland and Romania) have come closer to the West as democratic countries, members of the EU, having taken the path of capitalist development, but their economic and demographic strength is weakened by the population aging and a "*haemorrhage*" of labour moving abroad, connected to other existing challenges.

Poland and Romania are two countries which adhered the EU in two different stages (2004 and 2007 respectively) and therefore they have a different level of development (Ilieș et al., 2010; Morar, 2012a; Morar, 2012b; Herman et al., 2019; Niemets et al., 2021), in the same time, Russia is not a member of the European Economic Area. In other historical times, all three nations were part of the Community of Reciprocal Economic Aid (CAER)[1], created at the initiative of the USSR in 1949, as an economic organization of the European Communist states.

In the northern countries where the demographic transition took place in a "*natural*" way by following the stages of industrialization, urbanization and economic development, we can now observe a fertility below the generation replacement threshold, a high life expectancy, therefore aging at the top and bottom of the age pyramid and a shortage of manpower, partly filled by immigration.

In Eastern Europe, we observe the same characteristics except that here the process was much more abrupt with a drop in fertility not as a consequence of development and increase in life expectancy, but of a drop in the standard of life and the youth's massive migration to cities and abroad.

Faced with this situation, there are many challenges, especially with regard to the sustainability of health and pension systems, given that these countries have not had the time to put in place effective social policies, so aging could enhance the economic problems that caused it as in a vicious circle if we do not undertake the adequate reforms.

MATERIALS AND METHODS

To fully understand the complex process of demographic aging in Eastern Europe, it is first necessary to clearly explain the social, economic and political context in which the demographic transition has occurred in these countries compared to the western capitalist countries where the transition took place in a "*natural*" way over a long period of transformations (industrialization and progressive urbanization, sanitary and epidemiological revolutions, drop in infant mortality, increase in life expectancy, drop in fertility, aging).

In Eastern Europe, all these happened in a few years because of a Communist type planning. After the Second World War, these countries were rural and agricultural, little industrialized with a young population which was experiencing the dawn of a baby boom after the war and socio-economic reconstruction, so they followed the same path as Western Europe. The Communist regime accelerated the normal course of development and completely disrupted these societies. From one day to another, the rural population was dispossessed of properties and material goods and had two choices: to either stay in the village and work in the new agricultural cooperatives controlled by the State (and which constituted their property before), or to migrate to the cities (most of them artificially enlarged, without adequate infrastructure) to settle in standard apartments, built for small families and to work in large factories controlled also by the State. The older ones have chosen to stay, the younger ones have gone to towns. As a result, the villages became populated by an elderly and destitute population, so fertility rates fell drastically while the towns were overcrowded and made up of a young population, of working age, but who lived in conditions which discouraged the birth rate (food rations, small standard apartments, poverty, social insecurity).

After the fall of the Communist system, in the new social and economic chaotic context part of the long transition to the Capitalist democracy, the people from the cities who were having plenty of employment opportunities, income and housing guaranteed by the State and a free health and education system, have lost even this security.

[1] Former Community of Independent States (CSI)

From one day to the next, their jobs disappeared and their qualifications were no longer in demand on the job market. Consequences were that people reduce expenses and uncertainties as much as possible by decreasing the birth rate even further and emigrate massively abroad in the context of the opening of borders. After the depopulation and the aging of the villages during the Communist era, it was the time of cities to follow the same path, where the total population started to decrease.

The accession to the European Union with the non-refundable funds received for Romania and Poland have improved somehow the overall socio-economic context, leading to an increase in standard and life expectancy. The main demographic variables that account for the population aging are related to the decline in fertility, the increase in life expectancy and migration, but beyond these causes in the case of Eastern Europe we must add aging as a consequence of imposed policies, mentioned previously. The data obtained from the interpretation of the demographic indicators used, were processed and synthesized, the synthesis based on analysis generated results, being arguments for defining the conclusions.

RESULTS & DISCUSSION

Fertility

The fertility decline started later than in Western Europe, but at a higher speed. While Western countries needed over 60 years to go from a high fertility demography, to a low fertility one, the Eastern countries have passed from one stage to the next in about 20 years (Anderson, 2002). Fertility began to fall below generation replacement rates in 1960 (Zakharov, 2008). Afterwards, it had an upturn thanks to the pro-natalist policies put in place (notably the ban on abortion in Romania in 1966), but after 1990 the decline was more accentuated and well below Western Europe. Only Japan has experienced such a rapid decline in fertility (Hoff, 2008).

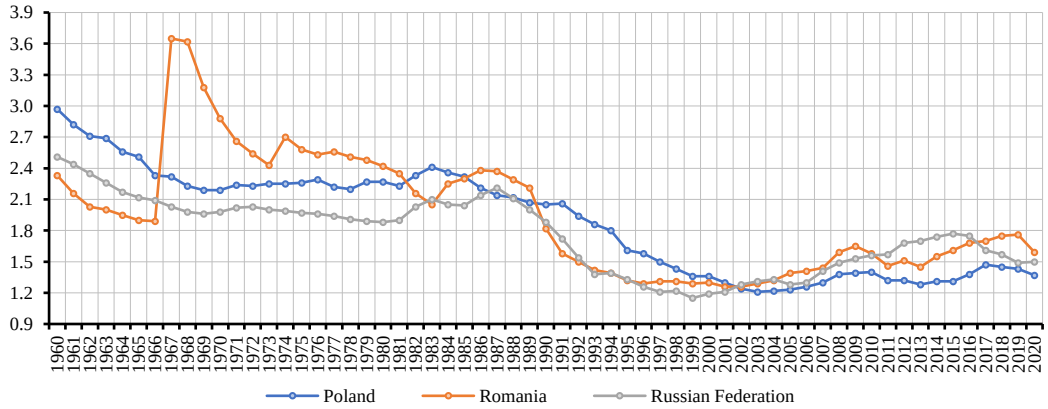


Figure 1. The Total Fertility Rate (children/woman) evolution in Poland, Romania and Russian Federation between 1960-2020
(Data source: World Bank, World Development Indicators, 2021)

We observe a much higher birth rate in the 1960s in Romania (the Total Fertility Rate ISF (Indice synthétique de fécondité) in Romania was 1.90 children/woman in 1966 before the abortion ban and next year in 1967, it was 3,66 children/woman (Mureșan et al., 2008)) than in Poland or Russia, but which also declined more rapidly thereafter in the 1970s (figure 1).

In the evolution of the Total Fertility Rate, by following the curves, we can distinguish four fertility evolution stages: a stage before 1989 with a higher rate for Romania and lower and similar rates for Poland and Russia; the second stage 1990-2000 with a more accelerated and similar decline for Romania and Russia and less accelerated for Poland; the third stage after 2001 with a more accelerated decline in Poland and a slight rise for the other two countries and the fourth

stage, recently, after 2011 where Romania and Poland continue to drop and move closer, and the rise of Russia (the only one in Eastern Europe which is rising), which according to forecasts will be maintained and will get closer to an Total Fertility Rate of 1.7 children/woman, thanks to the recent pro-birth policy (Zakharov, 2008).

A forecast made by the United Nations in 2020 (figure 2) for 2020-2100, by comparing the fertility rate in Europe as a whole continent, Eastern Europe and the analysed countries shows that the trend described previously in stage 4 will continue while Romania and especially Poland will remain below the Eastern European average, so in the long term their population will age more than the regional average while Russia will experience a slight "*rejuvenation*" or rather a less accentuated aging, because its rate of 1.7 children/woman (Table 1) is still below the generation replacement threshold, even if Russia has the highest abortion rate in Eastern Europe (Zakharov, 2008).

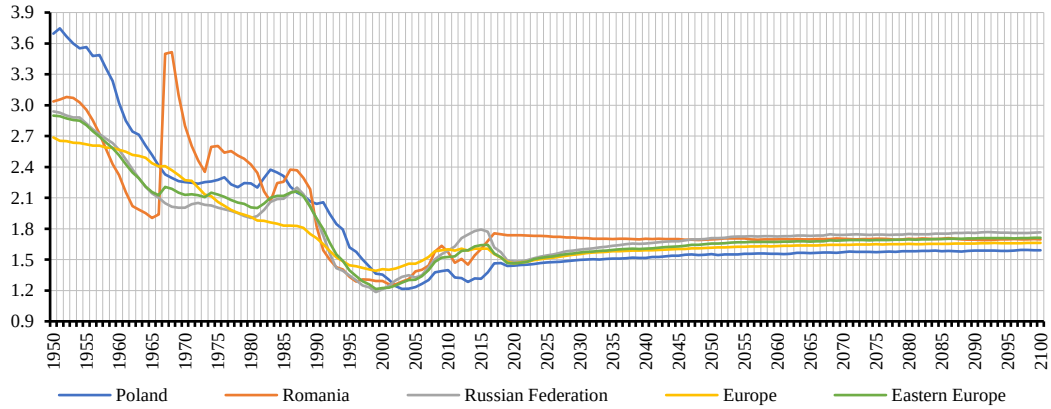


Figure 2. The comparative total fertility rate between Poland, Romania and Russian Federation (1950-forecast 2100)
(Data source: UN Population Division Data Portal)

Most of the consulted authors concluded that the fertility drop in Eastern Europe is a consequence of the difficult socio-economic conditions due to the post-communist economic transition, but they also speak of the second demographic transition (Sobotka, 2008; Kotowska et al., 2008; Mureșan et al., 2008) caused not only by the socio-economic crisis, but also by a change in social values and behaviours (postponement of age at first marriage and first birth, cohabitation is becoming more and more widespread to the detriment of marriage, the increase in the use of contraceptives and abortion, investment in the quality and education of children and less interest in an extended family etc) (Zakharov, 2008). With fertility rates below the generation replacement threshold and an increasing mortality, the population of these countries will continue to age and even decrease.

As peculiarities at the level of the analysed countries it is necessary to underline the following: marriage at the youngest ages in Romania, the lowest cohabitation rate in Poland (country of Pope John Paul II, where the Catholic Church is still influential), the abortion rate and contraceptive use in Russia (contraceptives were banned there during the Soviet regime).

The pro-natalist measures put in place seem to work only in Russia, which thanks to higher government revenues can afford a more generous maternity bonus, but also thanks to other measures (free nurseries, maternity leave paid at 100% of the wages of mothers, free hospital fees etc.). In Poland and Romania, pro-natalist measures do not work because of the difficulties of reintegration into work after maternity and less flexible working hours (in addition in these countries the costs of daycare are only partially state subsidized) (World Bank, 2007).

Table 1. Total fertility rate comparative in Poland, Romania, Russian Federation, Europe and Eastern Europe (1950-2020)
(Data source: UN Population Division Data Portal)

Year / Country	1950	1960	1970	1980	1990	2000	2010	2020
Poland	3.71	3.03	2.26	2.25	2.05	1.36	1.41	1.45
Romania	3.05	2.33	2.81	2.43	1.83	1.30	1.58	1.75
Russian Federation	2.95	2.58	2.01	1.91	1.90	1.22	1.60	1.49
Europe	2.70	2.58	2.28	1.93	1.72	1.42	1.61	1.47
Eastern Europe	2.91	2.52	2.14	2.02	1.91	1.23	1.53	1.47

Life expectancy

While the decline in fertility affects the age pyramid from the bottom, the increase in life expectancy produces an aging from the top of the pyramid (figure 7), as cohorts aged 65 and over take on increasing weight in the total population.

Life expectancy has not stopped increasing in the countries of Eastern Europe, but with peculiarities from one country to another and among gender. During the communist period, life expectancy was close to that of Western countries, especially that of women, but after 1990 the increase slowed down and in some cases even fell, as is the case of the life expectancy of women from Russia or between 1970 and 2000 life expectancy fell from 64 to 59 years (figure 3), a phenomenon never seen in peacetime and in the absence of pandemics. The explanation is excessive alcohol consumption and smoking, especially among men aged 35-49 (Hoff, 2008).

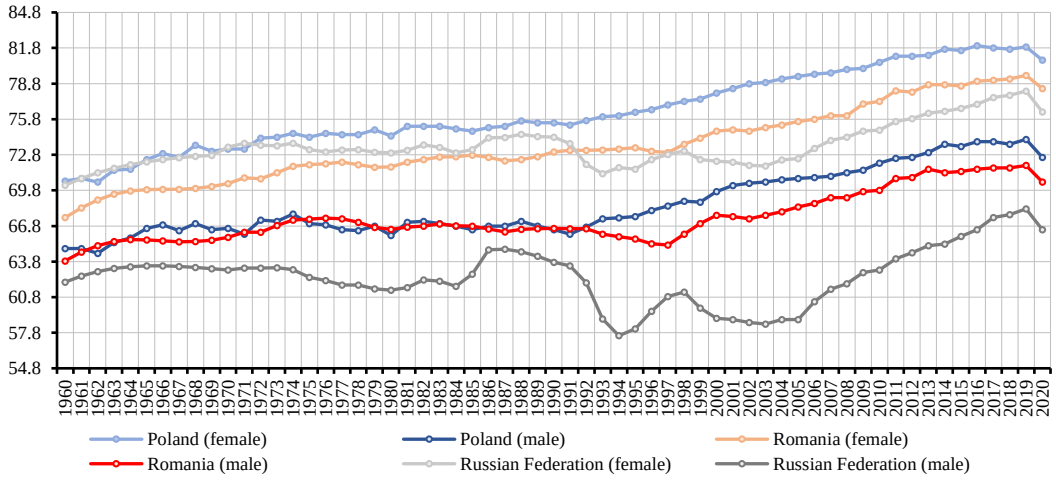


Figure 3. The life expectancy evolution in Poland, Romania, Russian Federation by sex (1960-2020)
(Data source: World Bank, World Development Indicators, 2021)

Russia also shows a great difference in life expectancy between sexes (over 11 years in 2015). Romania and Poland have experienced a steady increase in life expectancy since 1950 (figure 4), but they still fall below Western countries.

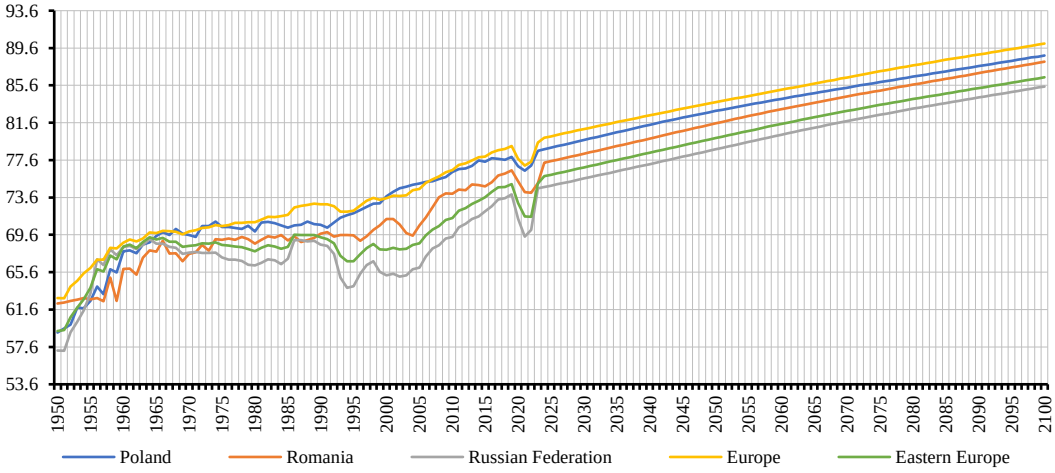


Figure 4. The comparative evolution of life expectancy in Poland, Romania, Russian Federation, Europe and Eastern Europe (1950-2020)
(Data source: UN Population Division Data Portal, 1950-2020)

Migration

Even if the data on migration are more difficult to measure, given that within the EU territory, movement is free and the flows at the borders are less controlled and centralized, it is true that in almost all the countries of Eastern Europe the migratory balance is negative except for Russia, as showed bellow (figure 5).

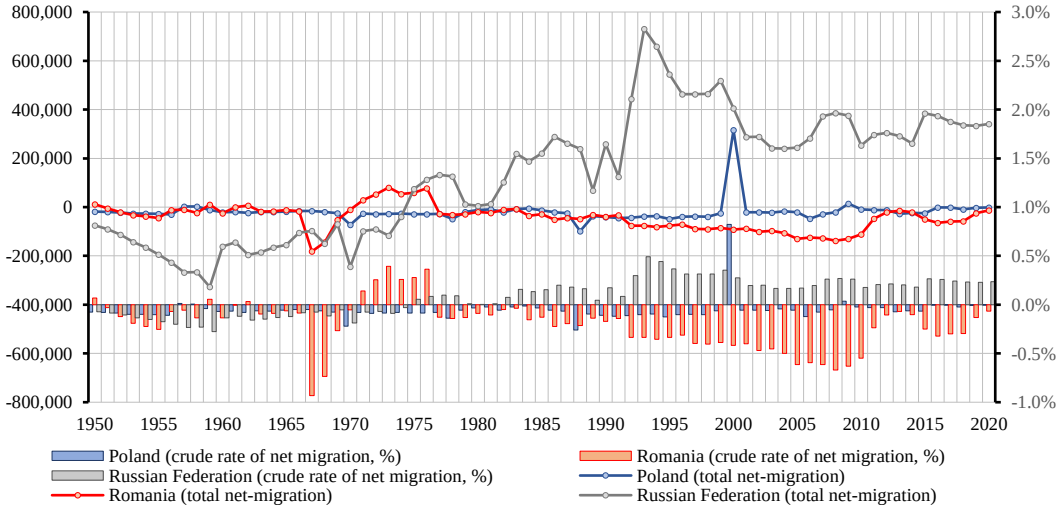


Figure 5. The evolution of the migration in Poland, Romania and Russian Federation (1950-2020)
(Data source: UN Population Division Data Portal, 1950-2020)

The negative natural balance in Romania and Poland is amplified by the negative migratory balance, with a negative influence on the workforce on the one hand (usually it is the active population that migrates) and population aging and the amplification of the dependency ratio on the other hand.

In Russia, between 2010 and 2015, the positive migratory balance managed to compensate for the natural losses so that the total population increased slightly (figure 5). This is explained by

the return migrations from neighbouring ex-Soviet countries, but also by economic immigration attracted especially to extractive industries (hydrocarbons, gold, diamonds) where wages are high.

For Poland we have recently seen (after integration into the EU in 2004) a tendency to gradually transform into a reception country for immigrants, while for Romania there has been a lot of return immigration since 2008.

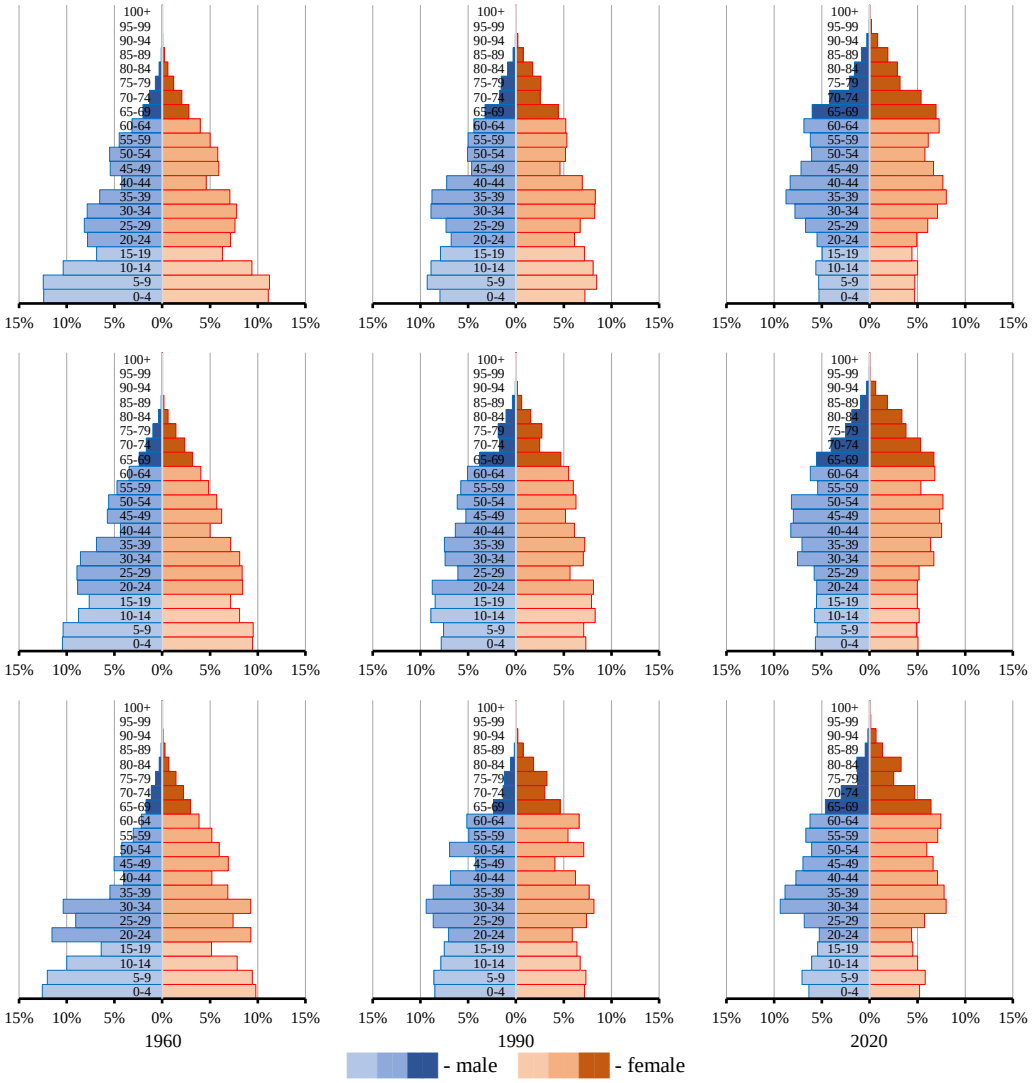


Figure 6. Comparative age pyramids in Poland (up), Romania (middle) and Russian Federation (down), in the years 1960, 1990 și 2020
(Data source: UN Population Division Data Portal)

Demographic changes consequences on the economy and taken measures

Due to a negative natural balance and a negative migration balance (except for Russia), all three countries are experiencing and will experience a decrease in total population, labour force and an older and more dependent society (figure 8).

The recent measures taken to boost fertility and combat the "*outward brain drain*" show that governments are aware of the challenges ahead and they still have time to take advantage of their demographic dividend and put in place sustainable and equitable social policies. Their aging, even if rapid does not have the amplitude of Western countries (figure 6) and their working population can support the retirement system which unfortunately is almost at 100% by distribution, which for the moment represents a very high percentage of the GDP, lower than Western countries (figure 7), but which in the future may become unsustainable.

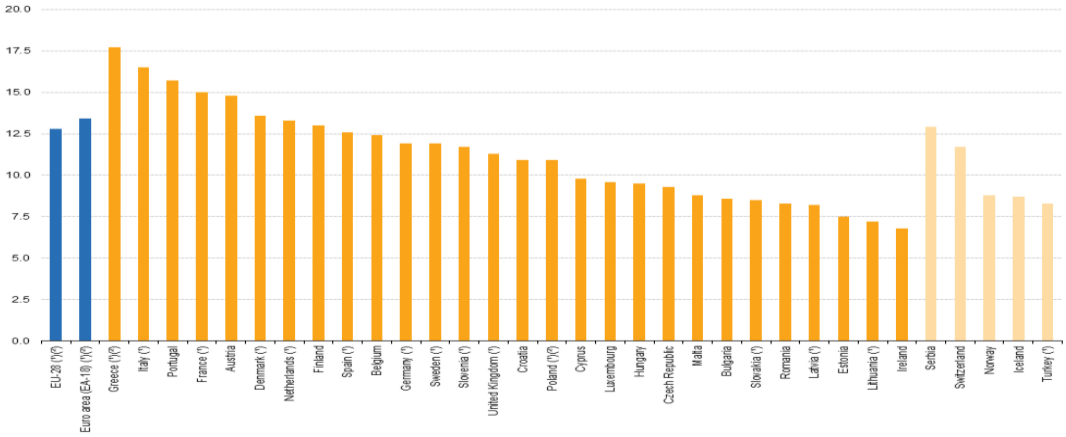


Figure 7. Expenditure with pensions as a percentage of GDP in Romania and Poland compared to other European countries, 2012
(Source: Eurostat, 2012)

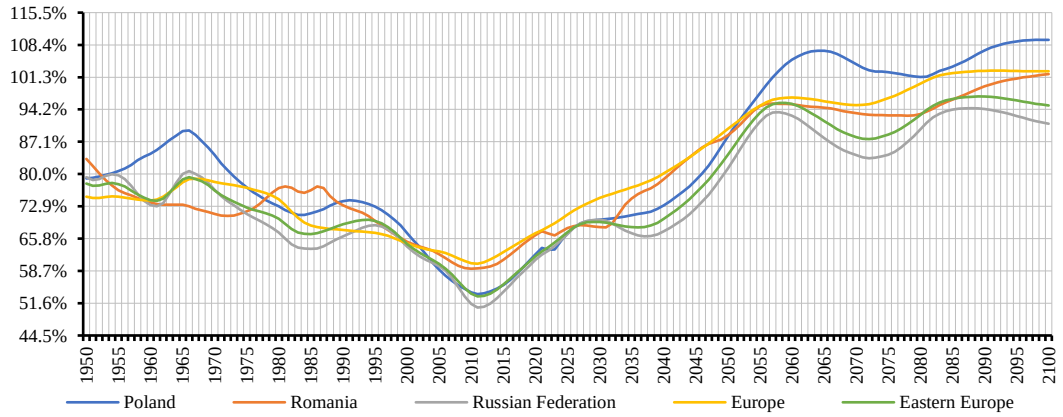


Figure 8. The evolution of the dependency ratio in Poland, Romania, Russian Federation, Europe and Eastern Europe (1950-2020)
(Data source: UN Population Division Data Portal, 1950-2020)

Apart from the retirement system costs, in the case of aging populations like the analysed cases, we are also interested in the costs of the public health system and its viability. For the 3 countries in our case study, these costs are still low compared to Western countries and therefore it shows that aging has a reduced impact on these costs as a percentage of the GDP (figure 9).

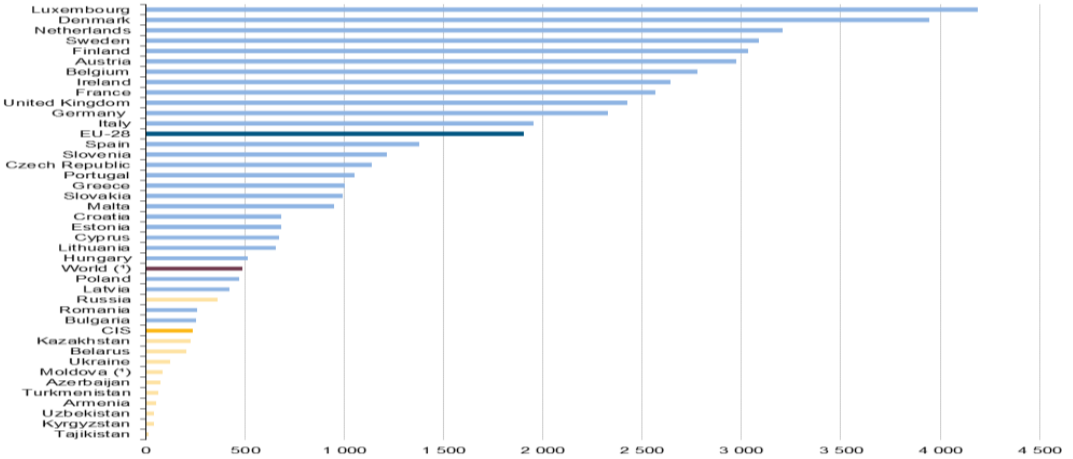


Figure 9. Comparative cost of the health system (in millions of euros) in some European and Central Asian countries, 2012

(Source: EU Member States: Eurostat – online data code: gov_10a_exp; CIS countries: WHO, Global Health Expediture Database – NHA indicators, Global Health Expenditure Database, World Bank data)

CONCLUSIONS

The three analysed countries currently show an aging society resulting from a demographic and economic transition disrupted by measures taken during the Communist era and after Communism (massive privatizations, unemployment, migration, fertility decline etc.), but who have started to react to these problems and to put in place pro-birth policies and social protection for the elderly.

By the Lisbon Agenda (2009), the European Union required Romania and Poland to put in place policies of poverty reduction and intergenerational equity and the reform of pension systems, education and health and also assist them with non-reimbursable cohesion funding. Russia, thanks to the benefits from its hydrocarbon exports, currently has funds to support its pro-natalist policies and its retirement and health system. Fertility seems to be undergoing a turnaround, in addition its workforce is supplemented by a contingent of large numbers of immigrants.

The problems that should be solved for a long-term economic and social development relate to job offers for young people to encourage them not to leave the country and to give them security to start a family and have children, more generous allowances for children and lower day care costs, lower tuition fees, a more flexible schedule to reconcile work with family, the opening of the working market for the elderly, a better distribution of public funds towards the most disadvantaged and the creation of a public savings fund for future retirees, etc.

The limited space of this research does not allow us to illustrate all the various faces and regional peculiarities of aging, because of the great social diversities of these countries.

REFERENCES

Aburto, J.M., & van Raalte, A. (2018). Lifespan Dispersion in Times of Life Expectancy Fluctuation: The Case of Central and Eastern Europe. *Demography*, 55(1), 2071-2096.

Anderson, B.A. (2002). Russia faces depopulation?, Dynamics of population decline. *Population and Environment*, 23(5), 437-464.

Botev, N. (2012). Population Ageing in Central and Eastern Europe and its demographic and social context. *European Journal of Ageing*, 9(1), 69-79.

Caselli, G., Vallin, J., & Wunsch, G. (2006). *Demography – Analysis and Synthesis*, Elsevier.

Eurostat. (2012). Online data code: gov_10a_exp. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_expenditure_by_function_%E2%80%93_COFOG [Accessed 12 July 2021].

Eurostat. (2012). Online data code: spr_exp_pens. Available online: https://ec.europa.eu/eurostat/databrowser/view/SPR_EXP_PENS/default/table?lang=en [Accessed 12 July 2021].

Gaymu, J. (2017). Aspects demographique du grand age en Europe. *Revue européenne des sciences sociales*, 55(1), 22-23.

Herman, G.V., Varodi, M.O., Grama, V., & Morar, C. (2019). Geographical Considerations Regarding the Tourist Destination Pădurea Craiului Mountains. *Analele Universităţii din Oradea, Seria Geografie*, 29(1), 102-108.

Hoff, A. (2008). *Research on Ageing in Central and Eastern Europe*. Paper given at the OIA Seminar Series "Implications of Population Ageing in Central and Eastern Europe", Oxford.

UN Population Division Data Portal. (2020). Interactive access to global demographic indicators. Available online: https://population.un.org/dataportal/home [Accessed 12 June 2021].

Ilieş, D.C., Blaga, L., Josan, I., Baias, Ş., Morar, C., & Herman, G.V. (2010). Cross-border natural Parks, support for regional development. Case study of the northern and western Romanian border. *Revista Româna de Geografie Politică*, 12(1), 126-139.

Kotowska, I., Jóźwiak, J., Matysiak, A., & Baranowska-Rataj, A. (2008). Poland: Fertility decline as a response to profound societal and labour market changes?. *Demographic Research*, 19(1), 795-854.

Lundquist, J.H., Anderton, D.L., & Yaukey, B. (2015). *Demography: The Study of Human Population - Fourth Edition*, Waveland, Press Inc.

Morar, C. (2012a), Demografic characteristics of the disadvantaged mining areas in the Bihor County, Roumania. *Analele Universităţii din Oradea, Seria Geografie*, 22(1), 163-174.

Morar, C. (2012b), Tourism development based on European and national funding programs in the Bihor County's disadvantaged mining areas. *Revista Română de Geografie Politică*, 14(1), 99-108.

Mureşan, C., Hărăguş, P.T., Hărăguş, M., & Schröder, C. (2008). Romania: childbearing metamorphosis within a changing context. *Demographic Research*, 19(1), 855-906.

Niemets, K., Kravchenko, K., Kandyba, Y., Kobylin, P., & Morar, C. (2021). World cities in terms of the sustainable development concept. *Geography and Sustainability*, 2(4), 304-311.

Petrova, T., & Inglot, T. (2020). Introduction: Politics and Current Challenges of Demography in Central and Eastern Europe. *East European Politics and Societies*, 34(4), 879–892. https://doi.org/10.1177/0888325420905886.

Poston, D.L., & Bouvier, L.F. (2010). *Population and Society: An Introduction to Demography*, Cambridge University Press.

Preston, S.H., Heuveline, P., & Guillot, M. (2001) *Demography, Measuring and Modelling Population Processes*, Blackwell Publishing.

Sobotka, T. (2008). Diverse faces of the second demographic transition in Europe, *Demographic Research*, 19(1), 171-224.

Thomas, R.K. (2018). *Concepts, Methods and Practical Applications in Applied Demography – An Introductory Textbook*, Springer.

United Nations. (2020). Population Division Data Portal. Available online: https://population.un.org/dataportal/home [Accessed 12 July 2021].

Vincent, J. (2003). *Old Age*, Routledge.

WHO. (2012). Global Health Expediture Database. NHA indicators. Available online: http://apps.who.int/nha/database [Accessed 12 June 2021].

World Bank. (2007). From Red to Gray. The "Third Transition" of Aging Populations in Eastern Europe and the former Soviet Union. Available online: https://openknowledge.worldbank.org/entities/publication/c53a39c8-b9fb-55d9-973c-0533fadbd898 [Accessed 21 July 2021].

World Bank. (2021). *World Development Indicators*. Available online: https://databank.worldbank.org/source/world-development-indicators [Accessed 12 July 2021].

Zakharov, S. (2008). Russian Federation: From the first to second demographic transition. *Demographic Research*, 19(1), 907-972.

Submitted:	Revised:	Accepted:	Published online:
December 27, 2021	March 15, 2022	October 04, 2020	December 22, 2022

Analele Universităţii din Oradea,
Seria Geografie

TOM XXXII, Nr. 2/2022 (December)

C O N T E N T S

ISSN 1221-1273, E-ISSN 2065-3409