LAND-USE/COVER PATTERN SCENARIOS IN ROMANIA MODELLED FOR 2075

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Key-words: land-use/cover pattern, scenarios, CLUE-s, Romania, national scale.

Abstract: Modelling land-use/cover (LUC) scenarios are essential issue to a better understanding of the potential future tendency in order to facilitate sustainable land management practices. Therefore, the present paper explores the simulated two LUC patterns for the year 2075, modelled through a spatially explicit model, i.e., the *Conversion of Land Use and its Effects at the Small Regional Extent* (CLUE-s). Hence, the location of the transitions and their quantity were analysed in comparison to the current pattern (year 2018) in order to explore the potential LUC pattern change in the 2018–2075 period. Overall, the resulting scenarios indicate an increase in built-up areas (+16%), arable lands (+3%), orchards (+13%), forests (+5%) and natural grasslands (+46%), but a decrease in vineyards (–31%), complex cultivation patterns (–21%), pastures (–9%), heterogeneous agricultural areas (–33%), scrub and/or herbaceous vegetation association (–69%), and open spaces with little or no vegetation (–43%). The analysis of the two scenarios shows that the LUC pattern does not vary significantly at national scale. However, the identified changes within the protected areas suggest that a more appropriate land management could have an important influence on the LUC system in the future. The overall scores of $K_{Simulation}$ (0.84) and its components, $K_{Transition}$ (0.97) and $K_{TransLoc}$ (0.86), indicate that the modelled data captured well the simulated trend in the LUC pattern, pointing to a high potential of the data to be used not only to better understand the possible impact on the LUC system, but also to explore the possible environmental and socio-economic implications.

1. INTRODUCTION

LUC change is recognized as a key driver of global change through its interactions with the climate, ecosystem processes, biogeochemical cycles, biodiversity, and human activities (IGBP and IHDP, 1999). This change is influenced by the spatial-temporal interactions between biophysical and human factors at different scales (Turner *et al.*, 1995; Veldkamp *et al.*, 2001; Verburg *et al.*, 2004; Verburg and Overmars, 2009). Given its implication for global environmental change, LUC change has become a priority research-topic of international programmes and projects: e.g., the Land Use and Cover Change (LUCC), launched in 1994 as a core project of the International Geosphere-Biosphere Programme (IGBP), contributing now to the current Global Land Programme (GLP) – a global research project of the Future Earth Initiative; NASA Land Cover and Land Use Change (LCLUC); Land Change Monitoring, Assessment, and Projection (LCMAP); the CORINE Land Cover Programme, coordinated by the European Environment Agency (EEA). These actions recognize the necessity to improve understanding, modelling, and projections of land-use/cover trend from a global

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to a regional scale. At the same time, the development of modern GIS analysis tools and remote sensing products have led to the exponential growth of studies related to LUC change, but with an increasing emphasis on interdisciplinary research (e.g., in relation to climate change, natural hazard and risk, ecosystem services).

Understanding past and recent LUC change and its driving forces is essential to predicting future transitions and, therefore, to facilitate the development of sustainable management practices designed to preserve essential landscape functions (Lin *et al.*, 2007). In this regard, different models have been developed in order to explain and predict the locations of change (Veldkamp and Fresco, 1996; Lambin *et al.*, 2000; Irwin and Geoghegan, 2001). One of the most widely used is the *Conversion of Land Use/Land Cover and its Effects at Small Regional Extent* (CLUE-s), an empirical model based on advanced statistical LUC change (Veldkamp and Fresco 1996). Specifically, CLUE-s is a process-based modelling framework that allows the user to develop a spatially explicit future LUC pattern dataset based on multiple scenarios. The model has been used across a wide range of scales of analysis, mainly in Europe, Asia and Central America; it was implemented to simulate forest-cover dynamics and conservation (e.g., Wassenaar *et al.*, 2007; Manuschevich and Beier, 2016), urban growth (e.g., Li *et al.*, 2014; Jiang *et al.*, 2015; Qian *et al.*, 2020), agricultural lands abandonment (e.g., Verburg and Overmars, 2009; Renwick *et al.*, 2013), or explore the impact of future LUC change on groundwater pollution (e.g., Lin *et al.*, 2007; Dams *et al.*, 2008; Lima *et al.*, 2015), ecosystem services (e.g., Wu *et al.*, 2015; Lei *et al.*, 2021), carbon storage (e.g., Jiang *et al.*, 2017) and land degradation (e.g., Promper *et al.*, 2014; Zare *et al.*, 2017; Chowdhuri *et al.*, 2021).

In Romania, after the fall of the communist regime, the LUC pattern underwent significant long-term changes, as a result of the socio-economic, political and institutional, as well as biophysical drivers (Strimbu *et al.*, 2005; Irimie and Essmann, 2009; Popovici *et al.*, 2013; Kucsicsa *et al.*, 2015; Popovici *et al.*, 2016; Petrişor AI. and Petrişor LE, 2018; Kucsicsa *et al.*, 2019a). The studies undertaken at national and regional level have revealed the strong connection between LUC change and environmental transformations (e.g., Bălteanu *et al.*, 2004, 2005; Bălteanu and Grigorescu, 2006; Popovici, 2008; Bălteanu and Popovici, 2010; Popovici, 2010).

This issue emphasizes the need for LUC prediction as a key step for the examination of the potential future consequences. Hence, few studies related to understanding and assessing the possible future LUC change, estimated through the CLUE-s model, were addressed at national scale. Specifically, based on the simulated LUC transitions (Kucsicsa *et al.*, 2019a), different related-topics were examined, i.e., the estimation of the main changes related to agricultural lands (Popovici *et al*., 2018), the estimation of the forest-cover dynamics (Kucsicsa *et al.*, 2019b) and their potential impact on aboveground forest biomass (Dumitrașcu *et al.*, 2020), and the estimation of future urban sprawl and its regional differences (Grigorescu *et al.*, 2021). However, the resulting simulations were done at a relative medium spatial and temporal scale (cell resolution = 500 m; time-period <2050), and based on the past LUC tendency calculated for a relatively short period (1990-2000, or 1990-2006). Hence, the aim of the present-study is to analyse possible LUC transitions and their magnitude, increasing the performance and complexity of the simulation by improving the spatial resolution (100 m), expanding the simulated period (up to 2075), as well by considering a hypothetical scenario that shows how appropriate land management practices can affect the LUC system in the area. The calculated past rate of the LUC change used to formulate the baseline scenario of the model was also expanded for 22 years (1990-2012), which may lead to a better estimation of future LUC transitions.

Due to their predictive character, the proposed scenarios represent a background for a further detailed analysis at national and regional scale, not only to quantify and understand the LUC system, but also to examine the possible environmental and socio-economic implication, all this aiming at designing sustainable development plans and strategies at a large spatial scale.

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2. STUDY AREA

Due to the complex biophysical features and specific socio-economic condition, Romania comprises a great diversity of LUC types, with significant regional differences. Overall, according to the CORINE Land Cover Database (EEA – European Environmental Agency, 2018), the actual LUC pattern (Fig. 1) is dominated by agricultural lands (arable lands = 8,665,700 ha, 36.4%; vineyards and orchards = 504,000 ha, 2.1%; complex cultivation patterns = 835,900 ha, 3.5%; heterogeneous agricultural areas = 916,700 ha, 3.9% and pastures = 2,623,400 ha, 11.0% of the total country surface), forests (7,129,000 ha; 29.9%) and built-up areas (1,277,500, 5.4% of the total country surface). A significant area is also covered by scrub and/or herbaceous vegetation associations (526,000 ha, 2.2%), and natural grasslands (578,400 ha, 2.4% of the total country surface). The low extension was noticed in the case of water bodies (379,100 ha, 1.6%), marshes (295,900 ha, 1.2%), open spaces with little or no vegetation (including beaches, dunes, sands, bare rocks and sparsely vegetated areas = 31,400 ha, 0.1%) and other categories (including mineral extraction, dump and construction sites = 41,200 ha, 0.2% of the total country surface).

In the recent past (post-1990), the significant socio-economic, political and institutional drivers have led to significant changes in the LUC system, having a major impact on agricultural and forest landscapes, as well as on artificial land expansion. The causes were mainly related to decollectivization and privatization processes, degradation/abandonment of the agricultural land improvement system, urbanisation, economic hardships or shadow businesses coupled with corruption, factors that led to a higher rate of agricultural land fragmentation and abandonment (Bălteanu and Popovici, 2010; Griffiths *et al.*, 2013; Popovici *et al.*, 2016; Dogaru *et al.*, 2019), urban growth (Kucsicsa and Grigorescu, 2018; Grigorescu *et al.*, 2019, 2021) and deforestation process (Dutca and Abrudan, 2010; Griffiths *et al.*, 2012; Popovici *et al.*, 2013; Dumitraşcu *et al.*, 2016; Kucsicsa and Dumitrică, 2019).

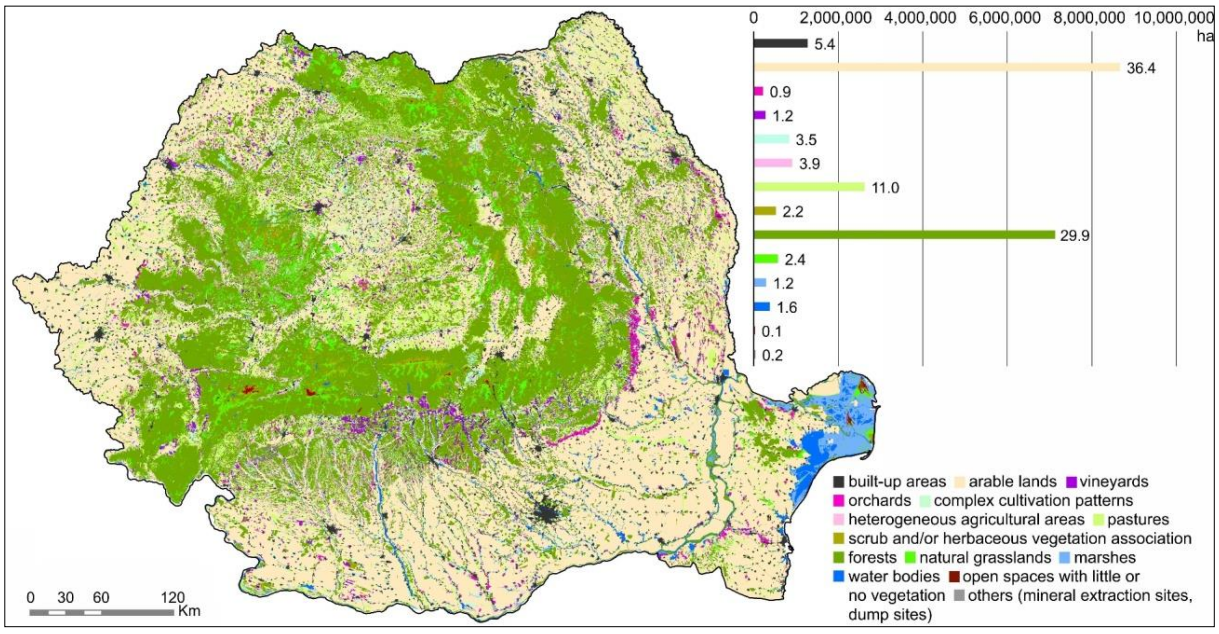

Fig. 1 – The actual distribution of the main land-use/cover classes in Romania
(Extracted from the CORINE Land Cover Database, 2018).

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3. DATA AND METHODS

3.1. The methodology used to estimate land-use/cover scenarios

The described and discussed LUC scenarios in the present paper represent new predicted outcomes as compared to the previous publications, in order to improve, in terms of spatial and temporal resolution, the number of simulated LUC classes and included determinant factors. The previous estimates already analysed the main future LUC flows (Kucsicsa *et al.*, 2019a), the potential changes concerning agricultural lands (Popovici *et al.*, 2018), the forest cover (Kucsicsa *et al.*, 2019b) and urban areas (Grigorescu *et al.*, 2019), or to estimate the future aboveground forest carbon stock dynamics (Dumitrașcu *et al.*, 2020) by 2050.

The implementation of the CLUE-s model

CLUE-s is a process-based modelling framework used to develop spatially explicit future LUC data that includes a non-spatial and spatial module (Verburg *et al.*, 2002), and combines statistical analysis and decision rules that determine the sequence of LUC types (Schaldach and Priess, 2008). The non-spatial module calculates the demands for LUC classes based on an analysis of the determinant factors, while the spatial one translates these demands into LUC change according to the probabilities and rules for LUC classes using a raster-based system (Verburg *et al.*, 2002).

The simulated LUC classes

The modelling integrates three CORINE Land Cover (CLC) datasets (EEA – European Environmental Agency, 2018): year 1990 and 2012, used to calculate the past LUC trend, and year 2018 to validate the outputs. Year 2012 was also used as the starting point of the modelling (year "zero") and to compute the simulation classes. The CLC classes were aggregated, in general, based on the level II of the CLC nomenclature: *built-up areas, arable lands, vineyards, orchards, complex cultivation patterns, pastures, heterogeneous agricultural areas, scrub and/or herbaceous vegetation association, forests, natural grasslands* and *open spaces with little or no vegetation*. Due to their characteristic and dynamics, several LUC classes (water bodies, wetlands, mineral extraction sites, road and rail networks and associated land, dumpsites, bare rocks) were not taken into account in the simulation.

The allocation procedure

The CLUE-s model requires four inputs (Verburg *et al.*, 2004): *LUC specific conversion settings, LUC demands, spatial policies and restrictions*, and *LUC location characteristics*. Subsequently, these requirements are synthetically discussed, but more details can be found in Verburg *et al.*, (2002) and Verburg and Overmars (2009), which provide a comprehensive description of the model implementation and procedure.

LUC specific conversion settings. The specific conversion settings, which indicate the temporal dynamics of the simulations (Verburg *et al.*, 2004), refer to two parameters required to characterize the individual LUC class: *conversion elasticity* (CE), indicating the reversibility of the LUC change (0 = easy to convert, 1 = irreversible change), and *transition sequences* (TS), expressing the potential conversion from one LUC class to another (0 = not allowed, 1 = allowed). The following values were considered for CE: 1.0 (for built-up areas); 0.3–0.4 (for arable lands); 0.4–0.5 (for vineyards); 0.5–0.7 (for orchards); 0.2–0.3 (for complex cultivation patterns); 0.2–0.3 (for pastures); 0.2–0.4 (for heterogeneous agricultural areas); 0.5–0.6 (for scrub and/or herbaceous vegetation association); 0.7–0.8 (for forests);

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0.5–0.6 (for natural grasslands); 0.6–0.7 (for open spaces with little or no vegetation). According to TS, for each of them the LUC was indicated so as to be able to convert into any other, except for built-up areas for which the transition into other categories was not allowed. CE and TS were set based on the authors' understanding of the LUC system and its recent dynamics at regional level.

LUC demands and spatial policies and restrictions. In order to explore the possible differences between the LUC change inside and outside the protected areas, two baseline scenarios were formulated to indicate the demands for LUC in 2075, considering for each of them a level of restriction within the specific locations. ***The first scenario*** **(S_1)** was based on the assumption that future LUC dynamics will be in accordance with the recent registered changes, including within the protected areas. Hence, the calculated annual rate for the 1990-2012 period was linearly extrapolated for the simulated 2013-2075 period. ***The second scenario*** **(S_2)** also points to the future LUC trend in accordance with the recent LUC changes, but it assumes one hypothetical level of LUC transitions within the protected areas in agreement with the appropriate environmental policies. Hence, two protected area categories were considered (The Ministry of Environment, Water and Forests, 2020): (1) those classified as National Parks, for which only de expansion of natural and semi-natural areas (forests, scrub and/or herbaceous vegetation association, natural grasslands and open spaces with little or no vegetation) was allowed; and (2) those classified as Natural Parks (including geoparks, Danube Delta Biosphere Reserve and the Site of Community Importance –SCI / Special Protection Areas – SPA, other than those included among the national parks), for which the deforestation process (including the removal of transitional woodland-scrub) was restricted, while the transitions between other categories were allowed.

According to the recent detected LUC change (1990–2012), an overall increase of built-up areas (+12%), arable lands (+3%), forests (+4%) and natural grasslands (+47%), and the decrease of vineyards (–51%), orchards (–17%), complex cultivation patterns (–21%), heterogeneous agricultural areas (–36%), pastures (–3%), scrub and/or herbaceous vegetation association (–62%) and open spaces with little or no vegetation (–41%) are expected at national level, but with significant spatial differences at regional level.

LUC location characteristics. The location characteristics, which define the "preference" for the specific LUC class at a specific moment in time (Verburg *et al.*, 2005), were empirically estimated as the relation between the LUC pattern (in this case: 2012) and the included determinant factors, by using the following binomial logit model (Eq. 1) performed through the forward procedure in order to select the most statistically significant factors.

$$Log\left(\frac{P_i)}{1-P_i}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} \ldots + \beta_n X_{n,i} \quad \text{(Eq. 1)}$$

where P is the probability of a grid cell for the occurrence of the considered LUC class on location i; $X_1, X_2 \ldots X_n$ are the determinant factors; $\beta_0, \beta_1 \ldots \beta_n$ are the estimated coefficients.

This "preference" (or probability of transition) was established by estimating the relations between each LUC class (as a dependent variable) and 13 biophysical and socio-economic drivers of LUC change (as independent variables). The factors were selected according to data availability and the knowledge of the study-area: *the elevation*, *slope angle* and *slope exposure*[1]; *horizontal relief fragmentation*[2]; *the main soil classes*[3]; *the average annual precipitation* and *temperature* in 1961–2015[4]; *the average number of inhabitants* (1992–2012) and *employees* (1991–2012)[5]; *the protected*

[1] extracted from the Digital Elevation Model obtained by the SRTM–NASA Shuttle Radar Topographic Mission).

[2] calculated using the river network dataset (provided by the EU-Hydro River Network database, available at: https://land.copernicus.eu/imagery-in-situ/eu-hydro/eu-hydro-river-network-database).

[3] extracted from the data provided by the Research Institute for Soil Science and Agrochemistry–ICPA, 1963–1993.

[4] extracted from the data provided by the National Meteorological Administration.

[5] calculated using the statistical data, provided by the National Institute of Statistics: TEMPO-Online Statistical Databases 1990–2018; available at: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table.

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areas[6]; and *the distance to roads*[7], *settlements*[8] and *towns*[9]. A total of 11 continuous and 12 categorical variables were resulted, adapted into spatially explicit factors through various statistical and geo-processing procedures. For the categorical variables, a binary raster indicating the "presence" (value 1) and "absence" (value 0) was computed. Furthermore, prior to the regression analysis, the effects of multicollinearity between the independent factors were examined through *Pearson* correlations. Hence, in the case of significant statistical correlations ($R_{\min \pm 0.7}$), the better predictor variable (in univariate trials) was subsequently used.

Modelling process

After providing all the requirements for the simulation, the process was completed through Dyna-CLUE (v 2.0) (Verburg & Overmars, 2009), a modelling framework which estimates, based on the LUC demand, probability maps and specific conversion settings, the most probable location changes for the simulated LUC classes, conducted by an iterative procedure (Verburg *et al.*, 2002). According to the biophysical potential, land-use history and socioeconomic specifics at regional level, the prediction was achieved for each Romanian Development Region (NUTS II). The regional outcomes have been merged in single maps for further analysis. Due to the type and scale of the data used, and the complexity and limitation of the modelling procedure, a final spatial resolution of 1 ha was chosen for the simulation.

3.2. The predictive performance of the results

The statistic $K_{Simulation}$ (van Vliet *et al.*, 2011) was used to evaluate the predictive performance of the model. The resulting coefficients express the percentage of agreement between the predicted and real data (presently: 2018), including both quantity ($K_{Transition}$) and location information ($K_{TransLoc}$). The $K_{simulation}$ scores vary between −1 and 1, where 1 indicates perfect agreement, 0 the level of agreement expected by chance, and −1 no agreement. The $K_{Transition}$ values range from 0 to 1, 0 indicating that there are no transitions within both the simulated and the reference map, and 1 pointing to the perfect agreement for the transitions. The $K_{TransLoc}$ values range between −1 and 1, 1 indicating an allocation which is as high as possible given the distribution of class transitions, 0 indicating the agreement as expected by chance, and <0 pointing to allocation of class transitions which are worse than can be expected by random allocation (van Vliet *et al.*, 2011). The comparison of the simulated and real data was performed with the help of the Map Comparison Kit (Visser and de Nijs, 2006).

4. RESULTS

4.1. The predicted LUC pattern for 2075. The potential changes between 2018-2075

Fig. 2 illustrates the predicted LUC pattern for 2075 (a) and the changes detected for the 2018–2075 period (b) under S_1 and S_2. In detail, the total amount of the simulated LUC classes and the expected changes for the analysed period are displayed in Fig. 3.

[6] provided by the Ministry of Environment, Water and Forests, 2020, classified into three classes: national parks, natural parks (including geoparks and the Danube Delta Biosphere Reserve) and others (the Site of Community Importance – SCI and Special Protection Areas –SPA, other than those included in the national and natural parks).

[7] calculated using the roads infrastructure, provided by the ESRI Romania database; the influence was established through the multiple *Euclidean* ring buffers (=1000 m).

[8] calculated using the data extracted from the CLC 2012 dataset; the influence was established through the multiple *Euclidean* ring buffers (=1000 m),

[9] calculated using the urban centres' locations; the influence was established through multiple *Euclidean* ring buffers (=1000 m).

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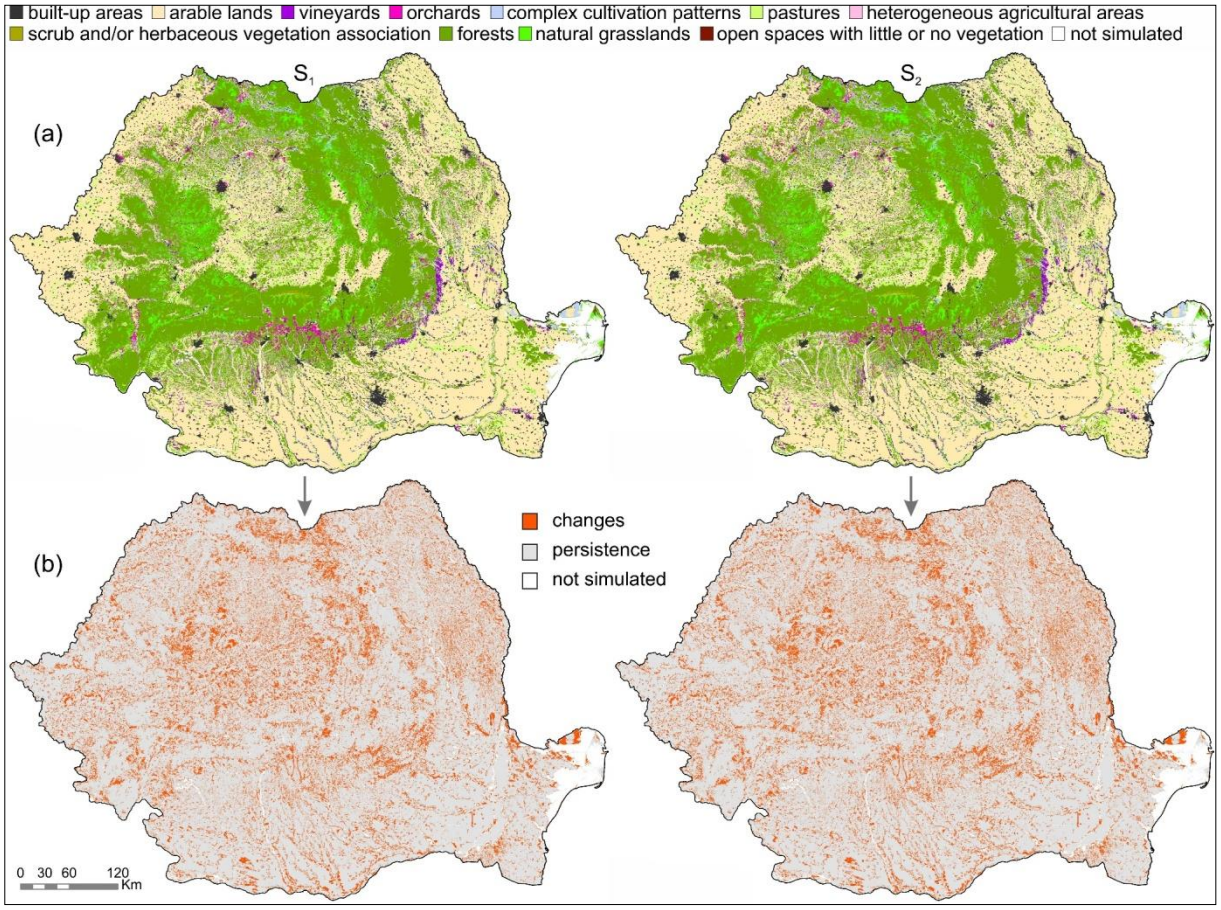

Fig. 2 – The LUC pattern in 2075 (a) and the affected areas by change in the 2018–2075 period (b) as predicted under S_1 and S_2.

The total predicted area of change adds up to 3,776,540 ha (16.4%) under S_1, and 3,840,340 (16.7% of the total simulated lands) under S_2, affecting about 16% of the total country area. Specifically, the model predicted an increase in built-up areas (+16%), arable lands (+3%), orchards (+13%), forests (+5%) and natural grasslands (+46%). On the opposite, the future trend is on the downturn for vineyards (–31%), complex cultivation patterns (–21%), pastures (–9%), heterogeneous agricultural areas (–33%), scrub and/or herbaceous vegetation associations (–70%), and open spaces with little or no vegetation areas (–43%).

The results show a relatively common trend for both S_1 and S_2, the degree of net changes between the scenarios varying insignificantly. Slight difference was obtained for the simulated vineyards (–1.4%), scrub and/or herbaceous vegetation association (+1.2%), complex cultivation patterns (+0.4%), heterogeneous agricultural areas (–0.2%) and natural grasslands (–0.2%) under S_2, in comparison with S_1. However, as expected, the location-specific restrictions indicated for S_2 are more evident within the protected areas, where the predicted forest area is +24.3% higher, and built-up areas are –19.0% lower. Values of –5.6% for agricultural lands and –21.0% for scrub and/or herbaceous vegetation association were also obtained. The values are more significant within the national and natural parks where the predicted forest area is +52.0% higher, and the built-up areas and the agricultural lands are –39.1% and –9.7% lower, respectively, under S_2, when compared to S_1.

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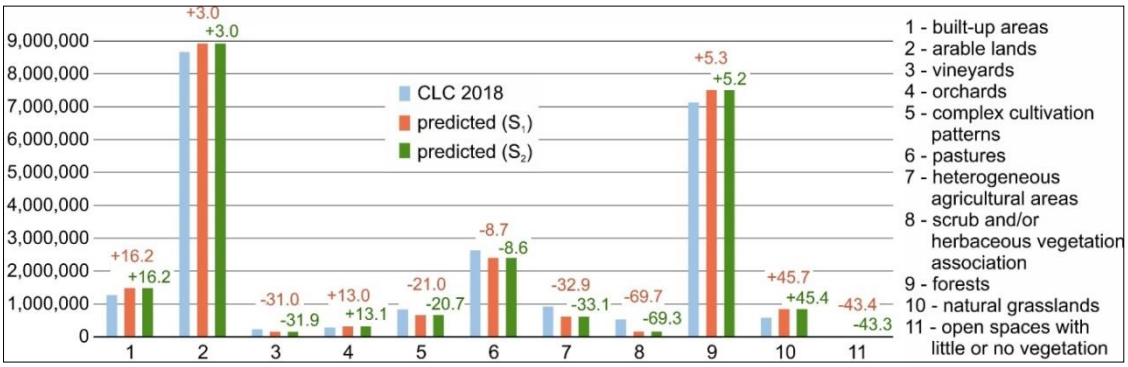

Fig. 3 – The amount (in ha) of the predicted LUC classes compared to the reference year, and the calculated potentially net gains and losses (in %) for the 2018–2075 period.

In terms of the possible transitions (Fig. 4), the built-up areas were predicted to increase mainly to the detriment of arable lands (about 30%), complex cultivation patterns (about 31% for each), heterogeneous agricultural areas (about 16%) and pastures (about 12% of the total). The arable lands were predicted to increase mainly to the detriment of pastures (about 43%), complex cultivation patterns (about 20%) and heterogeneous agricultural areas (about 15%), while orchards – to the detriment of pastures (about 28%) and arable lands (about 21% of the total). The increase in forest area was predicted mainly to the detriment of scrub and/or herbaceous vegetation association (about 39%) and pastures (about 24%), but also heterogeneous agricultural areas (about 14%) and natural grasslands (about 12% of the total). The natural grasslands were mainly predicted to increase on the areas covered by pastures (about 26%), scrub and/or herbaceous vegetation association (about 20%), heterogeneous agricultural areas (about 17%) and forests (about 16% of the total).

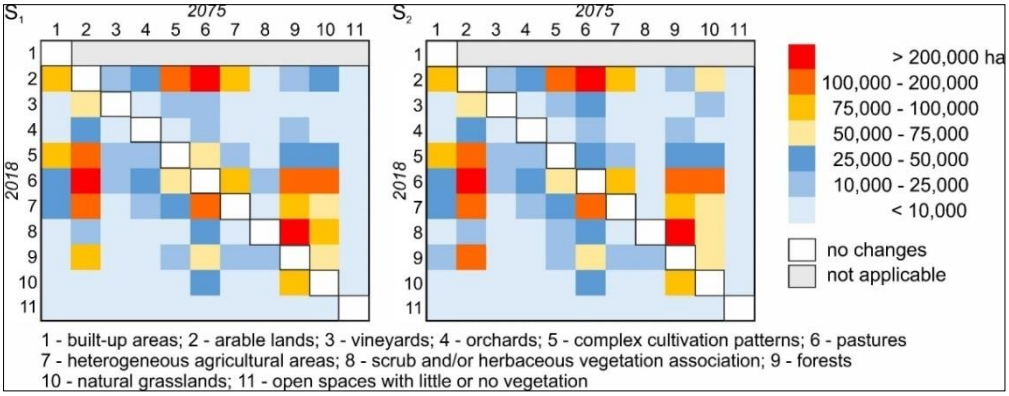

Fig. 4 – The total amount of the potential transitions between the LUC classes in 2018 and as predicted for 2075.

On the opposite, the decline of vineyards was predicted mainly in relation to the expansion of arable lands (about 48%), pastures (about 18%) and heterogeneous agricultural areas (about 17%), while the complex cultivation patterns were predicted in relation to the expansion of arable lands (about 42%), built-up areas (about 17%) and pastures (about 11% of the total). The decline of pastures was mainly predicted in relation to the expansion of arable lands (about 45%), forests (about 16%), natural grasslands (about 11%) and heterogeneous agricultural areas (about 17% of the total). As expected, the decrease of the scrub and/or herbaceous vegetation association was mainly predicted in relation to the expansion of forests (about 60%), but also natural grasslands (about 19%) and pastures (about 9% of the total).

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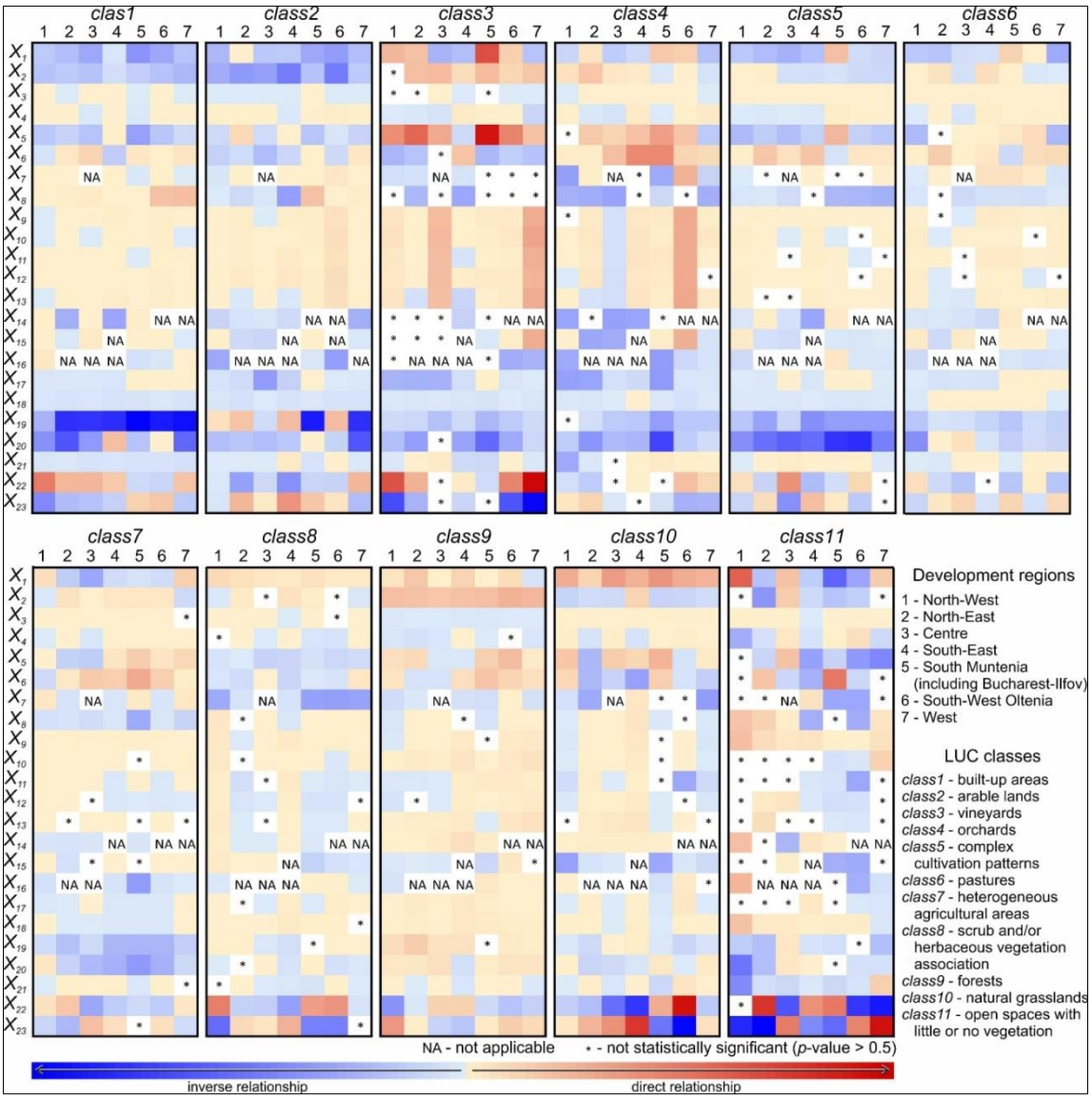
4.2. Driving change factors

Fig. 5 displays the effects of the explanatory factors on the LUC pattern, classified based on the estimated β coefficients in the regression models. In general, the most important explanatory powers are indicated for the specific socio-economic condition in the area, but also for the topographically related indicators and climatic conditions. With the exception of the few LUC classes, the categorical soil classes and the protective measures have, in general, a slight effect or, in some cases, are not statistically significant within a confidence interval of 95% (p-value >0.5).



X_1– Altitude; X_2 – Slope angle; X_3– Slope aspect; X_4 – Horizontal relief fragmentation; X_5– Average annual temperature; X_6– Average annual precipitation; X_7– Soil class (salsodisoils); X_8– Soil class (spodisols); X_9– Soil class (protisols); X_{10}– Soil class (luvisols); X_{11}– Soil class (hydrisols); X_{12}– Soil class (cernisols); X_{13}– Soil class (cambisols); X_{14}– Soil class (umbrisols); X_{15}– Soil class (vertisols); X_{16}– Major protected areas (national parks); X_{17}– Major protected areas (natural parks); X_{18}– Major protected areas (others); X_{19}– Distance to settlements; X_{20}– Distance to roads; X_{21}– Distance to towns; X_{22}–Average number of inhabitants; X_{23}–Average number of employees

Fig. 5 – The graph illustrating the effect of factors on LUC, computed based on the estimated β coefficients in the resulting min/max interval of –50.0/+50.0.

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Specifically, the regression coefficients indicated that the increase in built-up and agricultural areas are inversely related to the increase in *distance to the roads* infrastructure and *settlements* (including towns), and the decrease in the *average number of inhabitants and employees*. In other words, it all means that urban growth and agricultural lands are more likely to be found in areas with high accessibility, close to the existing (mainly urban) built-up areas. The effect of *altitude* is also evident, a strong negative outcome for the built-up areas, arable lands and complex cultivation patterns, but positive for the natural grasslands, forests, scrub and/or herbaceous vegetation association. Comparatively, the same influence direction was noted for the *slope angle*, the expansion of built-up areas and arable lands increasing whenever the slope declivity values decrease. However, a direct relationship was found between the vineyards, orchards and pastures, and the increase of the slope angle. The *slope aspect* has a slight contribution to the LUC pattern, the occurrence of built-up areas and agricultural lands being, in general, directly related to the increase in solar radiation. A slight effect was also found for the *horizontal relief fragmentation*, with a direct influence mainly on built-up areas, pastures, heterogeneous agricultural areas and natural grasslands, and a reversed effect on forests and open spaces with little or no vegetation.

The climatic condition also brings a significant contribution to the LUC pattern change, the built-up areas, arable lands, complex cultivation patterns and scrub and/or herbaceous vegetation association being more likely to extend in areas where the *average annual temperature* is lower. However, the probability of a LUC transition to vineyards increases where temperatures rise. The increase in the *average annual precipitation quantity* indicates a high suitability for agricultural lands development (except for vineyards) and forests expansion, but a low suitability for scrub and/or herbaceous vegetation association and open spaces with little or no vegetation.

In terms of categorical factors, the regression coefficients suggest that the soil classes, namely *protisols, luvisols, hydrisols, cernisols and cambisols*, are more favourable for the expansion of arable lands, but in general restrictive for the scrub and/or herbaceous vegetation association, and open spaces with little or no vegetation areas. The suitability for agricultural lands decreases in the areas where the *salsodisols, spodisols, umbrisols* and *vertisols* soil classes are well developed. In terms of *protective measures* (as measured according to the S_1), the statistical analysis shows a low probability for built-up areas and agricultural lands, but a high probability for the scrub and/or herbaceous vegetation association, and forests to be extended within the protected areas in the future. The effect of protective measures increases mainly within the national and natural parks, in comparison with the other protected areas taken into consideration (SCI and SPA located outside of the national and natural parks).

4.3. Model performance

The examination of the modelled data for 2018 in comparison with the real data (CLC 2018) shows a fraction of 88% as predicted correctly. In terms of the agreement regarding quantity and location, the resulting overall values were 0.84 for $K_{Simulation}$, 0.97 for $K_{Transition}$ and 0.86 for $K_{TransLoc}$, suggesting that the model performs better than expected by chance (van Vliet *et al.*, 2011). As detailed in Table 1, the better accuracy was obtained for the built-up areas, arable lands, forests, natural grasslands, orchards and pastures, for which the resulting scores were higher than 0.7, suggesting that the spatial allocation is fairly precise. However, the minimum resulting scores for open spaces with little or no vegetation, scrub and/or herbaceous vegetation association and complex cultivation patterns point to a level of uncertainty described by these metrics (van Vliet *et al.*, 2011), especially in terms of the degree to which the transitions agree in their allocations.

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Table 1

Model performance indicated by the statistics of $K_{Simulation}$, and its components, $K_{Transition}$ and $K_{TransLoc}$.

	per LUC class											Total	
	1	2	3	4	5	6	7	8	9	10	11		
$K_{Simulation}$	0.93	0.88	0.66	0.73	0.63	0.72	0.65	0.60	0.94	0.78	0.33	$K_{Simulation}$	0.839
$K_{Transition}$	0.98	0.99	0.83	0.88	0.96	0.95	0.99	0.86	0.99	0.99	0.56	$K_{Transition}$	0.974
$K_{TransLoc}$	0.94	0.89	0.79	0.83	0.65	0.76	0.66	0.70	0.95	0.80	0.60	$K_{TransLoc}$	0.862

1 = built-up area; 2 = arable lands; 3 = vineyards; 4 = orchards; 5 = complex cultivation patterns; 6 = pastures; 7 = heterogeneous agricultural areas; 8 = scrub and/or herbaceous vegetation association; 9 = forests; 10 = natural grasslands; 11 = open spaces with little or no vegetation

5. DISCUSSION

New versus previous outcomes

Overall, the produced LUC scenarios are in line with the results reported by previous simulations (Kucsicsa *et al.*, 2019a). However, when it comes to breaking things down, the location of changes and their amount significantly vary in the present outcomes, suggesting a different performance of the simulation. Specifically, different demands for simulation were formulated, more appropriate change factors were included, and a finer spatial resolution together with a longer temporal scale were chosen compared to previous outcomes. On the one hand, increasing the resolution of the simulation from 25 ha to 1 ha supported a better analysis of the location of potential LUC transitions and their amount of change at regional, but also local level. Then, the calculated past rate of LUC change for a longer period, used to formulate the baseline scenario of the model, has better indicated the potential tendency of the LUC pattern for the future. Furthermore, the simulated period up to 2075 resulted in an extended perspective (+25 years) for the analysis, thus supporting the implementation of other related LUC scenarios (e.g., natural hazards in relation to the future LUC change) for a longer time-period. On the other hand, the authors consider that the two formulated scenarios help to explore the potential effect of the more appropriate future protective measures compared to the current situation, thus contributing to a better understanding of how sustainable land management could influence the LUC system in the area.

LUC scenarios and change factors

A significant amount of LUC change was predicted for the study area. The results show that future LUC patterns are likely to continue on the same recent trend (except for orchards), with a calculated change rate of 66,255 ha/year under S_1, and 67,374 ha/year under S_2. The significant net gains were mainly predicted for the natural grasslands, built-up areas, orchards and forests, while net losses were modelled for the scrub and/or herbaceous vegetation association, open spaces with little or no vegetation, heterogeneous agricultural areas and vineyards by 2075. The magnitude of the LUC change between the two scenarios does not vary significantly. However, by analysing LUC transitions inside and outside the protected areas in relation with the formulated scenarios, we have found that a more appropriate land management approach could have an important influence on the LUC process. That is, the location-specific restrictions entailed by S_2 point to a higher level of the expansion of afforested lands, but to a lower level for built-up areas and some of the agricultural land classes in comparison to S_1. Nevertheless, the results suggest that the appropriate environmental policies within the protected areas could lead to an increase in the LUC transition outside them, close to their boundaries, possibly as the result of the increasing demand for wood resources, but also for the agricultural and built-up lands expansion.

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The statistical analysis suggests a varying effect of drivers for the LUC pattern, in terms of explanatory power and influence direction, showing that the mechanisms that influence LUC transitions and their magnitudes in the area are complex and interrelated. Among all included variables, anthropogenic factors were found to be the most important of the LUC change, the effect varying significantly according to the specific socio-economic characteristic (but also historical evolution) within the development regions. However, their influence is in relation with the local biophysical features, the effect changing according to the topographic, pedological and climatic characteristics. Thus, in general, the areas covered by the built-up, agricultural lands (with the exception of vineyards and orchards) and open spaces with little or no vegetation are expected to increase within the plains and tablelands, while forests, natural grasslands and scrub and/or herbaceous vegetation association are assumed to be on a rising trend in the hill and mountain units. Furthermore, the indicated relationship direction and the explanatory power for climatic factors suggest an important impact of future climate change on LUC transitions, mainly related to the forest-cover and agricultural lands dynamics. Thus, the observed climate variability and change in the study area (Busuioc *et al*., 2010) could suggest an increase in afforested areas, mainly at high elevations, but a decrease in arable lands and complex cultivation areas, principally at low altitudes. The (current) role of the protected areas is not, obviously, as expected. However, this seems to lead to a slight restriction in the expansion of urban and agricultural areas, supporting instead the expansion of natural/semi-natural areas (forests, scrub and/or herbaceous vegetation association, natural grasslands), especially within the national and natural parks.

The need for LUC scenarios

This prediction of the future LUC pattern offers the possibility to quantify and analyse in detail the LUC transitions in order to explore their possible effect on landscapes, not only at national, but also at regional and local level. For example, Fig. 6 presents the main important changes, aggregated according to the transitions described in section 4.1, with the possibility to quantify and analyse them for major relief units.

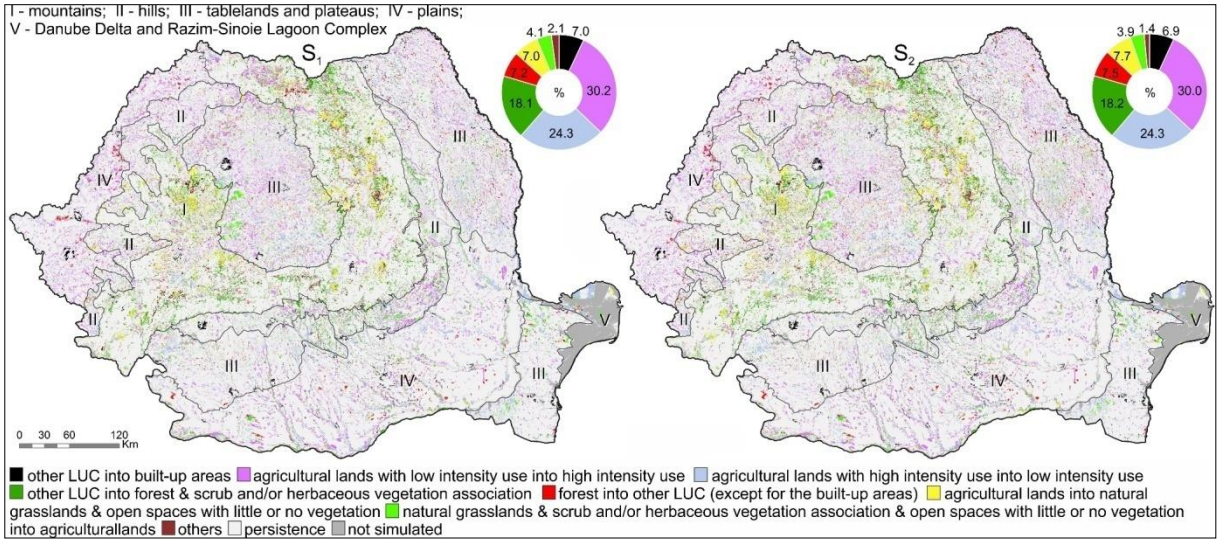

Fig. 6 – The main detected transitions between the LUC classes and fraction of the total changes within the major relief units of Romania.

Hence, the simulated transitions clearly suggest an increased future level of urban growth (7% of the total simulated changes), but taking up 1.8% of the current agricultural land areas, predominantly

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arable lands and complex cultivation patterns. Furthermore, the detected transition of agricultural lands from a low intensity to a high intensity of use (30% of the total simulated transitions) indicates a possible increase in the process related to the agricultural intensification, predominantly on the large area of plains and tableland/plateau regions. The opposite process (24% of the total simulated transitions) also indicates a possible increase in the risk for agricultural land abandonment in the area. In addition, the predicted increase in forest-cover area (18% of the total simulated transitions), mainly related to the decrease in agricultural lands and natural grasslands in the mountain regions, may suggest the increasing decline in traditional practices (including animal husbandry) for the future. At the same time, the predicted forest-cover gains at high altitudes may suggest the expansion of the recent upward shift in trees detected within the highest mountain units of the Romanian Carpathians (Kucsicsa and Bălteanu, 2020). Conversely, the spatial location and magnitude of the future deforestation process (7% of the total simulated changes) points to a continuous forest loss and fragmentation in the plain and tableland/plateau regions, but also in some of the Carpathian areas, resulting in an even more intense degradation and fragmentation of natural habitats. As the aim of the study is not focussed to such an analysis, further studies using the presented outcomes might examine in detail the LUC transitions, in the context of different topics. These could be combined in the main change flows as proposed by Haines-Young and Weber (2006) and Feranec *et al.* (2010, 2017), and previously examined for Romania at national (Popovici *et al.*, 2013, 2018; Kucsicsa *et al.*, 2019a) and regional level (Kucsicsa *et al.*, 2015; Popovici *et al.*, 2022).

The presented scenarios are not only a background to quantify and understand the possible impact on the LUC system, but also to design development plans and strategies at large spatial scale (Koomen *et al.*, 2008). For example, the estimation of the future potential LUC pattern change is an important key for the analysis addressed to the spatial-temporal variability of landslide hazard and risk (Promper *et al.*, 2014) and hazard mitigation plans (Frazier *et al.*, 2013), given that the study area is one of the European countries severely affected by landslides (Bălteanu *et al.*, 2010). Furthermore, the resulting spatial data could be useful to explore the possible consequences of LUC transition on landscape diversity and biodiversity (MacDonald *et al.*, 2000; Fischer *et al.*, 2008; Verburg *et al.*, 2009), the implications for ecosystem services (Field *et al.*, 2007; Zimmermann *et al.*, 2010), or aboveground carbon allocation (Le Page *et al.*, 2013; Dumitrașcu *et al.*, 2020).

The uncertainties of the simulation

Overall, the proposed scenarios captured the trend in LUC change, the accuracy assessment suggesting a concurrence between the simulated and the real data. However, the results could be subject to several errors mainly associated with the methodology, but also to the LUC base-data used for the simulation, as well as the change factors taken into account. Next, some of the most important uncertainties are concisely described, but more details can be found in the previously mentioned studies (Kucsicsa *et al.*, 2019a, b; Grigorescu *et al.*, 2019; Dumitrașcu *et al.*, 2020). On the one hand, the model parameters and structural uncertainties within the model (Verburg *et al.*, 2013) might lead to uncertainty for the future LUC patter outcomes and, therefore, to uncertainty within the future LUC transition and quantity of change. On the other hand, the possible miss-classification of the CLC database used may lead to some mistakes related to the recent real LUC transition (Popovici *et al.*, 2013; Kucsicsa and Dumitrică, 2019), thus resulting in an un reliable LUC pattern prediction. Furthermore, the LUC trend calculated for 22 years, used to formulate the baseline for the scenarios, may result in an underestimation of the future LUC transitions for such a long period of time (63 years). In addition, the proposed comparative scenarios were only in line with the understanding of how a more appropriate land management can influence the LUC characteristic. Thus, the formulated S_2 should be considered as hypothetical, since the implementation of such suitable protective future measures is more or less probable. Under these circumstances, the predicted maps must be regarded as indicating a LUC tendency rather than an accurately predicted location of change, the uncertainties increasing at the local level.

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6. CONCLUSIONS

The present study explores the newly predicted LUC pattern for the entire area of Romania, simulated regionally through spatially explicit LUC change modelling, i.e., the CLUE-s approach. We have produced and analysed two future potential LUC pattern change, based on the recent LUC change tendency in the area, but considering different specific transition criteria for the future.

The resulting spatial data demonstrate a significant LUC dynamic for the future, resulting in a significant positive tendency of built-up areas, orchards, forests and natural grasslands, but a decline in the case of vineyards, heterogeneous agricultural areas, scrub and/or herbaceous vegetation association, and open spaces with little or no vegetation by 2075. Furthermore, we tested whether the appropriate land management could have an effect on the LUC system, by exploring the situation of two different areas (protected and non-protected). Overall, our findings indicate that the magnitude of the LUC change between the two scenarios does not vary significantly at national scale, but does show significant differences at the regional level, as shown from the specific LUC transitions inside versus outside the protected areas.

The data also demonstrates that the mechanisms that influence LUC pattern are complex and interrelated, the change and its amount varying significantly depending on the regional biophysical and socio-economic specific characteristic. Overall, the statistical analysis suggests that the anthropogenic type is the most important of the LUC change factors, but their effect is linked to the specific biophysical features.

The detected LUC transitions and their quantity clearly suggest a possible involvement of LUC change in any future landscape transformation, with possible important environmental and socio-economic implications. Therefore, the presented outcomes were produced not only as a baseline for a further detailed analysis related to the LUC system, but also to explore other connected issues in the fields of geomorphology, biogeography or ecology. Furthermore, the findings resulting from the analysis of the relationship between the LUC pattern change and its determinant factors may increase the knowledge regarding the mechanisms that influence the LUC pattern change in different environments. Also, the predictive character of the study could represent a background to design appropriate plans for sustainable land management at different spatial scales.

Acknowledgements

The current study was carried out under the project *"The National Geographic Atlas of Romania*" conducted under the research programme of the Institute of Geography, the Romanian Academy.

The authors would like to thank the *European Environment Agency* (Copernicus Land Monitoring Service) for the provision of the CORINE Land Cover dataset (https://land.copernicus.eu/pan-european/corine-land-cover/view) and the *EU-Hydro River Network database* (https://land.copernicus.eu/imagery-in-situ/eu-hydro/eu-hydro-river-network-database), for its support of the European river network dataset. The climatic conditions and roads infrastructure are part of the spatial data used in the *RO-RISK Project* (Disaster Risk Assessment at national level–SIPOCA 30) carried out under the Administrative Capacity Operational Programme.

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Received October 12, 2022

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THE RESULTS OF SOCIO-ECOLOGICAL MONITORING DURING MILITARY OPERATIONS IN UKRAINE USING SATELLITE INFORMATION

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Key-words: military actions, remote sensing, socio-economic monitoring, impact on the environment, night illumination, fires, air pollution, destruction of dams.

Abstract. The article is the review of the impact on the Ukrainian environment (rather a review of the results of the social and ecological monitoring of the environment) in 2022 caused by military operations, using the analysis of remotely sensed data. The purpose of the study is to substantiate the theoretical and methodological foundations using multispectral images for operational monitoring of socio-ecological processes and their consequences during the period of military operations on the territory of Ukraine in 2022. To achieve this goal, the work used remote sensing data from the Sentinel-2, Sentinel-5P, Suomi NPP satellites. The visible results of the ecological damage after the Russian invasion of Ukraine, such as atmospheric air pollution, the destruction of dams (the drainage of the Oskil reservoir and the flooding of the Irpin river floodplain) and forests, grass fires, as well as the destruction of agricultural land are shown using images from Sentinel satellites for the March-June 2022 period. The article also presents the results of the analysis of the night illumination of Ukrainian cities from the Suomi NPP/VIIRS satellite for March and April 2021, 2022. In particular, it was established that the cities of Mykolaiv, Kramatorsk, Sumy and Mariupol were the most affected, where the values of night illumination decreased 13–20 times and range between 0.3–0.7 nanoWatts/cm^2/sr. A comprehensive analysis of the consequences of ecocide (the degradation of the natural environment, the destruction of economic, life support systems, housing, migration and the death of the population) is provided, and points towards a man-made humanitarian disaster and a high probability of an ecological disaster. The complex consequences of ecocide (the degradation of the natural environment, the destruction of economic complexes, life support systems, housing, migration, and the death of the population) indicate a man-made humanitarian disaster and a high probability of for an ecological disaster. In order not to waste time, it is necessary today, even in the conditions of war, to make balanced decisions regarding the environmental situation in order to at least mitigate the current and future environmental consequences of said military operations.

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Rev. Roum. Géogr./Rom. Journ. Geogr., **66**, (2), p. 117–136, 2022, Bucureşti.

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1. INTRODUCTION

In fact, there is no longer a separation between "nature" and "society" on planet, but there are complex man-made socio-biotic systems, which today man himself is mindlessly beginning to destroy (European Union *et al.*, 2015; Fujita, 2013). This is understandable, because technological innovations are created, used and understood, in theory, primarily by military science and the military-industrial complex. The war waged by the Russian Federation in Ukraine is being carried out by many means at the same time, which is what makes it so destructive.

Today, as before, it is the cities and their infrastructure that are the main problem area in modern wars, since war is waged simultaneously in all environments: air, land, and water. But real collisions take place in an extremely limited space. Moreover, this space includes not only the military forces of the warring parties, but also the civilian population. No matter how paradoxical it may sound, a war in the limited space of a particular city is, essentially, global.

Living in harmony with nature is one of the main principles of life on Earth. Almost every conflict has negative consequences for its ecology. Currently, this principle can be interpreted as ecocide – the man-made destruction of the ecological life on the planet, including the conditions of human existence. The interpretation of this term has the following meaning: "Ecocide is the mass destruction of plant and animal life, the poisoning of the atmosphere or water resources, as well as the commission of other actions capable of causing an ecological disaster." In recent years, a trend has emerged in international law to recognize ecocide as an international crime in its global interpretation: "Ecocide is the destruction of the country's economic space, accompanied by inevitable human casualties and the deterioration of living conditions, leading to hunger and the degradation and premature death of a large part of the population" (Crook *et al.*, 2018; Gardashuk, 2017).

Nowadays, according to the Stockholm International Peace Research Institute (SIPRI), more than 20 major armed conflicts are ongoing on the Earth, whose foundations were laid more than one decade ago (https://www.sipri.org/).

Special attention should be paid to environmental problems during military conflicts. Military operations are always accompanied by changes and the destruction of the natural environment. Depending on the scale of the used weapons and their types, military actions that destroy the natural environment can lead to an ecological disaster.

The goals, tasks, reasons and legality of the armed conflict are individual in nature. All of them circle around the idea of using different types of weapons and methods of conducting military operations. But the important moment in the regulation of legal relations between warring parties during military conflicts is that of full and unwavering compliance with international law. According to international law, in any armed conflict, the right of the parties involved in said conflict to choose the methods or means of conducting military operations is not limited (Kaplan *et al.*, 2022). International law includes the Geneva Convention of 1949 and the Additional Protocol 1 to the Geneva Convention (https://ihl-databases.icrc.org/ihl/INTRO/470). However, it is Protocol 1 that safeguards the protection of the civilian population, their property and the environment. One of the provisions concerns environmental protection. Article 35 forbids the use of weaponry that, through its very nature, may cause "excessive damage or incredible suffering", or whose usage and means of conducting military operations may cause widespread, long-term and serious damage to the natural environment.

The responsibility of the state for the destruction of entire ecosystems and damage to nature is formulated in the declaration adopted at the United Nations Conference on Environmental Problems (Geneva, 3 September 1992), during the Paris Convention on the Protection of World Cultural and Natural Heritage. Such documents, as well as other generally recognized norms and principles of international law, namely the Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction (https://treaties.un.org/

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pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVI-3&chapter=26), the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment (https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment), the Convention on Early Notification of a Nuclear Accident (https://www.iaea.org/topics/nuclear-safety-conventions/ convention-early-notification-nuclear-accident), the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (https://www.iaea.org/topics/nuclear-safety-conventions/ convention-assistance-case-nuclear-accident-or-radiological-emergency), the Partial Nuclear Test Ban Treaty (https://en.wikipedia.org/wiki/Partial_Nuclear_Test_Ban_Treaty), the Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (EMOD) (https://www.un.org/disarmament/enmod/), are the foundation for the regulation of environmental security issues both during peacetime, and during periods of armed conflict. The main idea of such international legal norms is the fact that conflicting parties are limited in the use of certain methods and means of conducting hostilities, so that the damage caused both to individual natural resources and objects, and ecology was decreased as much as possible.

Therefore, any war in human history is an ecological disaster, but the war in Ukraine, which began on February 24, 2022, is probably the most cynical in this regard. The actions of the Russian Federation in this conflict are characterized by the contempt shown towards the environment and the people.

Ukraine has been under constant enemy fire for more than four months. Armoured vehicles, heavy artillery, airplanes, as well as helicopters are used, mass bombardment is carried out, including by heavy artillery fire systems, guided and unguided missiles are used from sea, air and land bases. The damage to the environment is unprecedented. And such damage to the environment will eventually spread to the territory of the entire European continent and will change the balanced ecosystem not only of Ukraine, but also of Europe for at least dozens of years (European Union *et al.*, 2015). In addition to the most obvious losses from the Russian military invasion of Ukraine, such as the loss of life, the destruction of homes, and the destruction of infrastructure, all of this unfortunately leads to the deterioration of the country's economic state, threatens the environment, and worsens social living conditions. During the war, the authorities are focused on such urgent issues as financing the army, settling refugees and providing aid to the wounded. But at the same time, it is necessary to pay attention to other problems and possible future consequences of the war, and to study them comprehensively, because problems of the state of the surrounding environment can easily turn into threats of a social nature. Ukraine is now in an active gradation of military operations, that is, military operations are taking place on the territory of the state; subsequently, passive operations will follow - these are processes that are no longer under control, but they take place directly at the sites of military operations – such as demining, or the disposal of weapons. It has been concluded that war never ends in a split second, that it also has dynamic consequences, it is always associated with a risk that at any moment things can turn into a protracted ecological disaster. That is why a comprehensive approach is necessary to define the problems and consequences of the war in Ukraine and to come up with ways to solve them. Today, all environmental, social and economic problems require urgent monitoring.

In this case, it is expedient to use the obtained data of remote sensing of the Earth as a source of information for the practical instantaneous control of both the state of the natural environment and the urban environment. Many global studies have been conducted in this direction. In (Kaplan *et al.*, 2022) provides an overview of the remote sensing implementation of war activities for environmental monitoring. Other observations of the impact of armed conflicts on natural resources on a global and regional scale based on remote sensing data can be found in other country after the world wars (Welp, 2020), in South Sudan (Olsen *et al.*, 2021), in northeast Bosnia (Witmer, 2008), in Syria (Khaled Hazaymeh *et al.*, 2022), in northern Caucasus (He Yin *et al.*, 2019). It is satellite information that provides an extremely wide spatial resolution (from tens of centimetres to hundreds of meters), a significant number (dozens and hundreds) of spectral channels of various spectral resolution

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(hyperspectral imaging technologies), the urgency of obtaining visual information (up to real – or almost real – time), a high geometric image quality. Wide accessibility to the market of space information, both governmental and, especially, commercial programs and systems, is important for the present time. The variety of space equipment, the types of shooting in combination with modern computer processing technologies allow for a quick study of the complex socio-ecological and economic problems. The use of satellite data for the study of environmental and socio-economic destruction caused by the conflict in conflict zones can be found in the neighboring areas Bangladesh-Myanmar border (Thiri Shwesin Aung *et al.*, 2021) and in the Polish Carpathians (Affek *et al.*, 2021). The monitoring of the state of the natural and urban environment during the military operations is one of such tasks.

The purpose of the study is to substantiate the theoretical and methodological foundations of using multispectral images for the operational monitoring of socio-ecological processes and their consequences during the period of military operations on the territory of Ukraine in 2022.

2. MATERIALS AND METHODS

The work has used remote sensing data from the Sentinel-2, Sentinel-5P, Suomi NPP satellites, as well as the image processing application Erdas Imagine, geoinformation systems ArcGIS and MapInfo Professional, as well as the open resources of Google Earth and EO Browser. To carry out the research, the authors of the article developed a chart for monitoring the socio-ecological processes and their consequences during the period of military operations on the territory of Ukraine in 2022 (Fig. 1).

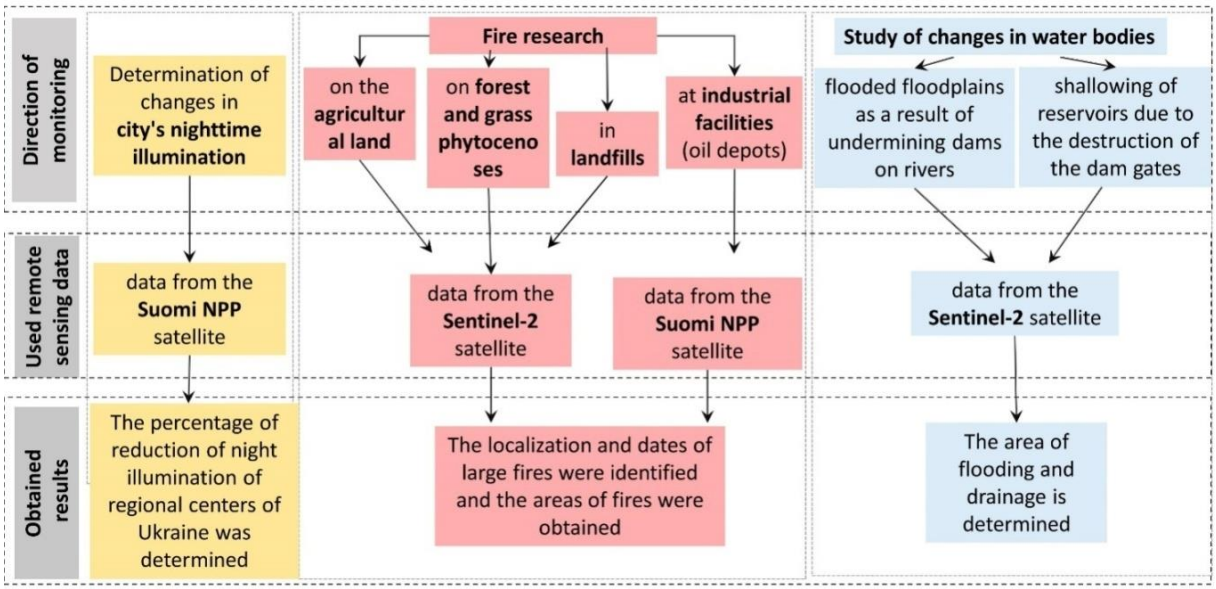

Fig. 1 – The chart for monitoring the socio-ecological processes and their consequences during the period of military operations on the territory of Ukraine in 2022.

The information garnered from the Suomi NPP satellite for March, April 2021 and 2022 was used to quantify the change in night-time illumination. It should be noted that for April 2022 there is no data for a significant territory of Ukraine. The Suomi NPP night-time illumination product has a spatial resolution of 450 meters and a physical dimension of nanoWatts/cm^2/sr. The processing of night illumination data from the Suomi NPP satellite was performed using the Erdas Imagine image processing application and consisted of the following stages: 1) the selection of the territory of

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Ukraine using the outline of Ukraine in *.aoi format with the SubSet function of the Erdas Imagine package, 2) the conversion images of the night illumination of the territory of Ukraine in 2021 and 2022 into the WGS 84 / zone 36 coordinate system using the Reproject function of the Erdas Imagine package, 3) using the city vector layer for the selected cities, the average values of night illumination on the dates of the study were calculated.

Data from the Sentinel-2 satellite and the Erdas Imagine image processing application were used to establish the areas of fires. With the help of the EO Browser resource, images from the Sentinel-2 satellite were found before the start of the fire, on which the fire process itself and the consequences of the fire are observed. Using the Erdas Imagine and the Layer Stack function, 11-channels images from the Sentinel-2 satellite were formed. Image analysis was carried out helping establish the contour of the fire and calculate the area affected by the fire.

The Erdas Imagine and EO Browser programs were used to appreciate the consequences of a fire at an oil depot. First, with the help of the EO Browser resource, the image from the Sentinel-2 satellite was ascertained, which shows a fire at a warehouse for fuel and lubricants. At the same time, data from the Sentinel-5P satellite was obtained, and the change in NO_2 concentration was studied. To evaluate the change, the concentration values before and during the fire were averaged and the changes were calculated in the Erdas Imagine application.

Two images from the Sentinel-2 satellite, dating from April 10, 2021 and April 7, 2022, were used to establish the consequences of blowing up the dam that separated the Irpin River from the Kyiv Reservoir. With the help of the Erdas Imagine and the Layer Stack function, the image was formed in so-called “natural colours”. The next step was to detect the area of flooding, and create a vector layer, based on which the area of flooding was calculated.

3. RESULTS AND DISCUSSION

In peacetime, more than 60% of the inhabitants of Ukraine lived in cities, and the rate of expansion of urban territories is two times higher than the rate of growth of the population herein. A feature of the largest of them was the excessive concentration of population in relatively small areas of population, transport, industrial enterprises, and housing and municipal structures (http://www.ukrstat.gov.ua). All this has now been mercilessly destroyed.

The bombed and destroyed Ukrainian cities of Bucha, Irpin, Gostomel, Borodyanka, Chernihiv, Sumy, Okhtyrka, Kharkiv, Mariupol, Izyum, Popasna, Rubizhne and many others had not witnessed such an onslaught since the Second World War.

As the war continues, indirect methods of assessment have to be used to evaluate the scale of destruction and assess economic losses. Moreover, such methods are often used not only to study the economic situation in the region, but also to have a clearer picture of the humanitarian situation in the war zone.

Cities of different size, number, and population density were selected as model examples, among which there are cities of thousands or millions of inhabitants, satellite cities, and urban-type settlements. Among themselves, they differ in terms of the criticality of the situation caused by the military operations.

It should be noted that a city in a critical situation is a “black box” that cannot be opened immediately, nor completely, since long and dangerous work is necessary to clear such cities in the wake of military operations. The experience of the war in Yugoslavia in the mid-1990s shows that, years later, its cities are prone to the danger of exploding mines, which are found as a result of construction work on territories that are being cleared, or during natural disasters (downpours, landslides) (https://ru.osvita.ua/vnz/reports/ecology/21279).

Table 1 shows the ratio of illumination, which allows the comparison of values during March–April 2021 and 2022.

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Table 1

The average value of night-time illumination (nanoWatts/cm2/sr) of Ukrainian cities for March and April 2021–2022.

N°	Ukrainian cities	Average value 2021		Average value 2022	The difference in lighting 2021/2022		
		March	April	March	April	March	April
1	Borodyanka	2.584	2.608	0.482	–	5.36	–
2	Bucha	13.837	13.07	2.122	–	6.52	–
3	Chernihiv	7.248	–	4.825	–	1.50	–
4	Gostomel	5.185	5.535	1.312	–	3.95	–
5	Irpin	15.861	13.569	6.768	–	2.34	–
6	Kyiv	22.889	23.894	9.698	–	2.36	–
7	Kramatorsk	6.11	5.909	0.348	0.416	17.56	14.20
8	Mariupol	14.659	8.474	1.271	0.807	11.53	10.50
9	Mykolayiv	8.942	8.997	0.425	0.374	21.04	24.06
10	Sumy	9.361	–	0.674	–	13.89	–
11	Kharkiv	12.335	11.356	2.197	2.026	5.61	5.61
12	Kherson	9.696	10.596	5.75	5.545	1.69	1.91

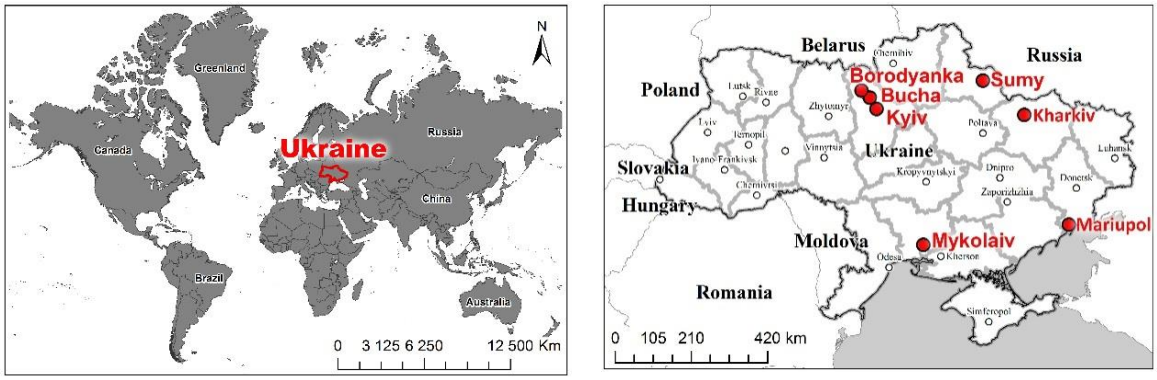
where "–" indicates the absence of night illumination values.

Analysing the data in Table 1, we may conclude that the cities of Mykolaiv, Kramatorsk, Sumy, and Mariupol were the most affected, where the values of night illumination decreased 13–20–fold and are 0.3–0.7 nanoWatts/cm^2/sr.

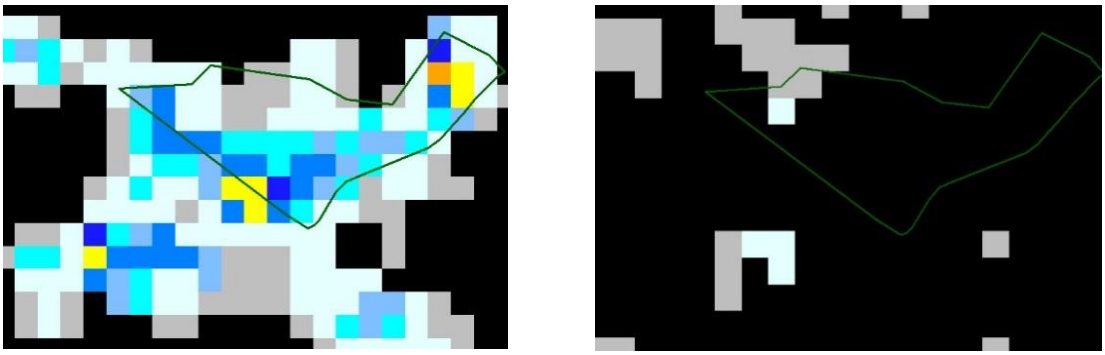
At the same time, the Henderson method was applied. According to it, a 1% decrease in night-time illumination of industrial and residential agglomerations corresponds to a 1% decrease in the economic activity of the studied region (Henderson *et al.*, 2012). At the same time, it turned out that the night illumination in industrial cities, regional centres, as well as in the cities in which fights took place, dropped by 7.78. Accordingly, economic activity probably decreased by the same amount, and this without considering the mass migration of the population from the territory of Ukraine. These indicators can give an idea of the losses suffered by the country's economy as a result of the war with the Russian Federation.

For clarification, Figure 2 shows examples of satellite images of cities for March–April 2021 and 2022.

The location of the study area

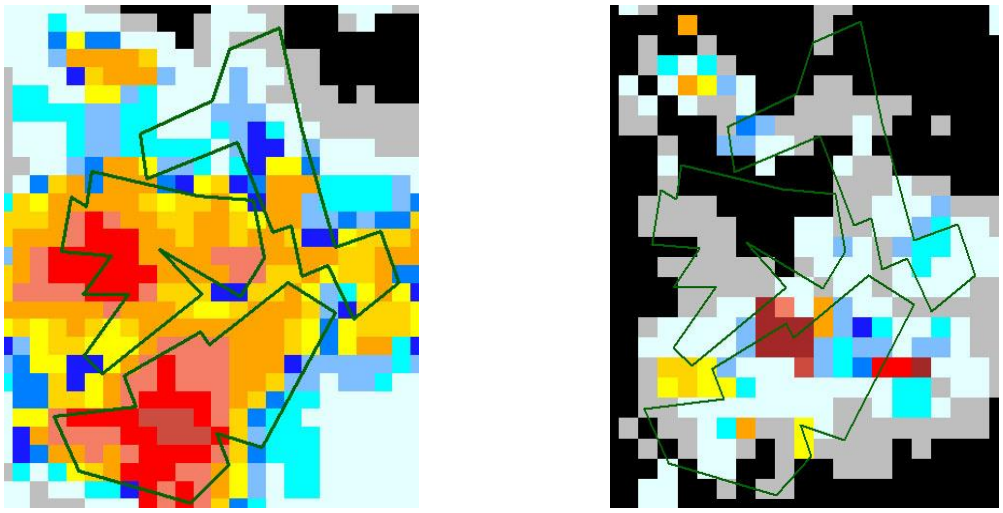


Borodyanka



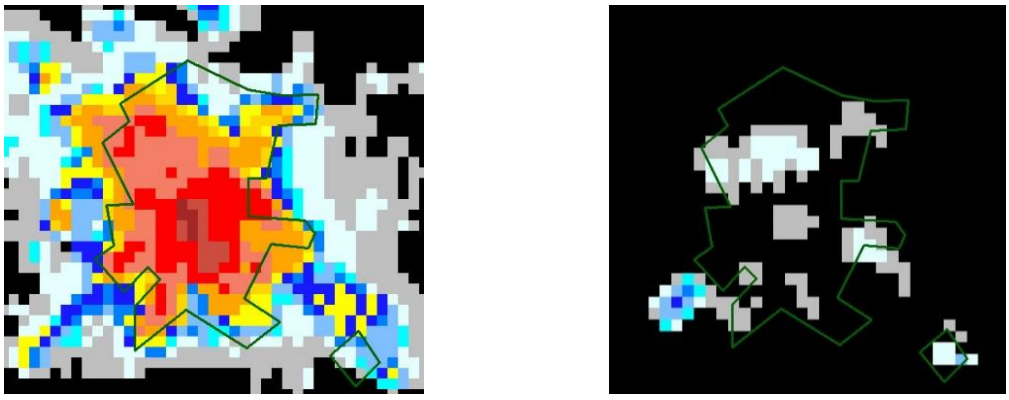
2021–03 2022–03

Bucha, Irpin, Gostomel



2021–03 2022–03

Sumy



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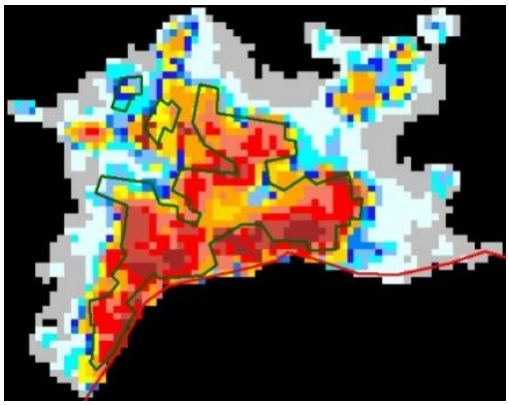
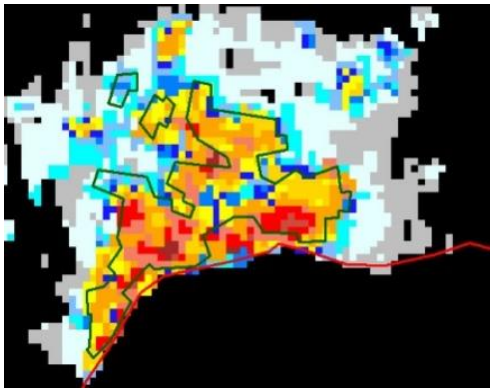
Mariupol

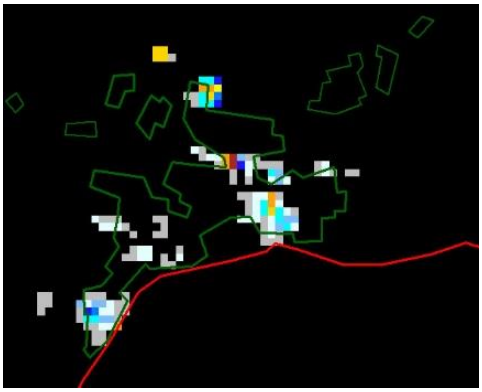


2021–03

2022–03

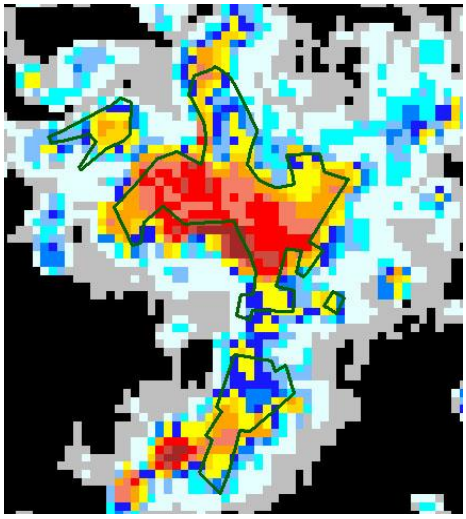


2021–04

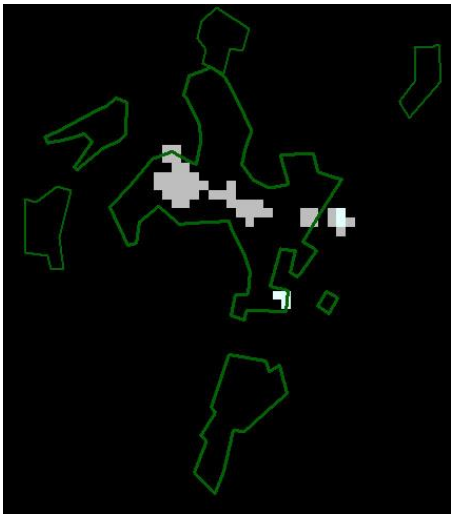


2022–04

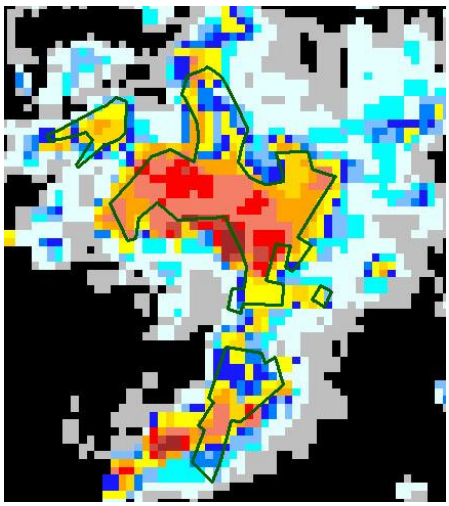
Mykolayiv



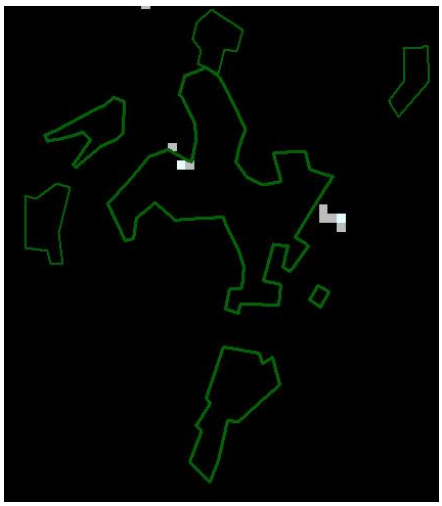
2021–03



2022–03

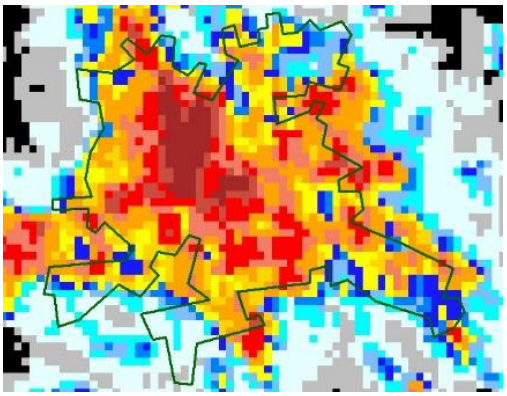


2021–04

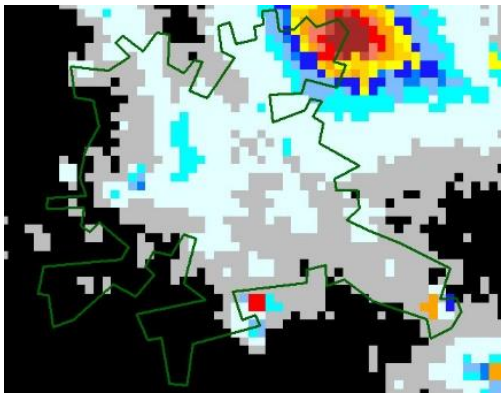


2022–04

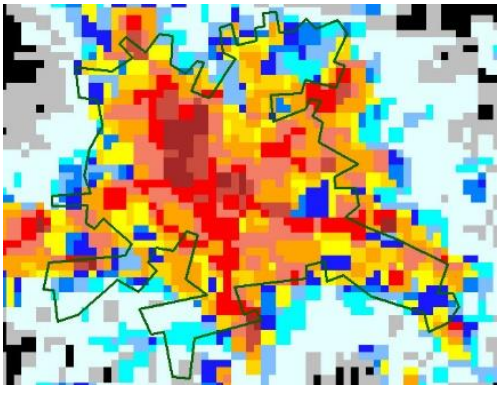
Kharkiv



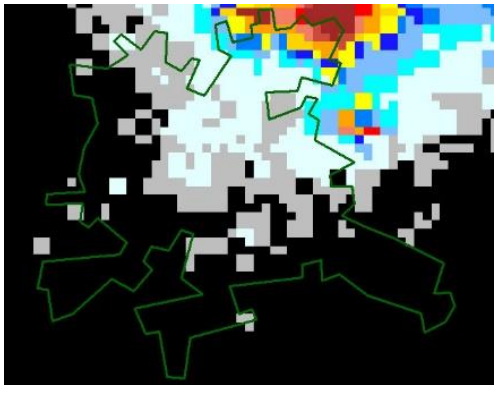
2021–03



2022–03



2021–04



2022–04

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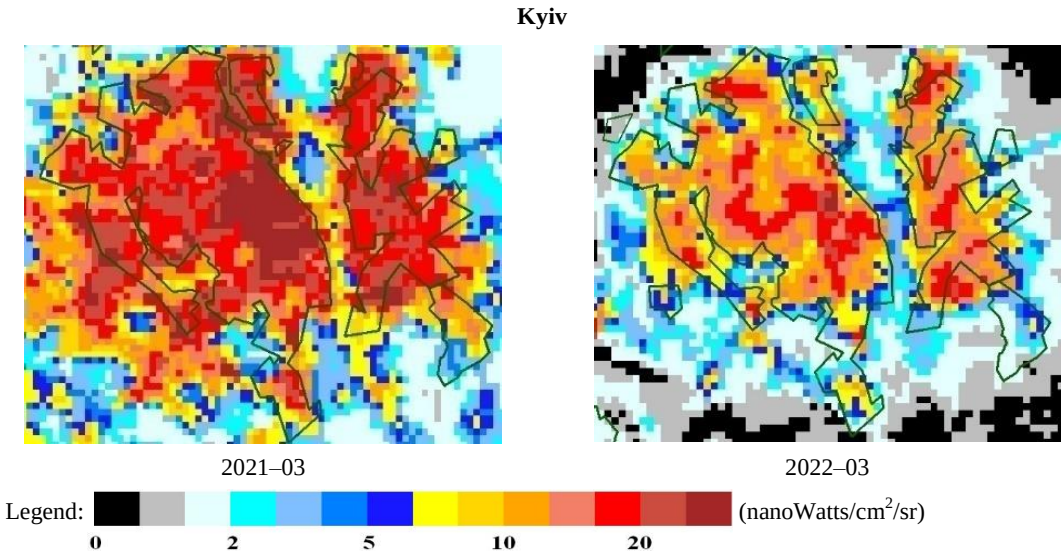

Fig. 2 – Night-time satellite Suomi NPP images of Ukrainian cities for March, April 2021, 2022 (https://eogdata.mines.edu/products/vnl/).

The images of Figure 2 show the major decrease in night illumination compared to the peace time of 2021. In all of the above-mentioned cities, the area and intensity of night-time illumination of the territory has significantly decreased.

As an example, the area and intensity of night illumination of Kyiv, the largest city in Ukraine and the seventh in Europe in terms of population, is given. Together with the suburbs, it forms the Kyiv agglomeration with a total population of over 4 million inhabitants (http://www.ukrstat.gov.ua). There is a 2.36-fold decrease in illumination in the city itself, which is most likely due to martial law.

The settlements northwest of Kyiv suffered the greatest destruction in the Kyiv region. According to our calculations, in the cities where fierce battles took place, the illumination rate dropped: for Borodyanka, from an average value of 2.584 (nanoWatts/cm^2/sr) for March 2021 to 0.482 to (nanoWatts/cm^2/sr) for March 2022, i.e., 5.36 times, for Bucha the drop in night illumination was 6.52 times, for Gostomel 3.95 times, for the city of Irpin – 2.34 times.

Cities on which the Russians continues to carry out artillery and air strikes, Kharkiv – the second largest city in Ukraine –, and Mykolaiv – a city of half a million people of regional importance – have registered a catastrophic decrease in lighting, which is a consequence of brutal battles, the destruction of civil infrastructure and the evacuation of the population. Thus, Fig. 1 shows that in the city of Kharkiv relatively large values of night illumination in 2022 are located in the north, almost beyond the city limits, and correspond to military actions (shelling and its consequences). Compared to last year's pictures for 2021, the maximum values of night illumination correspond to the central part of the city and, in numerical terms, the drop in night illumination was 5.61. For Mykolaiv, the drop in night illumination is the maximum for the studied cities and amounts to 21–24 times, while in Fig. 2 there is no night activity at all, which is a catastrophic situation for the regional centre.

Mariupol was in a critical situation. A city besieged for several months is indeed a critical situation. Here, active, non-stop fighting (shelling, bombing etc.) took place at a constant rate. In the city, the lighting completely disappeared, only the centre of light intensity was recorded in the area of Azovstal, which indicated continuous bombing by the Russian Federation.

Cities such as Mariupol, or others throughout the history of military conflicts (Aleppo, Grozny), are a typical example of a modern global-regional-local conflict on the backdrop of war.

The experience of restoring many cities of the world affected by ecological, man-made disasters shows that their former life cannot be restored primarily for economic reasons: it is much more

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profitable to demolish the ruins and rebuild the city anew. Although the surviving population usually seeks to revive their settlements at least partially (Fujita, 2013).

There is no need to talk about the rapid restoration of fragile natural ecosystems, which were subject to the negative impact of modern climate changes and human activity from the consequences of war, just as in peacetime. Any war carries enormous environmental threats to the population, but hostilities in Ukraine can lead to particularly catastrophic consequences for the environment. Nuclear power plants, seaports, hazardous waste warehouses (mineral fertilizers, polyurethane foam, paint and fuel and lubricant materials etc.), industrial enterprises, including chemical and metalworking plants, are now in areas of active hostilities. Fires have been recorded at oil depots, gas stations, landfills, and there are records of damage to heat and water supply facilities (sewage pumping stations, filter stations, water pumps) (https://www.ecoleague.net).

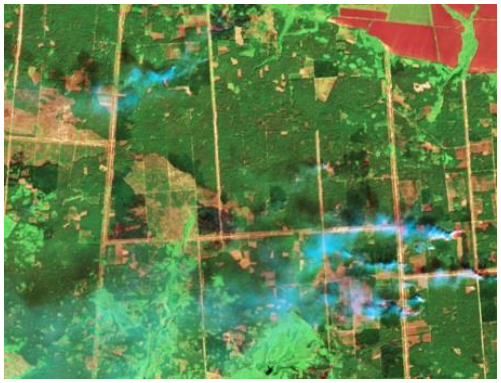
One of the serious consequences of the hostilities is a fire hazard situation. Unfortunately, fires during the war in Ukraine are not uncommon. According to the State Emergency Service, a third of all fires in Ukraine are now caused by shelling. The number of fires in Ukraine increased by 33%, compared to 2021. Previously, such fires occurred several times a year. Now, they are an every-day occurrence (https://dsns.gov.ua). During hostilities, both civilian objects and large-scale grass and forest vegetation fires take place.

Due to climate change and other factors, forest fires have been a huge problem even in peacetime. Now, when any missile may ignite a fire, Ukrainian forests are a real powder keg.

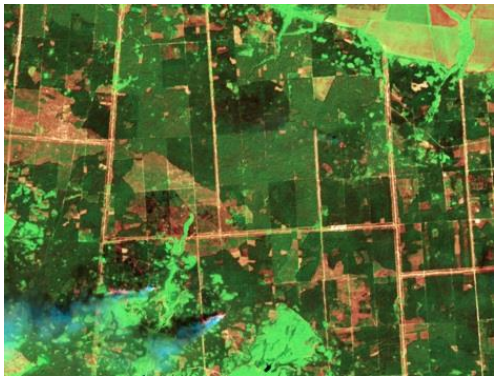
Examples of the results of the assessment of the forest and grass fire area (Figs. 3, 4) were carried out using Sentinel-2 satellite images.

Map of Ukraine showing the location of the city of Izum

April 26, 2022



May 6, 2022



June 10, 2022

Fig. 3 – Results of forest fires west of the city of Izyum, Kharkiv region, according to data from the Sentinel-2 satellite (https://www.sentinel-hub.com).

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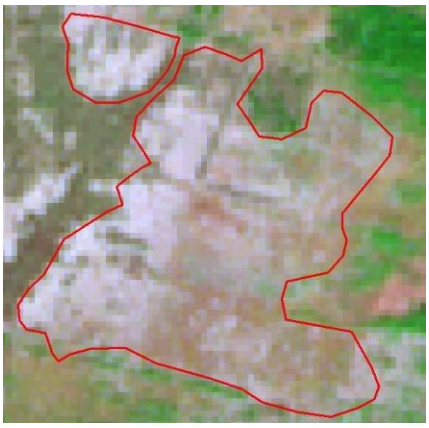
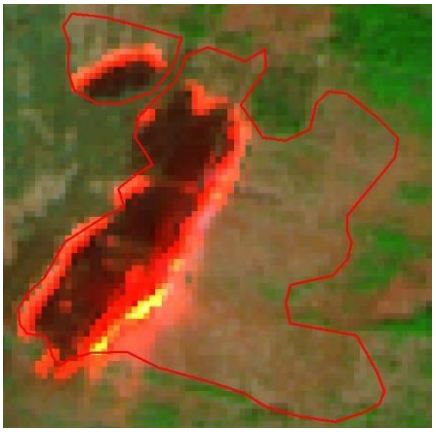
An analysis of the images shows that there is a constant destruction of forest plantations as a result of active hostilities, as can be seen by fires and plumes of smoke for the May–June 2022 period. The final assessment of the damaged forest cover can be given only after the end of the war; at present, we are able to discuss the targeted fire areas. An example is given of the area of the fire on March 11, 2022, which is 0.38065 km^2; after 10 days, on March 21, 2022, it became 0.95681 km^2, that is, the area affected by the fire increased 2.51 times (Fig. 4).

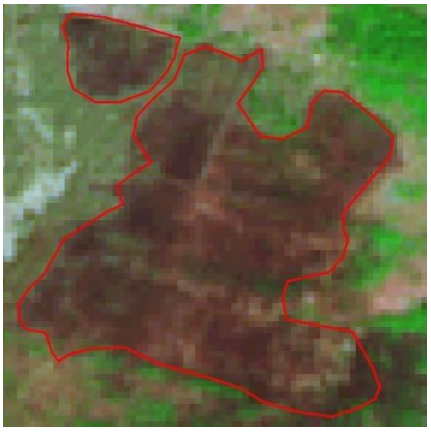
Map of Ukraine showing the location of the Chernobyl exclusion zone



March 26, 2021



March 11, 2022



March 21, 2022

Fig. 4 – Establishing the consequences of a fire on the grass of the Chernobyl exclusion zone according to data from the Sentinel-2 satellite (https://www.sentinel-hub.com).

When analysing the image in Figure 4, it is revealed that the use of channel 12 of the Sentinel-2 satellite, a wavelength of 2100–2280 nm, allows for the accurate calculation of places where there are strong open fires: the yellow colour in the figure approximately 2–3 times higher than the value of the spectral brightness of normal fire (red colour) and 4-5 times higher than the value of spectral brightness for scorched earth (burgundy colour).

As a result of the military aggression on the territory of Ukraine, the field is contaminated with chemical elements. As a result of military operations, hectares of arable land are mechanically damaged, which in turn degrades the destroyed upper fertile layer of the soil, while grain fields are also burning. As a result of bombing and artillery shelling, deep craters appear in the soil layer. According to

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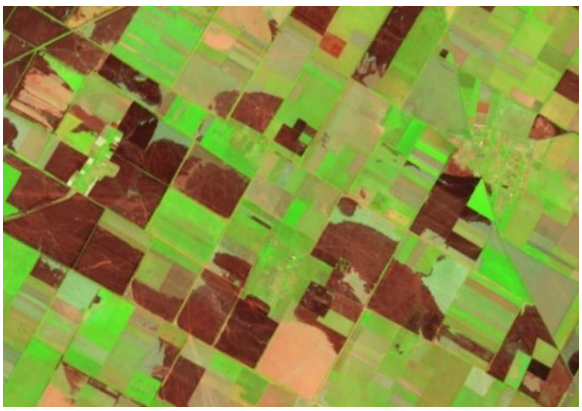
estimates, a bomb weighing 240 kg creates a crater with a diameter of 8 m and a depth of 4 m. The soil in the crater and in its immediate vicinity becomes unsuitable for agricultural work (Libanova, 2015; https://www.ndi.org/our-stories/time-conclude-1990s-conflict-balkans; https://ru.osvita.ua/vnz/reports/ecology/21279/).

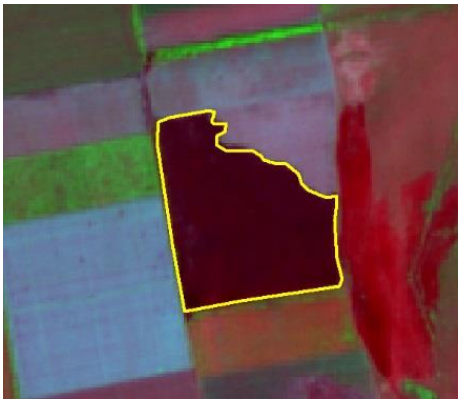
Examples of negative environmental consequences for agricultural fields based on remote sensing materials are shown in Figure 5. According to data from the Sentinel-2 satellite, the area of the fire was 0.33 km^2.

Map of Ukraine showing the location of the study area in Kherson region



General view of the territory of the Kherson region as of July 08, 2022

Before the fire as of June 3, 2022



After the fire as of June 13, 2022

Fig. 5 – Examples of fires on agricultural land in the South of Ukraine according to data from the Sentinel-2 satellite (https://www.sentinel-hub.com).

During the war, fires were also recorded in landfills. Landfills burn constantly and for a long time, garbage deposits heat up to 50–100°C. In addition to the threat of fires for nearby residential areas, it is primarily a source of poisonous substances for humans. When garbage is burned, carcinogens are released into the air, which increases the risk of developing cancerous tumours; for example, phosgene may also be released, which was known during the First World War as a combat gas (https://rethink.com.ua/uk/news-and-events/ekologichni-problemi/chim-nebezpechne-gorinnya-smittezvalishch).

One such example is the one near the village of Novi Petrivtsi, Vyshgorod district, on the territory of the landfill (total area of 7 hectares), where a fire broke out on an area of 2 hectares, as shown in Figure 6.

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Map of Ukraine showing the location of the village of Novi Petrivtsi

March 16, 2022 (the start of the fire)

March 18, 2022

March 23, 2022

Fig. 6 – Dynamics of the development of a fire at a landfill in the village of Novi Petrivtsi, Vyshgorod district, Kyiv region, according to data from the Sentinel-2 satellite (https://www.sentinel-hub.com).

As a result of fires, combustion products pollute the atmosphere. Below are examples of observing damage to infrastructure facilities and emissions of harmful substances into the air at the same time.

Oil depots were among the first to suffer (becoming the most common category of man-made hazards in various regions that were subjected to targeted shelling). In total, at least 60 oil depots were affected, including other storage facilities for fuel and lubricants in 23 regions (https://en.wikipedia.org/wiki/Environmental_impact_of_the_2022_Russian_invasion_of_Ukraine).

One of the largest fires at oil depots took place on March 3, on the territory of Kombinat Aistra in Chernihiv. During shelling, a shell fell on the oil depot. As a result, a tank set with a total capacity of 5,000 m^3 caught fire and the detonation and destruction of jet fuel storage facilities (4,500 t) and diesel fuel (11,000 t) took place (https://dixigroup.org/wp-content/uploads/2022/06/100days.pdf). On the afternoon of March 19, 2022, the Russian army continued shelling the western part of Chernihiv, the result of which was a fire at the warehouse of fuel and lubricants, as shown in Figure 7.

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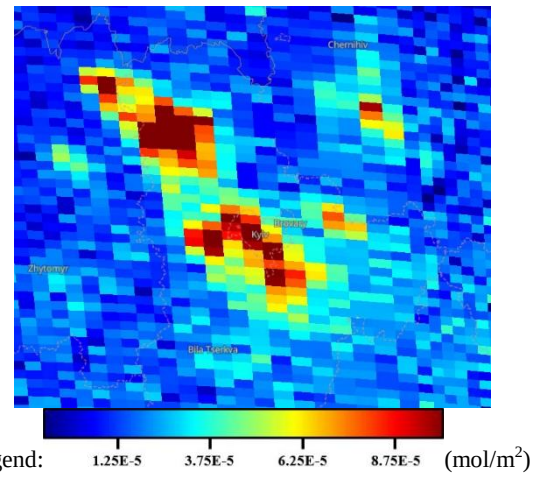
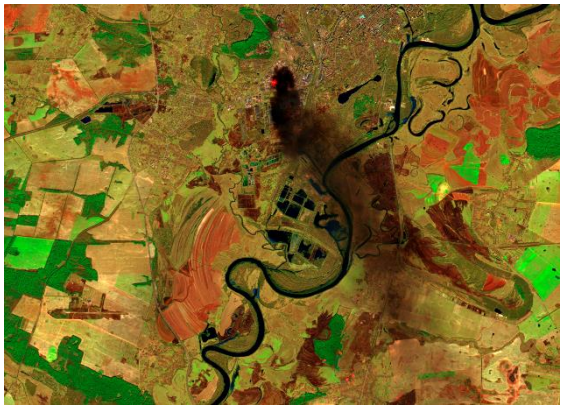
Map of Ukraine showing the location of the city of Chernihiv



Sentinel-5P data for March 23, 2022

Sentinel-2 data for March 21, 2022



Sentinel-2 data for March 23, 2022

Fig. 7 – The results of the influence of military operations on the state of the air as a result fire at a fuel and lubricants warehouse in Chernihiv., The Sentinel-5P space image shows an increase in the concentration of NO2 over the territory of active military operations around Kyiv and over a fire at a PMM warehouse in Chernihiv. The Sentinel-2 space images show the direction of the plume (https://www.sentinel-hub.com).

Military actions on the territory of Ukraine have been causing serious threats consisting of man-made emergency situations triggered by the actions of the occupiers. The risks to the population associated with damage to objects that pose an increased environmental hazard are of particular concern at this time, because in the absence of control and the possibility of eliminating their negative consequences, the scale of the negative impact potentially increases.

In Ukraine, hydroelectric power plants, dams and locks on the Dnieper Cascade may pose a danger to the population during military operations against them or air attacks: Dniprovska HPP (Dnipro HPP, Zaporizhzhya), Middle Dnipro HPP, Kakhov HPP, Kremenchuk HPP, Kaniv HPP, Kyiv HPP, small and medium hydropower plants on the Dniester cascade, dams (http://epl.org.ua/announces/vijna-pidvyshhuye-ryzyky-nadzvychajnyh-sytuatsij-na-ges).

On February 26, 2022, in the area of the village of Kozarovich, Russian troops destroyed the dam that separated the Irpin River from the Kyiv Reservoir. The total area of flooding according to remote sensing data from the Sentinel-2 satellite with a spatial resolution of 10 meters on April 7, 2022 is approximately 20 km2 (Figs. 8, 9).

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According to satellite data, the distance between the "flood water" and the nearest buildings is 50–100 meters.

In the village of Demydiv, the most difficult situation occurred because of flooding. The flooding of the Kozka River actually divided the village into two parts, so that the central part of the village is free of water only on the southwestern direction. The tense situation to the east of the village, as shown in Fig. 9, where homesteads are flooded, means that the water has already reached the nearest residential buildings, and the distance to another ten residential buildings is 5–20 meters. In the village of Chervone, the direct distance to residential buildings is 200 meters. In the village of Rakivka, the distance is 210–250 meters. In the village of Huta-Mezhihirska, according to remote sensing data, 10 residential buildings have already experienced the encroaching of "high waters".

Such a situation is catastrophic in itself, but everything is made more complicated by the consequences of military actions. Such a rise in the water level subsequently leads to a rise in the level of groundwater, which in turn leads to excessive moisture. For residential buildings, the penetration of groundwater into basements means that the communication networks laid underground will be subjected to an additional load. One negative factor of such flooding is the impossibility of using the fields for this year's harvest.

In addition, mass flooding greatly slowed down communication within the region and neighbouring villages.

Map of Ukraine with the location of Kyiv Reservoir

February 26, 2022
(before the dam was destroyed)

March 11, 2022

March 18, 2022

Fig. 8 – The results of the dam blast on the Kyiv Reservoir according to data from the Sentinel-2 satellite short wave infrared composite (SWIR) (https://www.sentinel-hub.com).

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Map of Ukraine with the location of the village of Demydiv

Blue counter from the Sentinel-2 satellite March 18, 2022 superimposed on a March 22, 2022 Maxar Technologies photo

From the satellite of Maxar Technologies for March 22, 2022

From the satellite of Maxar Technologies for March 22, 2022

Fig. 9 – Flooding locations in the village of Demydiv as a result of the spill of the Irpin River to data from the Sentinel-2 satellite and satellite image taken by the company Maxar Technologies. General view of the area and extent of the spill, highlighted in blue on the Sentinel-2 satellite image, and detailed close-up examples on the satellite images, taken by Maxar Technologies*)(https://museum.kpi.ua/map/?ns=war&d=north&l1=2022-03-22&l2=&z=13&lon=30.365094&lat=50.731245).*

The destruction of one of the sluice gates of the Oskilsky Reservoir in Kharkiv Oblast on April 2 is one of the biggest changes in the environment that occurred as a result of the Russian-Ukrainian war (Fig. 10). Approximately 355,500,000 cubic meters of water were rapidly released from the reservoirs, causing the level of the Siversky Donets River to rise and exposing about 9,000 hectares of silted riverbed. The rise in the water level of the Siverskyi Donets River, into which the Oskil flows, helped stop the advance of the Russian troops, who still cannot cross the largest river in Eastern Ukraine. However, in addition to the short-term tactical advantages important for the defence of state, there are also long-term environmental consequences. The Oskil reservoir was created to regulate the water level in the Siverskyi Donets-Donbas canal. This reservoir is connected with the water supply of the vast majority of the population of the Donetsk and Luhansk regions (https://uncg.org.ua/en/should-the-oskil-reservoir-be-rebuilt-after-the-war).

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Map of Ukraine with the location of the Oskil reservoir

View before the destruction of the dam on March 29, 2022

View after the destruction of the dam May 8, 2022

View after the destruction of the dam October 18, 2022

Fig. 10 – The destruction of the Oskil reservoir in Kharkiv Oblast as a result of the destruction of the dam gates, according to the remotely sensed data (Sentinel-2) (https://www.sentinel-hub.com).

Therefore, terrorist attacks and the conduct of hostilities on the territory of Ukraine with the capture of objects of the energy structure can lead to catastrophic consequences for life and health of people, industrial objects and the natural environment.

4. CONCLUSIONS

Periodically, any country, including modern Ukraine, experiences war. In this case, the eco-destructive nature of war keeps exceeding the negative impact on the environment during the peace period of the country's life, and the issue here is not only the extremely negative direct environmental consequences of the war, but also the long-term consequences of a collateral nature. The war in Ukraine has already become an emergency situation, triggered by a violation of the ecogenic and technogenic security at the regional level with cross-border consequences. The harmful effects of many environmental problems will, in many cases, be of a supra-regional nature.

The losses have already skyrocketed. It is very difficult to evaluate them at this time when the war is still ongoing. When one thinks about environmental damage, one often thinks about qualitative characteristics. It is the use of satellite information that makes it possible to support such information with quantitative estimates. The qualitative growth of space technologies is the factor that reduces the degree of significance of traditional factors that had previously determined the success of ecological, economic and social development of countries during peacetime, especially during wartime, when

there is no possibility to operate with reliable statistical data. In particular, new approaches to the study of urban protection problems are needed. Modern and promising military and space technologies, or nanotechnologies will affect the structure and typology of urban spaces. It is thus necessary to revise the historically formed principles of fortification, which in turn will ensure the safety of cities.

The complex consequences of ecocide (the degradation of the natural environment, the destruction of economic complexes, life support systems, housing, migration, and the death of the population) indicate a man-made humanitarian disaster and a high probability for an ecological disaster. Despite the fact that the end of the military confrontation is most likely far away, all participants in the conflict should waste no time in discussing the environmental problems of military operations and come to an agreement that would at least mitigate the current and future environmental consequences of said military operations. When peace is eventually reached, the Ukrainian government will not only have to restore the destroyed economy and social sphere, but also the ecology, which had already been a most problematic aspect in Ukraine prior to the war, according to many indicators.

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Received October 12, 2022

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LANDSLIDES MORPHOGENETIC COMPLEXITY IN THE BUZĂU CARPATHIANS AND SUBCARPATHIANS. IMPLICATIONS FOR HAZARD ASSESSMENT

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Key-words: landslides, Buzău Carpathians and Subcarpathians, typology, susceptibility, hazard.

Abstract. The Vrancea Seismic Region, corresponding to the Curvature sector of the SE (Romanian) Carpathians and Subcarpathians and including their Buzău sub-unit, is a very active geomorphic region, marked by a wide variety of fluvial, slope gravitational and seismic processes. The morpho-litho-structural traits, the active neotectonic movements, the climatic regime and the anthropic activities are the main controlling factors within complex multi-hazard environments. In this context, numerous landslide hazard evaluations have been developed during the past decade, employing the existing landslide inventories to calibrate and validate statistic and probabilistic susceptibility models. Previous results of various landslide hazard assessment initiatives suggested that fine-tuned regional susceptibility models, performing properly from a statistical point of view, could result in differently-distributed susceptibility classes, which increases the uncertainty of results and may decrease their uptake by stakeholders and end-users. It is the purpose of this paper to outline the geomorphic complexity of landslide typology in the study-area, and the induced sources of epistemic uncertainties in hazard assessment. The study discusses the landslide distribution and typologies, as derived from existing landslide inventories (based on field mapping, optical remote sensing imagery, radar interferometry). Furthermore, a wide range of aspects such as slope sensitivity, the geomorphic complexity of landslides, their evolution, frequency-magnitude relationship, triggering thresholds, morphodynamic sectors and connectivity are evaluated from the perspective of potential epistemic uncertainty sources. The study elaborates a series of geomorphic-driven recommendations for enhancing the robust predictability of susceptibility models in support of a more accurate hazard evaluation. By improving the methodological framework for evaluating the past, present and future behaviour of such mass movement processes, geomorphologists should engage relevant stakeholders when developing their hazard assessment approaches to advance and optimize the risk management decision-making process through informed proactive measures for risk prevention and preparedness and effective reactive actions for response and recovery.

1. INTRODUCTION

Mass movements, in general, and landslides, in particular, are some of the most complex slope modelling processes, and the importance of studying them has both fundamental and applied ramifications. The recognition of the role of landslides in slope modelling is unequivocal, even if in the early theories regarding the evolution and modelling of landforms, dominated by the role of fluvial erosion, the place of gravitational slope processes was largely substituted and reduced to local manifestations of (extremely) short intensity. From here to the suggestion that, alongside, for example, a coastal, fluvial or karst geomorphology, *landslide geomorphology* can express its solid individuality and find a legitimate place within the broad geomorphology (Crozier, 2010), is but a small leap. Through the first theories interpreting the evolution of the landforms (Davis, 1899; Penk, 1953; King, 1962), the landslides have been seen as "accidents", within the long evolution of these surfaces. Later on, their role in both the removal and accumulation of more or less cohesive materials, over extended surfaces and extended periods of time (and even between large-scale triggering events), was reconsidered, showing that such processes impose themselves through imprinting their own specific patterns of slope evolution in mountainous and hilly regions (Skempton, 1953; Hutchinson, 1965;

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Rev. Roum. Géogr./Rom. Journ. Geogr., **66**, (2), p. 137–152, 2022, Bucureşti.

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Selby, 1974; Carson and Kirkby, 1972; Crozier, 2010; Korup, 2010). Landslides cover a wide variety of processes and resulting landforms, which derive especially from their evolution under different morphoclimatic conditions. Their spatial-temporal distribution covers extremely wide spectrums (i.e., processes whose frequency can follow a monthly-annual pattern, but with a low magnitude; processes that can occur once every ten to hundreds of years, characterized by a higher magnitude). Under such conditions, landslides emerge as a consistent topic of geomorphological, geological, hydrogeological, hydro-meteorological or socio-economic research. There is a wide variety of stakeholders involved in landslide research (e.g., scientists, government or private end-users, financial planners, education providers, NGOs, civil society representatives), and their interest in understanding the future (potential) spatial-temporal occurrence and evolution of such processes has constantly increased. The *Sendai Framework for Disaster Risk Reduction* 2015–2030 (SFDRR) outlined that, in the past decades, there has been strong evidence of a faster exposure of assets and individuals to landslide risk in comparison with the decrease in vulnerability. Such a context was noted mainly at the level of local communities, despite the overall important advance in the landslides hazard research. In geomorphologically-active regions, such as the Vrancea seismic region, the scientifically robust evaluation of landslide hazard is of paramount importance, as the potential damages inflicted by such processes may cause consistent disturbances, not only to the directly and indirectly-exposed elements at risk, but also to medium and long-term investment strategies and adaptation planning. The mountain and hill regions of Buzău County are a national and even European landslide hotspot (Zumpano *et al.*, 2014, Micu 2017, Bălteanu *et al.*, 2020), with a high complexity of predisposing, conditioning and triggering factors for multi-hazard processes like landslides, erosion, rain- and river-induced floods and earthquakes. The effects of a large number of landslides, occurring in various forms and stages of activity, and of the recurrent flash-flood episodes are enhanced by the intensive human activity, e.g., the recent deforestations and inappropriate land management measures. The wide typological variety of landslide forms and processes, alongside their spatial and temporal patterns influence the results of hazard evaluations. Building robust predictive models of landslide susceptibility, with a high predictive performance, largely depends on the quality and relevance of existing landslide inventories. Moreover, the elaboration of hazard scenarios, based on the accurate identification of a certain (often replaced by only a more or less strongly potential) triggering factor, individualized based on an estimated threshold value with a distinct return period, also depend on the adequate classification of processes that the entire evaluation refers to. In the absence of representative and comprehensive multi-temporal landslide inventories, the hazard scenario elaboration process may be subjected to numerous uncertainties, either epistemic or aleatory (i.e., as dealing with one of the most complex natural processes, highly unlikely to be the subject of an easy, straightforward simplification through modelling). A proper understanding of the morphogenetic patterns of landslide occurrence (as either first time failures or subsequent reactivations) is therefore of critical importance, as it provides key elements for the development of reliable predictive susceptibility models and hazard evaluations.

2. STUDY AREA

The study focuses on an area increasingly known as one of Europe's most important landslide hotspots, namely the Curvature sector of the Romanian Carpathians (South-East European Carpathians), where the Buzău Carpathians and Subcarpathians are situated (Fig. 1). This region offers a large spectrum of favourability factors for the occurrence and development of gravitational slope processes, often combined with sheet and gully erosion. The heterogeneous lithology and structure imprint different physiographic and morphometric traits, which result in different movement parameters. The climate provides propitious conditions for landslide and gully occurrence in both cold and warm seasons, both in the Carpathian and Subcarpathian sectors. According to the Koeppen-Geiger climate classification scheme, the characteristic climate types within the study area are Dfc (snow climate, fully humid with cool summers) in the mountains and Cfb (warm temperate climate with warm summers) in the hill areas.

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The inner sector of the studied area is represented by the Buzău Carpathians, mountains built on Cretaceous and Palaeogene flysch deposits (alternation of more – Cretaceous - or less – Palaeogene – cohesive sandstones with conglomerates or schistose clayey and marly intercalations). They are low and medium-altitude mountains, reaching only 1771m in height (Penteleu Peak), with a topography that reflects the more cohesive and harder lithology and the intensely folded structure: steep slopes (20–50^{o}), deep fragmentation (400–600 m) and good forest coverage. Towards the exterior, the mountains are bordered by a quasi-parallel succession of hills and depression, which form the Buzău Subcarpathians. This hilly and depressionary region (reaching a maximum altitude in Cornet Hill – Manta Peak, 988 m) is built on Mio-Pliocene Molasse formations (marls, clays, sands, salt breccia, gravels, loose sandstones with marly-clay intercalations), and their topography reflects the loose and less cohesive lithology and the intensely folded and faulted structure. Some of the Subcarpathians' morphometric features, such as its 300–500m relative relief, 3–8 km/km^2 river network density, and 15–45^{o} slopes, highlight the increased potential for the occurrence of mass movements (Micu and Bălteanu, 2013).

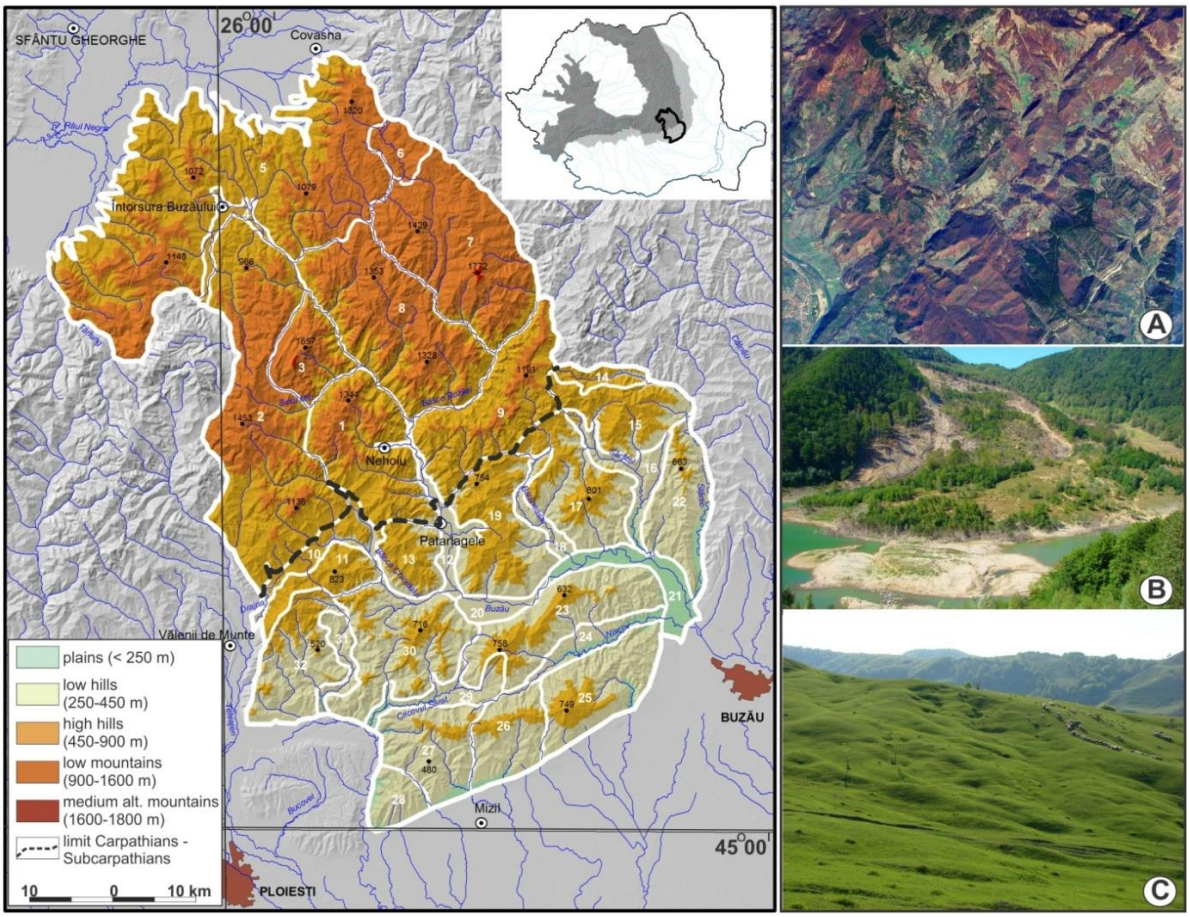

Fig. 1 – The location of the Buzău Carpathians and Subcarpathians (and their subunits: 1. Monteoru Ridge; 2. Tătaru Ridge; 3. Mălâia Ridge; 4. Întorsurii Depr.; 5. Întorsurii Mts.; 6. Comandău Depr.; 7. Penteleu Mts.; 8. Podul Calului Mts.; 9. Ivănețu Ridge; 10. Drajna-Chiojd Depr.; 11. Priporu Hills; 12. Pătârlagele Depr.; 13. Cornet Hill; 14. Lopătari Hills and Depr.; 15. Bocu Hills; 16. Sărățel Depr.; 17. Dâlma/Botanu Hills; 18. Bălăneasa Depr.; 19. Blidișel Hill; 20. Cislău Depr.; 21. Pârscov Depr.; 22. Pâcle Hills; 23. Ciolanu Hill; 24. Nișcov Depr.; 25. Istrița Hill, 26. Dealul Mare Hill; 27. Ciortea Hills; 28. Ceptura Hills; 29. Cricovul Sărat Hills; 30. Salcia Hills; 31. Podeni Depr.; 32. Lazu Hills; after Badea, 2014). Conditioned by the structural and lithological traits (reflecting in the predominant NW–SE orientation of major structures and landforms – A – the active tectonic process taking place in the Curvature sector, responsible also for the increased seismicity), the landslides follow a pattern of high magnitude and low frequency in the Carpathians (B) and low magnitude-high frequency in the Subcarpathians (C).

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Against the general background of the uplift of the Curvature Carpathians and Subcarpathians, tendencies of local amplification of these neotectonic movements (anticlinal bending, local subsidence in depression areas) have been recorded, with measured values of 3–4 mm/year (Zugrăvescu *et al.*, 1998). This fact confirms the current trend of relief energy increase due to the lowering of the local erosion bases, a fact that has led to the accentuation of the degree of instability of the slopes and the individualization of an extremely wide range of mass movements, evolving from creep to landslides and flows, often combined with fluvial erosion. The seismicity of the region represents a key factor in conditioning, preparing and even triggering a wide variety of landslides. The Vrancea Seismic Region, marked by its two domains (i.e., Vrancea crustal, with focal depths not exceeding 60–70 km, and Vrancea intermediate, with focal depths clustering below 100–150 km; Radulian *et al.*, 2000), represents the most important source of seismic energy in Romania, causing effects during the high magnitude events triggered in the intermediate field regions extending to Russia, Ukraine, Bulgaria, Serbia and Greece.

The climate of the Curvature Region is temperate-continental. The Curvature sector of the Carpathians plays the role of an orographic barrier for the prevailing westerly airflows, leading to a high frequency of Föehn effects in the Subcarpathian and border plain areas. The complex interactions between the large-scale atmospheric circulation and local topography influence the distribution patterns of the heavy precipitation events (frequency and intensity), and could explain much of the dynamics and magnitude of slope modelling and hydrological processes across the entire Curvature region of Romania, recognized for its intense erosion rates all across Europe (Popa, 2016). The precipitation regime of the study-area is moderate-to-dry in the hill (Subcarpathian) sector and moderate-to-humid in the mountain (Carpathian) sector. The total precipitation in the Curvature region ranges between 600–700 mm in the Subcarpathians, and 800–900 mm in the Carpathians (Clima României, 2008). There is a great concentration of rainfalls over the April–October interval, with a share of about 75% of the total annual amount. The summer droughts are only moderately intense in this region (e.g., 1990, 2007-2008, 2012). The wettest decades over the 1970–2000 period were the 1970s (with great focus on the 1972 and 1975 years) and the 2000s (e.g., 2005, 2010). The very heavy precipitation events (>20–30 mm) span mostly over the May–August period in the Subcarpathians and over the June–August period in the Carpathians, overlapping the convective interval of the year. Although rather rare throughout the 1970–2010 period (under 5% occurrence probability), extreme rainfall episodes resulted in more than 50–60 mm/day and were recorded in both the Carpathian and Subcarpathian sectors of the study region.

The vegetation cover reflects the topographic and climatic conditions, as well as the intense human intervention. The Carpathians comprise large and compact beech (Fagus sp.) and spruce (Picea sp.) forests, generally providing the soil and regolith with a good root cohesion. Especially during more recent times, one of the most active factors involved in preparing and even triggering landslides is anthropic activity. In the Subcarpathians, the long-lasting human habitation transformed the original vegetation into a secondary one by largely replacing forests with pastures, grasslands and orchards. In this sector, anthropic activities contribute to slope instability both directly (e.g., the case of National Road 10, built along the valley of the Buzău River during the 60s–80s, which cut the slope in its middle sector, triggering numerous landslides) as well as indirectly (e.g., the management of the water level in reservoirs, which can prepare the landslide initiation as was the case of the 2006 Groapa Vântului landslide – see Micu and Bălteanu, 2013, or deforestation). Quantifying the human impact on slope equilibrium is still a challenge under the given high complexity of the socio-economic context (closely related to the political one), which render the understanding and discretizing in clear actions rather difficult. Although, at a local level, the effects of anthropogenic activity can be significant indeed, at the general (regional) level its quantification is even more difficult due to the heterogeneous pattern of manifestation of these interventions; however, the changes in land use and cover are impacting the probability of future landslide occurrence, as described by Jurchescu *et al.*, 2020.

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In this general framework, landslides are associated with numerous occurrence-prone areas, conditioned mainly by structural and lithological traits. Often, the processes are complexly combined with gully erosion, one leading to the occurrence/development of the other, resulting in complex or compound forms. In the Carpathians, the large, deep-seated landslides (high magnitude, low frequency) characterized by a very rich micromorphology, are allowing gully erosion to install and eventually control, further on, through erosion-transport-accumulation processes, the landslide's local or even entire morphodynamic behaviour. In the Subcarpathians, an area intensely affected by shallow and medium-seated landslides (of low magnitude and very high frequency), gully erosion can be recognized as induced by landslides, but also (sometimes associated with additional processes like piping) as the causes of slope gravitational processes. In addition, they may occur at the same time (the process' morphodynamics is controlled by the physical, mechanical or chemical properties of the *in-situ* rocks, regolith or soil, the precipitation regime and the topographically-controlled flowing parameters).

3. DATA AND METHODOLOGY

The favourability of precipitation regime characteristics for the initiation of shallow landslide processes in the Curvature Region of Romania was analysed over the 1970–2010 period, using the daily precipitation data provided by two representative weather stations, in terms of geographical location, data homogeneity and length of record interval, for deriving the main features of the precipitation regime in the two sectors of the Curvature Region: Pătârlagele (Buzău Valley – Pătârlagele Depression; 45°19'N, 26°22'E, 289m a.s.l.) in the Subcarpathian sector, and Lăcăuți (in the vicinity of Vrancea Mountains, immediately outside the study-area towards the NW; the 45°49'N, 26°23'E, 1,776m a.s.l.), for the high-elevation Carpathian sector. The daily precipitation data was provided by the National Meteorological Administration within the framework of the FP7 CHANGES project.

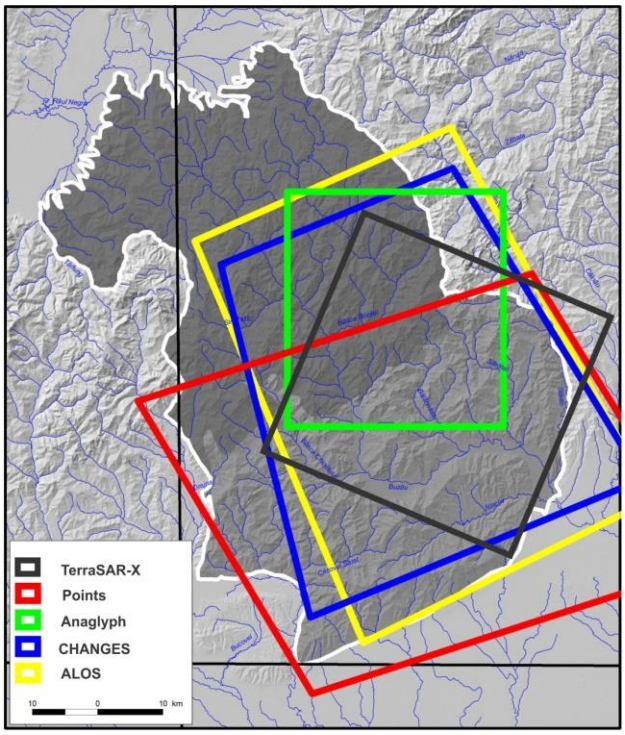

Fig. 2 – The coverage of different landslide inventories used for typological evaluations.

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Several landslide inventories (Fig. 2) were used to investigate the correlation between the climatic factor and other predisposing factors (as follows): anaglyph (2014; 1028; obtained through the digital stereographic interpretation of 2005 and 2008 ANCPI aerial photos within the IncREO FP7 and CHANGES FP7 Projects; undifferentiated landslides; polygons, with scarp and body mapped as either distinct or indistinct; 1028 deep-seated landslides; Damen *et al.*, 2014); CHANGES (compiled in 2014 within CHANGES FP7 Project; 1579 undifferentiated shallow slides and flows; points; Zumpano *et al.* 2014); ALOS-PALSAR (compiled in 2014 within CHANGES FP7 Project using ALOS PALSAR 2007–2010 archive imagery and D-InSAR for automatic detection and PS-InSAR for kinematics; 515 alleged landslides, 193 confirmed; Provost *et al.* 2015)*;* TerraSAR-X (compiled in 2014 within the IncREO FP7 Project using TerraSAR-X Nov. 2013 – Jun. 2014 archive imagery; 60 alleged landslides, 12 confirmed; Riedmann *et al.*, 2014)*;* Punctual (2017; 4047 slides, 72 flows; point; Micu *in print*).

4. RESULTS AND DISCUSSIONS

The study area is characterized by an extremely wide variety of landslides, highly different from a morphogenetical, morphological and dynamic point of view (Fig. 3). The litho-structural conditions (predominantly NE–SW-oriented major structures of intensely folded and faulted inner Cretaceous and Palaeogene flysch in the Carpathian Mountains, stretching towards the exterior by the Neogene molasse deposits on which the Subcarpathian hills are modelled) reflect the intense tectonic activity associated with this typical, intra-continental plates collisional area. The (relatively) more cohesive inner flysch formations consist of alternations of thick (more or less) cohesive sandstone with schistose intercalations of marls, clays or bitumen. The molasse formations are built out of a heterogeneous mixture of clays, marls, salt breccia and sands. The relief's morphology reflects the differentiated denudation, with steep slopes, narrow valleys and continuous ridges in the mountains, and large depressions and valleys, rounded summits and slopes almost entirely covered by colluvial deposits in the hill sector. The large landslide typology mainly reflects the complexity of predisposing factors. The inner, mountainous flysch sector is characterized by the existence of large, dormant (partially relict) landslides (rock and debris slides, rock falls or complex landslides). Showing a low frequency-high magnitude pattern, these landslides present many sectors with recent reactivations, situated either at their toe or scarp. The outer, hilly molasse area features very frequent but low-magnitude landslides, in the form of earth slides and flows, rock slides, and rarely in the shape of debris flows/slides. Here, landslides form large complex areas where they associate with (either as conditioning or being induced by) erosion processes, especially in the form of sheet wash, rills and, rarely, gullies.

Slopes below 3° (6%) are particularly characteristic of floodplains, terraces and landslide/alluvial accumulation cones, as well as part of the slopes affected by weak surface erosion processes. Slopes of 3–10° (31%) are characteristic of colluvial slopes, as well as some slope sectors that can be affected mainly by shallow landslides, given a prone lithology. Slopes of 10–15° (29%) frequently coincide with the lower and middle slope sectors, which are intensely shaped by sliding and flowing processes, while slopes of 15–20° (18%) usually correspond to the upper sectors of the slopes, affected in significant proportions by both shallow and deep-seated landslides and erosion. Slopes of 20–30° (11%) have a much wider distribution in the mountain areas and are mostly forested; with the increase in inclination, the place of sliding processes is slowly taken over by erosion forms and rock falls. Surfaces with slopes of 30–40° (4%) include litho-structurally conditioned mountain slopes (mainly cuestas), shaped predominantly by frost weathering or gravity (falls), while surfaces with slopes greater than 40° (only 1% of the studied area) correspond to rock walls modelled on hard rocks or steep river banks; the predominant processes are rock falls, rock slumps and rock topples.

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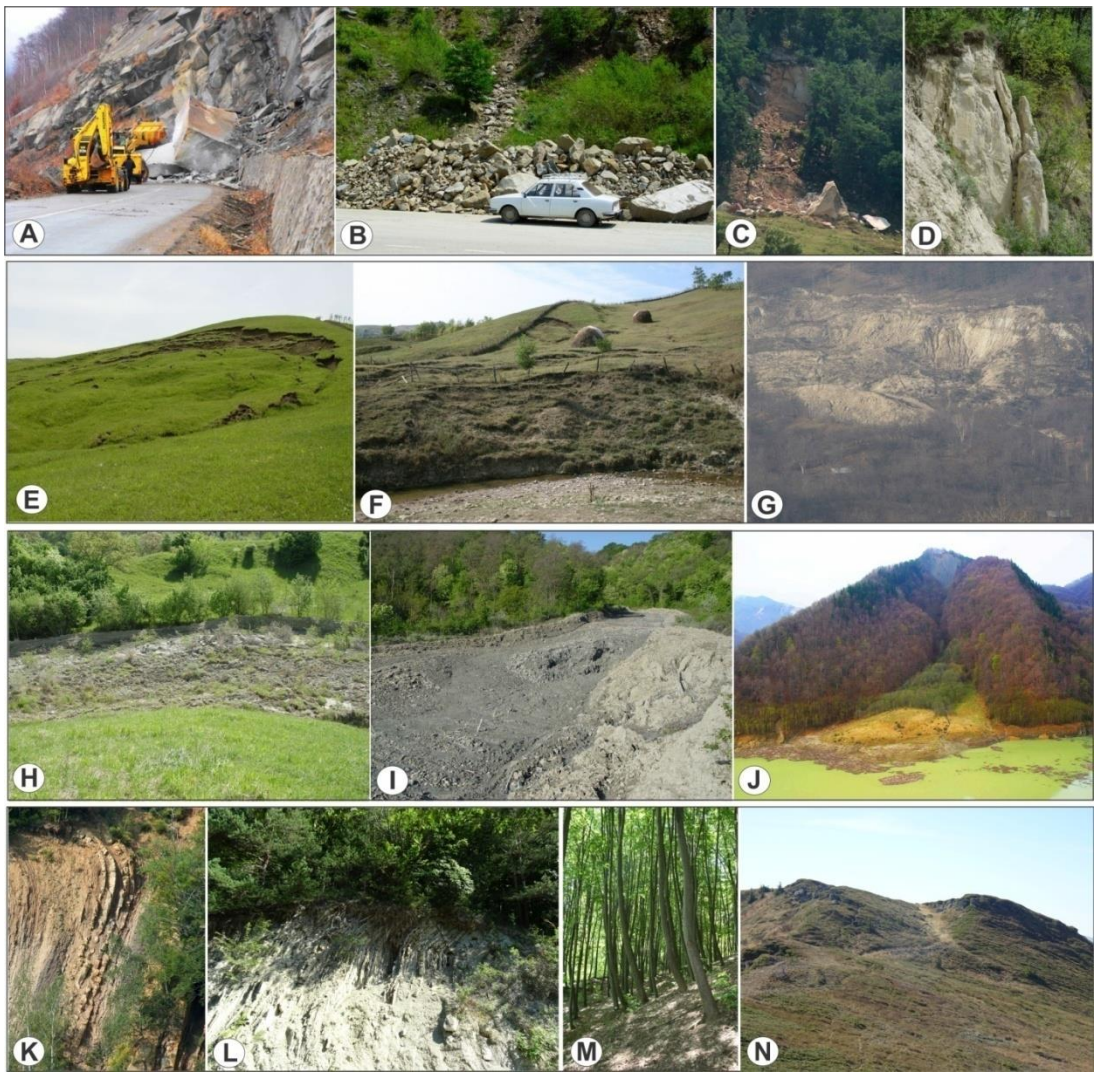

Fig. 3 – Landslide types (according to the Varnes-updated terminology proposed by Hungr *et al.*, 2013) in the study-area: A) rock falls (Podul Calului Mts); B) boulder/debris falls (Podul Calului Mts); C) rock flexural topple (Ivănețu Ridge); D) sand/silt topple (Cornet Hill); E) clay planar slide (Cornet Hill); F) clay rotational slide (Cornet Hill); G) rock rotational slide (Priporu Hills); H-I) earth flow (Cornet Hill); J) debris flow (Siriu Mts.); K-L) rock slope deformations (Ivănețu Ridge); M) soil creep (Cornet Hill); N) mountain slope deformation (Siriu Mts.).

Analysing the distribution of (mainly shallow) earth/debris slides and flows within the four inventories with regional coverage (Table 1), a series of features stands out highlighting the specificity of the processes within the two major units. If the CHANGES and ALOS inventories can be considered representative for the entire study-area, the anaglyph inventory more precisely reflects (using a representative perimeter) the image of landslides in the Carpathian area, while the point inventory does so in the Subcarpathian area. Thus, in both areas, a predominant distribution of processes in the slope inclination classes of 3–30^{o} is noted, with lower values (10–20^{o}) characterizing the Subcarpathian area, while in the Carpathians, deep-seated landslides, conditioned by the specific lithology, need even steeper slopes (30–35^{o}) to be initiated. The distribution of landslides within the inventories confirms the difficulty of RS radar images to capture landslide processes on forested slopes (especially those with northern exposure) and the higher possibility of capturing landslides on

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slopes with eastern and western exposure, a fact also imposed by the satellite trajectory with the NE-SW litho-structural disposition. The correlation between the landslide location with the corresponding land use/cover, was difficult to establish for the landslides occurring under (or covered by) forests. These events have been identified by employing interferometry techniques or based on the records in the official reports of local authorities. In the areas covered in pastures, hayfields or old, degraded orchards, one has noted a plausible overestimation of the number of landslides due to the easier visual interpretation of available imagery archives. The reduced presence of slides and flows records in built-up areas support the author's personal observation, namely that the traditional construction approaches (including the location) were (and still partially are) taking into account the areas prone to such slope processes, and most cases of damage to the built-up fund may be attributed to the most recent construction, many times organized with less attention to the natural conditions (pre-existing landforms and landscapes). Landslide distribution by lithological formations highlights their maximum concentration on Middle Miocene-Middle Pliocene formations (shale sandstones, clay shales, marly shales, intercalations of gypsum and salt, clays, marls; Helvetian-Dacian) in the Subcarpathians, while in the Carpathian area, the highest concentration is recorded on the lower Oligocene formations (sandstone flysch with shale intercalations – the Fusaru facies, the Kliwa facies), prone to slow-moving landslide processes; besides the long duration of the process (several days to one/two weeks), the magnitude of the latter processes makes them more easily detectable on aerial radar images. However, in the meantime, these landslides are not frequently recorded in official reports because they occur predominantly in uninhabited areas, without causing particular damage to man or personal property. The external Subcarpathian area, built on Upper Pliocene-Quaternary formations, is more prone to rapid movements, such as earth flows (frequently associated with erosion), themselves not particularly successful in remote sensing radar monitoring procedures.

Table 1

Landslide distribution (on different classes of predisposing factors) according to different inventories

Inventory	**Slope** (^{o})							**Aspect**			
	0–3	**3–10**	**10–15**	**15–20**	**20–30**	**30–40**	**40–90**	**N**	**E**	**S**	**V**
CHANGES	1	17	31	28	18	5	<1	14	12	37	36
ALOS	1	19	27	26	19	7	<1	7	13	19	61
Anagliph	1	10	23	28	32	5	<1	10	9	37	44
Punctual	1	35	45	15	4	<1	<1	13	17	33	38

Inventory	**Fragmentation depth** (m/km^2)					**Units**				
	0–50	**50–150**	**150–250**	**250–350**	**350–650**	**Plain**	**Low hills**	**High hills**	**Low mts.**	**Average mts.**
CHANGES	<1	20	18	40	21	4	44	48	4	<1
ALOS	<1	12	20	34	33	3	37	41	19	<1
Anagliph	*	*	5	17	78	*	12	69	18	*
Punctual	<1	21	66	13	<1	<1	40	60	*	*

**non-existent within the inventory extent*

Inventory	**Land use**					
	Built-up	**Forests**	**Pastures, hayfields**	**Orchards, vineyards**	**Arable**	**Bedrock**
CHANGES	6	22	38	17	17	<1
ALOS	1	31	48	12	8	<1
Anagliph	5	59	21	6	8	<1
Punctual	5	14	39	23	19	<1

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Table 1 (continued)

Inventory	**Lithology 1** (age)										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
CHANGES	<1	<1	0	1	1	5	13	1	0	29	8
ALOS	0	0	0	9	2	4	23	0	0	25	8
Anagliph	*	*	<1	7	3	18	37	0	1	26	5
Punctual	*	*	*	1	<1	*	4	0	1	32	11

*1 – Lower Cretaceous; 2 – Mid Cretaceous; 3 – Upper Cretaceous; 4 – Low-medium Eocene;5 – Upper Eocene; 6 – Undifferentiated Eocene; 7 – Lower Oligocene; 8 – Upper Oligocene; 9 – Upper Oligocene – Lower Miocene; 10 – Mid Miocene; 11 – Upper Miocene; * Non existing inside the inventory extent*

Inventory	**Lithology 2** (age)									
	12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
CHANGES	6	14	13	5	2	0	0	0	1	1
ALOS	4	15	7	1	1	0	0	0	2	0
Anagliph	0	1	<1	*	*	*	*	*	*	*
Punctual	22	6	*	19	1	*	0	0	0	3

*12 – Lower Pliocene; 13 – Mid Pliocene; 14 – Upper Pliocene; 15 – Upper Pliocene – Lower Pleistocene; 16 – Lower Pleistocene; 17 – Mid Pleistocene; 18 – Mid-Upper Pleistocene; 19 – Upper Pleistocene; 20 – Lower Holocene; 21 – Upper Holocene; * Non existing inside the inventory extent*

In this context, the landslides in the study area completely reflect, both on a spatial and temporal scale, the geomorphological specificity of each region. To understand the landslide system in the Buzău Carpathians and Subcarpathians, a series of concepts governing its functionality must be followed: complexity, evolution, frequency/magnitude, threshold, sensitivity, morphodynamic sectors and connectivity. To exemplify these concepts, we will use a comparative image (Fig. 4), between a perimeter affected by deep-seated landslides located in the Carpathians (the Buzău Valley in the Pălticeni basin sector) and another in the Subcarpathians (the Muscel small catchment in its middle third), characterized by the predominance of shallow translational slides.

Fig. 4 – The Pălticeni depressionary basin (left) and Muscel catchment (right) outlining the difference in landslide magnitude between the Carpathian and Subcarpathian sectors of the study area.

The **complexity** of landslides practically represents the materialization of the interaction between the multitude of predisposing factors (lithology, structure, morphometry), preparatory factors (neotectonics, changes in land use) and triggers (precipitation, earthquakes) specific to the two major units (Carpathians and Subcarpathians). The prevalent deep-seated character of landslides in the Carpathians (controlled by a less friable lithology that also imposes a specific structure, where the alternation of cohesive and less cohesive rocks within the flysch deposits imprints the consequent or

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insequent typology of the landslides) is opposed to that of the Subcarpathian area, where the superficial and medium depth landslides are more spread out. Here, the lithological heterogeneity of the molasses deposits imprints a similarly-increased heterogeneity in the typology of landslides, modelled by frequent transitions from plastic to viscous displacements and back again. The same litho-structural predisposition factors also impose the combination of landslides either among themselves or with erosion processes: if in the Carpathian area, rockfalls and rock avalanches (such as those from Terca, Lopătari-Luncile, Budești, Brăești, Fișici, Scăeni, Colții de Jos etc.) are frequently associated with deep landslides; in the Subcarpathian sector, the combination of shallow earth slides with flows (frequent shifts between Atterberg limits due to the high content of clay minerals), sheet wash, rills or gullies (especially towards the outside, within the predominantly sandy and loessoid Romanian-Quaternary formations) frequently favours the development of large perimeters evolving under the combined forcing of mass movements and erosion.

The **evolution** of landslides in time and space outlines different evolutive typologies in the two sub-regions. The large magnitude of the processes in the Carpathian area allows for greater accuracy in their morphological individualization, the (largely local and very rare total) reactivation processes being usually smaller in coverage and not disturbing the morphological profile imprinted by the primary failure. On the opposite side is the Subcarpathian area, where numerous slopes show a polycyclic evolution through successive generations of new and reactivated processes (partially and even totally), which many times makes the development of (complete or representative) landslides inventorying extremely difficult and subjected to potential mapping errors of first-time failure and subsequent reactivations.

The **frequency-magnitude** relationship is defining for the individualization of two different patterns in the Carpathians and Subcarpathians. The low frequency (return periods of 20–50 years and even more; Micu *et al.*, 2013, Surdeanu *et al.*, 2009) and high magnitudes (often 2–5 million m^3; Micu and Bălteanu, 2009) of landslides in the Carpathians (also as a reflection of the lithology, in particular) correspond to a completely different pattern of landslides in the Subcarpathians; here these processes occur much more frequently, many times throughout a single year (in the spring, when the snow melts or when spring showers are overlapping, or in summer, as a result of heavy convective precipitation condensed over short intervals of time, which cause earth flow pulsations or flash-flood events, actively contributing to slope undercut). This fact comes as an apparent compensation of the comparatively lower magnitude. Establishing a trigger threshold based on certain return periods can be highlighted as an important element in calibrating (and then validating) hazard scenarios to estimate exposure and quantify vulnerability or risk. This task is highly challenging for several reasons: in the Carpathian area, the low frequency of occurrence makes it difficult to create a comprehensive multi-temporal inventory, and the complexity (in most cases) of the process implies (very often) more than one triggering factor; in the Subcarpathian area, the presence of numerous moments of partial or total reactivation of some existing landslides makes it difficult to distinguish between the first initiation and the reactivations, which would allow the quantification of primary or secondary rock physical or mechanical parameters. Nevertheless, this polycyclic evolution doesn't allow for a clear delineation between dormant or just suspended processes.

The identification of a distinct **trigger threshold** for various landslide types has had the most important contribution, along with frequency and magnitude, to the calibration of hazard scenarios and validation of hazard assessments. Thresholds can be seen as responsible for breaking the slope equilibrium (either due to external or internal agents) and inducing a more or less long time of interstadial evolution, thus leading to a nonlinear relationship between the forcing and the morphodynamics of the processes. Despite its theoretical importance, this threshold is, practically, extremely difficult to be estimated and even more so, to be validated as relevant, for the entire Curvature area. The morphometric complexity of the relief of the Curvature region, the seasonal or even diurnal air circulation pattern, as well as the lack of a dense network of observation points hardly allow the individualization of a distinct threshold. This leads either to possible erroneous conclusions (as an example, between 2001–2015, several large-

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scale pulsations of the Chirlești earth flow could not be quantified from this point of view due to the strictly local behaviour of the summer, convective precipitation which triggered it, so that at the nearest weather station – Pâtârlagele, 6.5 km downstream – we encountered a complete lack of recorded precipitation). The separation of antecedent factors from those of the moment is also a highly challenging process. In the case of earthquakes, determining a triggering threshold has proven an even more difficult endeavour (Micu, *in print*), since, beyond a simple correlation with seismic parameters (epicentral distance, hypocentral distance and depth, magnitude, intensity) and depending on the degree of water saturation of the soil, regolith or rock deposits, elastic movements may combine with and enhance the visco-plastic ones. Nonetheless, local side effects, either topographic (with amplifications of seismic waves in convex areas, and attenuations in concave ones) or lithologic (amplifications within loose cohesive deposits and attenuations in the case of massive, compact ones), if not properly quantified, may challenge the accurate landslide zonation procedures. Investigating the meteorological conditions during some severe floods of the 1970s in Romania, Milea (1976) showed that daily precipitation exceeding 20 mm could trigger flood events in hill and mountain areas under high soil moisture conditions, while those above 30 mm, account for the initiation of flood and erosive events under dry soil conditions. Considering the importance of soil moisture content for shallow landslides and gully formation (Casalí *et al.*, 1999; Castillo *et al.*, 2003; Poesen *et al.*, 2003), the greatest 1-day (R24h) and 3-consecutive days (R72h) amounts were regarded as a proxy indicator for the soil moisture content (Table 2).

Table 2

Main characteristics of the precipitation regime in the study-area: total precipitation amounts (Rtot); average number of wet days (Rwet) and very heavy precipitation days (R20); greatest 1-day precipitation amount (R24h); greatest 3-day precipitation (R72h)

Decades	Rtot (mm)	Rwet / R20 (days)	R24 (mm)/Date of occurrence (RT)	R72h (mm)/Date of occurrence (RT)
Curvature Subcarpathians				
1971–1980	685.1	85.0 / 7.6	177.8/July 2, 1975 (380.2 years)	203.8/July 1975 (284.1 years)
1981–1990	550.3	74.9 / 5.0	67.4/August 6, 1983 (8.6 years)	88.3/May 1988 (7.3 years)
1991–2000	635.9	78.7 / 7.1	60.0/January 21, 1998 (5.6 years)	93.4/January 1998 (9.1 years)
2000–2010	688.5	83.9 / 8.3	69.3/March 23, 2007 (9.5 years)	93.3/September 2006 (9.1 years)
Curvature Carpathians				
1971–1980	954.0	128.4 / 8.7	101.2/July 2, 1975 (44.6 years)	200.7/July 1975 (145.3 years)
1981–1990	574.9	100.8 / 3.1	50.7/June 18, 1989 (2.7 years)	103.9/June 1988 (6.1 years)
1991–2000	635.9	99.0 / 6.8	88.0/June 18, 1999 (20.9 years)	115.7/June 1994 (9.1 years)
2000–2010	715.4	47.6 / 8.3	91.5/July 12, 2005 (25.5 years)	140.8/July 2005 (21.3 years)

The recurrence period (RT) of these indicators was calculated for the two representative stations and for the 1970–2010 period, using the Generalized Extreme Value Distribution. The peak 24-h precipitation value was recorded in July 1975 (the effects of those extreme rainfall events were documented by Bălteanu, 1983), reaching 177.8 mm in the Subcarpathian sector (a return period of 380 years) and 101.2 mm (a return period of 45 years) in the Carpathian one. The frequency of heavy precipitation days (above 10 mm) and very heavy precipitation days (above 20-30 mm) in the region is very low (5.2% and 1.8%, respectively). For comparison, the probability of such events in 2005 (a historical record-year of excessive rainfall across the region and countrywide) increased to 9.3% and 4.1%,

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respectively. Dragotă (2006) delineated the regions exposed to intense rainfalls in Romania, based on an index defined as the average of the top five maximum rainfall intensities (I5max) over the 1961–1996 period, using the records of 130 weather stations located up to 1,500 m in altitude. The variation range of the index in Romania is between a maximum of more than 6 mm/min (e.g., parts of the Moldavian, Dobroujan, Transylvanian and Getic Plateaus, Western Hills) and a minimum of under 3 mm/min (in high Carpathian areas). Accordingly, the Curvature Subcarpathians are assigned to the regions where the I5max is 4–5 mm/min, while in the mid-elevation areas of the Curvature Carpathians it is 3–4 mm/min. The concentration of snowmelt runoff is also a significant control factor of shallow landslide initiation, particularly in terms of their spatial expansion. The average date of snowmelt is during mid-March in the Subcarpathian sector and late-May in the Carpathians. The potential for shallow landslide initiation and rill/gully formations increases significantly in the late winter to early spring interval (generally from February to April), when snow melting overlaps the fall of liquid precipitation, particularly in the Subcarpathian sector, where the minimum temperature values become exclusively positive starting March. During the snowmelt season, the share of liquid/mixed precipitation in the total annual number of precipitation days is lower than that of solid precipitation (15% compared to 20%). As described by Micu (2008) and Dragotă *et al.*, 2008, by mapping landslide occurrences in small catchments at the Carpathians-Subcarpathians limit (Cornet Hill, Muscel, Viei, Rea basins) during 2005, a year marked by extreme precipitations, several potential shallow landslides triggering thresholds were identified: greatest 1-day precipitation over 25 mm; greatest 1 to 3 consecutive days precipitation between 50 and 100 mm; at least three wet days cumulating 32 to 41 mm (such precipitation amounts could trigger floods/flash-floods in low soil moisture hill and mountain areas according to Stăncescu, 1968); 10 days antecedent precipitation prior to the landslide failure between 36 and 122 cm. For the clear delineation of triggering thresholds with regional relevance, these values should be backed up by similar studies, which are still missing. Moreover, it has been estimated that the preparing/triggering role of the climate factor in the case of deep landslides is even more difficult to evaluate, in the context of the lack of a clear, well-founded case study archive with a representative spatial-temporal coverage. Based on a limited (4) number of events, deemed representative for the study-area, in terms of thickness and size of the affected area, a first estimate was made by Micu (*in print*). In these cases, the length of the rainfall for the analysed antecedent period is considered more important to characterize the quantitative rainfall threshold leading to the occurrence of these complex processes. The frequency of heavy precipitation (*FR10*) and very heavy precipitation (*FR25*) days was decreased, such extreme precipitation days having an occurrence probability below 10% (or under 16 days) over the antecedent precipitation period considered in the analysis, with a total precipitation amount of 120–290 mm; the maximum number of wet spells (the number of episodes of consecutive precipitation days) was 7, with a maximum duration ranging from 4 to 7 days, resulting in a total precipitation value of 26–49 mm; the total precipitation during the antecedent precipitation interval ranges between 250 and 471 mm, distributed as follows: 3–21% of the total precipitation in the first 1 to 7 days of the antecedence period (short-term, before the landslide failure), 10–25% over days 8 through 30 (medium-term) and 70–80% over days 31 through 180 (long-term); the maximum daily precipitation intensity rates (mm/day) of 23–38 mm for up to one month before the landslide failure, with return periods of 21 to 66 years.

Sensitivity is the geomorphic response of the slope system that can be different for the same external forcing. The sensitivity of a slope is higher as the lag time (that is, the time difference between recording the first external impulse and the one in which the system starts to react) and the relaxation time (the time difference between the moment of the first reaction and that of reaching a specific shape) are shorter (Jain *et al.*, 2012). Both at the level of morpho-litho-structural units and the level of the slope sector, different sensitivities can be registered in the context of the same climatic or seismic forcing. In the Subcarpathians, in the case of the predominantly shallow earth slides and flows, sensitivity is higher in comparison to the Carpathians, where the morphodynamic characteristics of the

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predominantly large, deep-seated rock and debris slides are prolonged sometimes to weeks (as seen in the case of Groapa Vântului complex landslides; Micu and Bălteanu 2013), comprising both lag and relaxation times.

Approaching landslides from the point of view of **morphodynamic sectors** is in direct relation with evolution and frequency/magnitude. Highlighting the distinct or indistinct features of the morphodynamic sectors in the Carpathian area is made difficult by the advanced age of the processes. The detailed assessments to which those large-scale processes must be subjected (where high accuracy field geomorphological maps are supplemented with an external input derived from geophysical surveys) allow for the individualization of primary and secondary sectors, first activations and various episodic or quasi-continuous reactivations, which enable the outlining of a morphogenetic framework where elements such as agents, processes and resulting forms can be understood and quantified. In the Subcarpathian area, the polycyclic evolution of many slopes that follow a redundant pattern of first activation-partial reactivation-total reactivation often makes it difficult to correctly establish, especially within multi-temporal inventories, the depletion and accumulation sectors. The strongest impact of this uncertainty is reflected in the different distribution of susceptibility or hazard classes within a regional study, based on (possible) multi-temporal inventories.

Connectivity is a concept whose quantification has only started to become possible a short time ago and which has experienced sustained growth over the past 5–10 years. Be it functional (through stream-level interactions) or structural (physical connections), it enables an improved understanding of the nonlinear response of the slope-channel coupled with external forcings and allows the quantification of the indirect impact (Jain *et al.*, 2012). The most visible manifestation of this interaction is in the form of landslide dams, and in the Buzău Carpathian and Subcarpathian region, numerous cases of such dams are recorded in literature along the streams of Cașoca, Siriu, Bălăneasa, Bâsca Rozilei (for detailed descriptions see Ielenicz, 1984, Bălteanu, 1983, Cioacă, 1996, Micu and Bălteanu, 2013). These dams usually have a short lifetime, of around weeks or months (in agreement with the result of the synthesis of Costa and Schuster from 1988, which states that 85% of slide dams are destroyed by erosion in their first year of being operative). A useful benchmark for estimating the geomorphic response of connectivity in the study area is provided by Korup's (2005) classification (based on a consistent inventory of such events in the New Zealand Southwestern Alps) of geomorphological impact types and impact surface features.

Thus, according to the category of the slope-channel coupling interface, one may note in the area of the Buzău Carpathians and Subcarpathians the following types (Fig. 5): *area* (when very large volumes of landslide material produce major reorientations of the hydrographic network; less comparable than other mountainous regions of the world, especially due to the relatively low relief energy and slope inclinations, it can be found on a smaller magnitude scale in the case of the deep-seated landslides that have diverted the course of the Bâsca Rozilei river downstream from the village of Varlaam and up to the confluence with the Buzău); *linear* (when more than 50% of the length of the contact follows the direction of the river; the cases are numerous and most of the tributaries of the 1st and 2nd order of the Buzău river in its Subcarpathian sector present such couplings); *point* (below 50% contact; the distribution is similar to the previous case); *indirect* (produces the separation of rivers or reservoirs; such a case may be that of the Groapa Vântului landslide, which interrupted water flow inside the Siriu reservoir for one month) or *nil* (when there is no contact between the landslide deposits – left suspended on the slope for structural, petrographic or varied reasons – and the drainage lines; this situation is widespread throughout the upper catchments of the 1st and 2nd degree tributaries of the Buzău river). The classification of the geomorphological impact is in agreement with the previously mentioned study: *buffered* (when landslides do not make direct physical contact with the drainage system); *riparian* (direct contact of the landslide deposit with the hydrographic network, lateral erosion being dominant and controlling the triggering of landslides and the further drainage of landslide deposits reaching the river banks); *occlusion* (the diversion of the river course by the landslide deposit); *blockage* (appearance of landslide dams); *obliteration* (covering kilometres' worth of sectors, of the alluvial plain with complex deposits).

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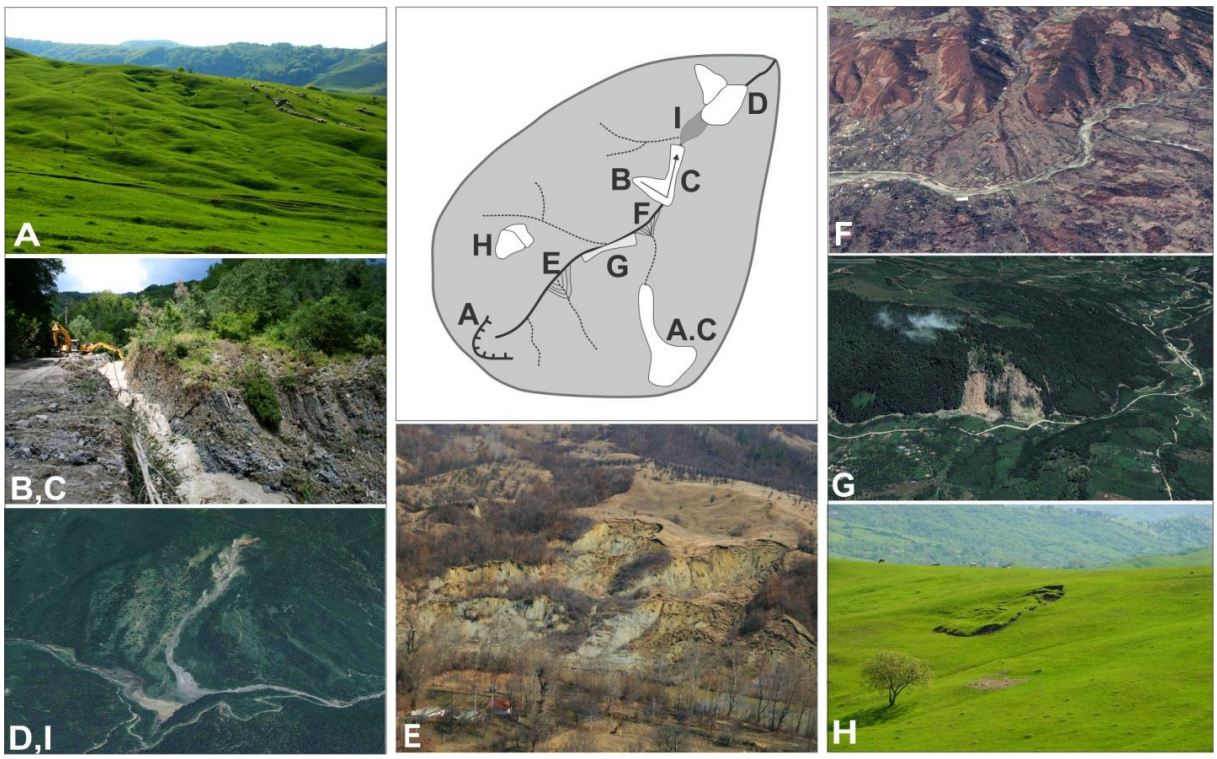

Fig. 5 – A schematic representation of impact types caused by landslides at the slope-channel interface: **A**) shallow earth slides initiation (and headward evolution) in the uppermost catchments (Viei basin, Cornet Hill); **B**, **C**) lateral input from landslide accumulation deposit and sediment loading/material transfer to the river (Viforâta landslide, Penteleu Mts.); **D**, **I**) full river blockage and landslide (permanent or temporary) dam formation (Răoaza debris flow, Vrancea Subcarpathians, immediate vicinity of the study-area); **E**) temporary deposition of the landslide accumulation fan (Păltineni debris flow, Ivănețu Ridge); **F**) long-lasting supply of fine sediments resulting from landslide accumulation fan river undercut (Terca, Ivănețu Ridge); **G**) landslide accumulation blockage by the morphometric buffer of terrace/ floodplain formations (Terca, Ivănețu Ridge); **H**) landslides retained on slopes, with a null/very low contribution to river sedimentation (Muscel catchment, Cornet Hill) (adapted after Korup, 2005).

5. CONCLUSIONS

Landslide susceptibility modelling and hazard evaluations are key geomorphic services meant to build proactive risk mitigation measures. A sound scientifically-based evaluation of the hazard and its level, hazard zonation processes, the assessment of elements at risk, their exposure and vulnerability could contribute to an enhanced preparedness and prevention which could further ensure the proper implementation of effective risk management strategies. All these strategic goals rely on the improved understanding of landslide typology, their past and present-day behaviour, as well as their future likelihood of occurrence. In regions showing such a high susceptibility to various landslide types across small areas, the development of more robust and highly predictive susceptibility models and hazard evaluations should be the subject of a comprehensive sensitivity analysis relying on a reliable landslide typological understanding, which may improve the susceptibility model quality in terms of reliability, the model's robustness to changes in the input data, the error associated with the probabilistic estimates, the goodness of fit and overall predictive performance. The study-area outlines the necessity of using representative inventories for each spatial unit, adapted to the site-specific conditioning and triggering factors. While, a susceptibility analysis at the regional level may prove successful for shallow landslides (earth slides and flows), for deep-seated landslides (debris and rock

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slides) such an approach may prove difficult because of the morphogenetic complexity of such processes, answering more to local preconditioning features (structure, lithology) and to more complex triggering contexts (frequently associated with superposed factors and longer lag and relaxation times). However, due to their large magnitude (expressed in large surfaces and volumes), deep-seated landslides may represent key issues in modelling landslide susceptibility to shallow processes when their (partial or even total) reactivation potential is fully understood and quantified. In such active areas (in agreement with other reviews or synthesis works; see Reichenbach *et al*., 2018), a geomorphic-based sensitivity analysis for susceptibility and hazard assessment should address the following: a) the reason (or constraints) why a certain/particular method was chosen with respect to another; b) the type and the choice of variables (how representative they are for each region and for the respective landslides typology, what the reason was when being chosen, which combinations gave the best results and in the opposite case, whether there were any other choices of variables or any other more or less suitable reclassifications); c) variables classification (continuous versus categorical); d) the modelling technique; e) landslide points versus landslide polygons and the procedure of transforming polygons into points (how many points were/should be used for each landslide entirely or for each scarp); f) the number of run models; g) the robustness of the model and the predictive capacity of different results (success and prediction rate curves, ROC, confusion matrix etc.); h) assessing the level of agreement among susceptibility first-to-last classes and the evaluation of middle values in order to know in which classes they would be included; i) final classification (which classifying method – automated or manual – proved to give the best results and for what reason).

Acknowledgements

The results of this work were obtained through the research theme of the Institute of Geography "*The National, Regional and Local Evaluation of Natural Hazards: Geographical Studies Within Pătârlagele Natural Hazards Research Center-2022*".

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Received October 21, 2022

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THE IMPACT OF COVID-19 ON TOURIST ACTIVITIES IN THE NORTH-WEST DEVELOPMENT REGION, ROMANIA

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Key-words: COVID-19, tourism, indicators, impact, decrease, North-West Region, resorts.

L'impact de COVID-19 sur les activités touristiques dans la Région de Développement Nord-Ouest de Roumanie. La région de Nord-Ouest a été l'une des plus affectée de Roumanie par le déclin de l'activité touristique à la suite de la pandémie de COVID-19. Dans cet article nous avons analysé l'évolution de l'activité touristique et de la capacité d'hébergement touristique dans cette région pendant la période 2018–2021 à l'aide des plusieurs indicateurs: les nuitées, la durée de séjour, la capacité d'hébergement touristique totale et celle utilisée. Tous ces indicateurs montrent la même évolution générale – un déclin abrupt au cours de 2020 (surtout dans les périodes de confinement et des restrictions des déplacements et des activités considérées comme non-essentielles, y compris le tourisme) suivi d'un faible repris dans 2021 – à l'échelle régionale on ne peut pas constater le retour aux niveaux d'activité touristique d'avant la pandémie. Dans ce cadre général, au niveau des principales destinations touristiques de la région (stations touristiques et grandes villes) on peut identifier la même trajectoire ou des trajectoires différentes pour les unes ou les autres des indicateurs. Des analyses supplémentaires nous ont permis de découvrir des explications fortement dépendent des contextes locaux pour la situation meilleure ou pire de ces cas particulières.

1. INTRODUCTION

The COVID-19 pandemic and the measures that governments implemented in order to prevent the spread of the virus (lockdowns, quarantined areas, temporary border closings, travel restrictions, testing etc.) impacted the tourism activities, as well as their volumes and patterns, all over the world. International travel dropped by 72% in 2020 compared to 2019, while the recovery of 2021 was modest, the numbers of international tourist arrivals in 2021 still being lower than those of 2019 by 71% (WTO, 2022). The impact varied across counties and global regions, depending on the share of the tourism sector in the states' economy (WTO, 2021), and on other aspects such as a country's overall health system performance, the severity of the shock and the uncertainty concerning the evolution of the pandemic (Aronica *et al.*, 2022). However, even in the first stages of the COVID-19 pandemic, this crisis was also seen as a context for building better future tourism and increasing the sector's resilience to upcoming uncertainties and crises (one of them being the looming climate change crisis). In the early stages of the pandemic, OECD (2020) had already highlighted the need for promoting digital transition in tourism and for a greener tourism alongside the preparation of plans and implementing measures for any short-term recovery. Two years into the health crisis, valuable lessons have been learned in terms of destination crisis management, tourist behaviour and tourism industry trends (Aldao *et al.*, 2022). However, Gössling and Schweiggart (2022) conclude that most evidence show that the positive changes in tourism appear to be mostly at the micro-scale, while global tourism has become more vulnerable.

As a major global tourist destination, Europe was also hit by the decreasing number of international travellers. Eurostat data (2022) shows how the widespread lockdowns set the European Union's tourism at very low levels in the spring of 2020 (almost zero inbound international arrivals in tourist accommodations), followed by a small increase during the summer, driven mostly by domestic tourism (however, in July and August 2020 domestic arrivals were 9% lower than in the same period of the previous year, while international arrivals dropped by 65%). The tourism activity increased in the summer of 2021 (55% more international arrivals and 15% more domestic arrivals in July–August

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2021 than in 2020), but the total number of arrivals was still lower than in 2019 (there were 27% more nights spent at tourist accommodation in 2021, but still 37% less than in 2019).

Romania was not an exception to these evolutions (Găitan, 2020), registering a 52% reduction in tourist arrivals in 2020 compared to the year 2019 (Bănică *et al*., 2021), and lower levels than the pre-pandemic values of 2021.

The first measures the Romanian government took to prevent the spread of the SARS-CoV-2 virus started with the announcement of a state of emergency period and a national-wide lockdown between mid-March and mid-May 2020, when travel was severely restricted and restaurants, bars, hotels, spas, and other leisure facilities were closed. After that, the state of emergency continued with the state of alert that was prolonged on a monthly basis until March 2022. During this period, the mobility limitations were eased and then eliminated, but the activities in the HoReCa industry were still restricted, e.g., tourism and wellness facilities opened at limited capacity, physical distancing rules and the screening of customers based on testing and vaccination status had to be applied, their level of activity was linked to the number of COVID cases at local level etc. (https://www2.deloitte.com). Moreover, since May 2021 the implementation of the EU digital COVID certificate has facilitated international travel and tourism, leading to a further strain on domestic tourism in Romania.

However, during this period, the government also took several measures to help the tourism sector mitigate the effects of the reduced activity during the pandemic, such as granting financial aid and reducing specific taxes for HoReCa businesses (in order to compensate for the loss of their revenues in 2020 compared to 2019 – www.economie.gov.ro), supporting the employees that were at risk of losing their jobs, extending the term of use for vouchers granted to state employees to be used for domestic tourism etc.. However, in spite of all that, recovery has been low, and the tourism activity has not yet reached its pre-pandemic levels (Popescu *et al*., 2022).

The North-West Region had a promising evolution and a rather obvious upward trend, in what tourism is concerned, in the years before the COVID-19 pandemic. However, with the manifestation of the first waves of the pandemic, in early 2020, several economic and social impacts of the new situation became, in turn, more and more imposing on the tourism sector; among such impacts were the decline of activities in all economic sectors (including transport, with a decisive role on tourism), the significant decrease of incomes for several social categories (Eurostat, 2020), the associated decrease in expenditures, and the overall aspects regarding the perception of travel safety. Cretu *et al.* (2021) found that, at the beginning of the pandemic, the ten most frequently used words in answering open questions related to the perception of travel for tourism were: restrictions, rules, protection, vaccine/vaccinate, hygiene, crowded, virus, distancing, risk/risky, and pandemic. They also found that the surveyed Romanian tourists showed an increased preference for open-air, natural destinations in comparison to cities, and for travelling in small groups. Similarly, Kinczel and Müller (2022) showed how the pandemic temporarily changed the travelling behaviour and tourist activity of surveyed people in two adjoined regions in Hungary and Romania (the Northern Great Plain Region and, respectively, the North-West Region) – during the 2020–2021 period the majority of the respondents mostly visited domestic destinations (in 2018–2019 only 18.5% of respondents did not go on an outbound trip, compared to 60,1% in the 2020–2021 period) and chose shorter stays (on multiple occasions) over longer stays (57,2% declared the statement was entirely or partially true in their cases). Additionally, Aivaz and Micu (2021) concluded that "2020 was the year of Romania being rediscovered by Romanians" (p. 334) showing that internal tourism grew in importance for a significant part of national citizens. But this did not compensate for the lower touristic activity in general or for the strong decline in foreign tourists (Popescu, 2021).

The impact of the pandemic on the tourism sector has been strongly felt in all the development regions of Romania and can be well observed by analysing the evolution of the *Tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation* indicator (data from the National Institute of Statistics) in the eight development regions, in the period prior to COVID-19, in 2020, and in 2021. The North-West Region has been among those regions most impacted by the pandemic,

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thus making it the one to register some of the most abrupt decreases of 2020 (a more worrisome situation being recorded only in the Bucharest-Ilfov and Centre regions). However, one can note that for the year 2021, the North-West Region had a notably more sustained recovery in comparison to the other regions, the difference between the incoming tourists' values of 2021 and 2019 being of approximately 28% as opposed to the 55.2% difference registered in 2020 (for comparison, in the West Region there was a decrease of 55.2% in 2020, at the same time, the decrease of 2021, although lower than the one of the previous year, was still rather high, i.e., 36.71%, while the most significant declines were recorded in the Bucharest–Ilfov Region, reaching 72.4% in 2020 and 54.94% in 2021).

The present paper aims at analysing more in depth the situation in the North-West Development Region and providing an insight as to the impact of the COVID-19 pandemic on tourism in the main destinations within this area. To this end, we have analysed the main statistic indicators regarding tourism in the main cities and in the tourist resorts of national and local importance in the region. For it is there that 75% of the region's tourist accommodation capacity is located, and where 85% of the tourist arrivals in 2019 were registered.

We have analysed each of the main destinations in the Nord-West Region in order to avoid the implicit generalization of a regional level analysis, and to highlight the local evolutions and the various resulted trajectories based on local contexts and factors.

2. STUDY AREA

The North-West Development Region comprises the counties Bihor, Bistrița-Năsăud, Cluj, Maramureș, Satu Mare and Sălaj, while covering an area of 34,160 km^2 (https://www.nord-vest.ro/regiunea/) and a population of 2,826,756 inhabitants (the legally resident population in 2021, according to data provided by the National Institute of Statistics). The urban-rural share of the resident population is fairly balanced, with a slightly higher percentage of the population living in the urban areas (53.78%) in comparison to the rural areas of the region (46.21%). The main cities of the region, encompassing the highest numbers of inhabitants are Cluj-Napoca (328,103), Oradea (220,131), Baia Mare (143,425), Satu Mare (117,526), Bistrița (94,740) and Zalău (68,738), which are also the main development poles of the region.

From a touristic point of view, the regional potential is constituted by important natural and anthropic tourist resources. The main natural parks (Rodnei and Apuseni) and natural reserves of the region, and together with the ecotourist destinations of Mara-Cosău and Pădurea Craiului are all areas of great potential for the development of ecotourism and geotourism. The high mountain peaks and glacial landscape of Rodnei Mountains, the Karst landscape of Apuseni Mountains, including some of the best-known caves in Romania (Cetățile Ponorului, Vântului, Valea Firei Cave etc.) and some of the most representative gorges (Galbenei, Turzii, Someșului Cald etc.), and other important geomorphosites are valuable resources for the development of outdoor tourism and speleotourism. The mineral and thermal waters of the region have been important assets for the development of the main tourist resorts of the area (Felix, 1 Mai, Ocna Șugatag, Tășnad etc.) while being able to sustain the development of a competitive spa and wellness type of tourism. The potential for cultural and religious tourism is significant both in the main cities of the region (Oradea Fortress, the Cluj-Napoca historic centre and museums etc.), as well as in the rural areas containing many heritage sites such as the wooden churches of Maramureș (eight of them being UNESCO sites) and historic landmarks such as castles, manors, or archaeological sites. Other novel types of tourism have been developed around particular or unique resources, like the Turda salt mine or the Merry Cemetery of Săpânța, or even specific events, such as music or film festivals organized in the main cities of the region. The tourist potential of the region has been extensively analysed in several studies, among which Cocean and Pop (2020) or Ilieș *et al*. (2014).

The region has two main cities that can be considered actual tourist poles for the analysed territory: Cluj-Napoca and Oradea, with the city of Baia Mare trying to rise up to the level of the first

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two. There are also seven tourist resorts of national importance in the region: the six mentioned in the document *Annex No. 5 of 20.08.2021 to HG 852/2008* – Băile Felix, Zona turistică Centrul istoric Coridorul Crişului Repede–Oradea, Sângeorz Băi, Borșa, Ocna Șugatag and Tășnad, and the most recently declared one, Vișeu de Sus (http://turism.gov.ro/web/). The regional tourist network is rounded off by 34 tourist resorts of local importance, including the very new resorts of Marghita and Vadu Crișului from Bihor County, and Săpânța from Maramureș County, that received this status in 2022 (Fig. 1).

In recent decades, the tourism infrastructures in the region have developed, their numbers have substantially increased, their types have become more diverse, and they have been offering more qualitative services. In fact, the numbers of *establishments of tourists' reception functioning as tourists' accommodation (*data provided by the National Institute of Statistics*)* have continually grown in past years, from 292 units in 2000, to 480 units in 2005, 658 units in 2010, 771 units in 2015 and 1,124 units in 2019. The counties with the highest existing tourist accommodation capacity are Bihor and Cluj (13,552 and 11,911 places in 2019, respectively) followed by Maramureș (7,213 places). The other three counties have visibly lower capacities: 3,449 places in Bistrița-Năsăud, 2,232 places in Satu Mare and 1,797 places in Sălaj, for the same reference year. As expected, the main cities of the region (Cluj-Napoca, Oradea, Baia Mare and Bistrița) and Sânmartin Commune (which includes Felix and 1 Mai spa resorts) have the highest number of accommodation options. More than half of the existing accommodation capacity of the region is located in hotels (20,469 places, that is, 50.97%) while more than 34% are located in agro-touristic and touristic boarding houses; the rest can be found in hostels, motels, touristic villas, camping sites etc. (each of the other types encompassing under 4% of the accommodation capacity).

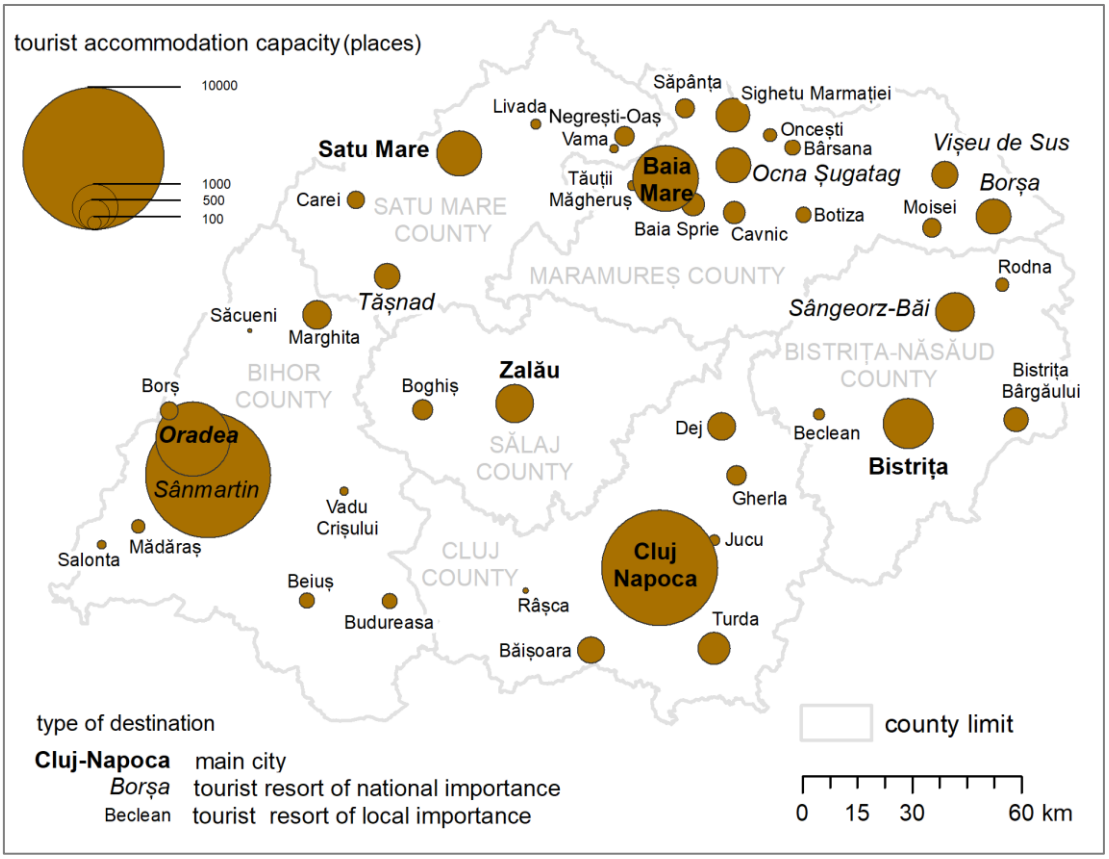

Fig. 1 – The main destinations in the Nord-West Region and their accommodation capacity in 2019 (Data source: National Institute of Statistics).

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The tourism demand has also proportionally increased, *the tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation* (data provided by the National Institute of Statistics) clearly demonstrating this growth. The total number of tourists' arrival has grown from 702,838 persons in 2010, to 1,140,667 in 2015, and 1,766,289 in 2019. Moreover, the numbers of foreign tourists have also notably increased, from 124,683 persons in 2010 to 208,767 in 2015 and 271,491 in 2019.

3. DATA AND METHODOLOGICAL ASPECTS

We have analysed data made available by the National Institute of Statistics regarding the tourism sector in the North-West Development Region. These data were retrieved for the following indicators:

- *The tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation, by main tourist destinations, type of establishments and category of comfort* – the number of persons spending at least one night in a touristic accommodation outside their area of residence;
- *The overnight stays in the establishments of tourists' reception functioning as tourists' accommodation* – the number of nights that are spent in accommodation units;
- *The duration of stay* – resulting from the ratio between the overnight stays and the arrivals;
- *The establishments of tourists' reception functioning as tourists' accommodation* – accommodation units with more than five places;
- *The tourists' accommodation capacity in use* – the functioning capacity, considering the periods in which the units are open;
- *Index of net using the working tourist accommodation capacity* – resulted from the ratio between the overnight stays and the functioning accommodation capacity.

Data was retrieved for the analysed types of administrative units: the region, the six counties, the main cities, and those administrative units that included tourist resorts. This fact constitutes one limitation of the study, because when we analysed the resorts in the region we had to work with data regarding the city or commune in which the resort is located. This had an impact on some cases in particular, the most notable one being the case of Sânmartin commune, which includes both Băile Felix and 1 Mai resorts. We could not get distinct data for the two resorts, so we have used the available data for Sânmartin commune.

4. RESULTS AND DISCUSSIONS

We can note a rather homogenous trend for all the analysed indicators: a strong decrease registered in 2020, concurrent with the first waves of the pandemic, the lockdown, and the subsequent attenuation measures, as well as a mostly mild recovery in 2021. Although we use the term *recovery* throughout the paper, we ought to mention that in most cases, there still was a decrease in comparison to 2019, albeit at a slower rate (more so than the decrease of 2020). However, in some very particular cases, which we have indicated where needed, the 2021 numbers (and sometimes, even the 2020 numbers) were close to those of 2019, or even surpassed them.

4.1. The tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation

The impact of the pandemic is incontestable for all the counties in the North-West Region, all of the units registering an evident decrease between 2019 and 2020 in terms of *Tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation*, with rates oscillating

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between 43% and 61%. The steepest descending curves can be observed for Cluj and Bihor, the counties with the highest touristic circulation.

The situation is somewhat different in terms of Romanian tourist arrivals, with the sharpest declines registered in Sălaj (a decrease by 59.7%) and Cluj (a decrease by 55.9%), the only counties in the region that registered a downturn in excess of 50%. In terms of foreign tourists, all the counties have registered pronounced cutbacks in arrival figures, of over 70%.

The relative recovery of 2021 can be noted in all the counties of the North-West Region. However, the six counties experienced this recovery at different rates. Thus, for Cluj County, for instance, this recovery has been much slower than for the others. This could be due to the fact that the county had also lost the highest numbers of tourists. We must also mention that this recovery follows a different pace for foreign, as opposed to Romanian tourists, with a more sustained recovery in the case of the latter, due to the fact that in the first months of the pandemic and the period that followed, tourists were generally hesitant to engage in international travel (as Kinczel and Muller, 2022, showed for Hungarian tourists).

The main trends identified at county level are valid for the major cities of the six counties, as well. Cluj-Napoca has recorded the most significant impact (Fig. 2A), the number of tourist arrivals in tourist establishments decreasing by 63.8% in 2020 (the year with the strictest restrictions imposed in order to mitigate the pandemic, and when two major festivals that usually attracted around 500,000 participants were postponed for 2021) in relation to the previous year, and by approximately 43% in 2021 in relation to the same year of reference. The recovery of 2021 is therefore rather slow, the total number of tourist arrivals remaining much lower than its previous, 2019 level.

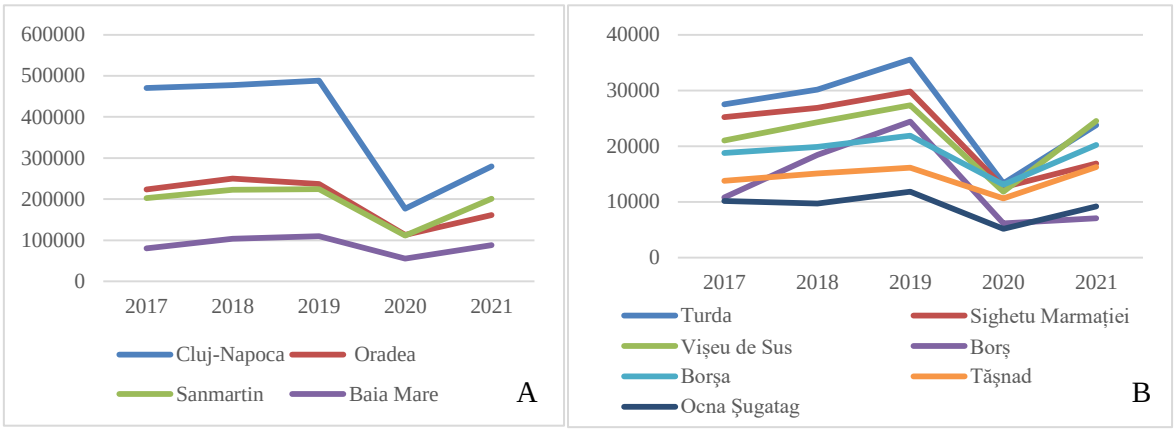

Fig. 2 – Tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation in the main destinations of the North-West Region (A) and in other resorts that registered more than 10,000 arrivals in 2019 (B). Data source: National Institute of Statistics.

In the cities with a more limited touristic circulation, this recovery is more articulated in terms of percentages. In Satu Mare, for instance, the decrease registered in 2021 in relation to 2019 did not exceed 11.1%. However, one must take into account the fact that in cases like this one, there are virtually fewer tourists registered as a reference point, so it is easier to return to the reference value (considering that we are talking about cities with a medium-high tourism potential). Still, the hypothesis of having a smaller but more loyal demand cannot be ruled out.

The tourist resorts of national importance from the North-West Region have also registered decreases of 40% to 60% in terms of tourist arrivals in accommodation units. However, an interesting case is that of Sângeorz-Băi, the resort with the most prominent decrease in incoming tourists in the region, of 69.9%. The resort's decline has been ongoing since the '90s, a quantitative decline,

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expressed by the decrease in accommodation capacity, as well as a qualitative decline that left incoming tourists feeling disappointed (Cocean, 2016). The main reasons quoted by the author were the two main hotels focusing on the same types of tourists as they did in previous decades, and the insufficient local means necessary for the upgrade of the resort. Another observation refers to the ever-decaying infrastructure and services of Sângeorz-Băi in comparison to other resorts; in Erdeli *et al*.'s 2011 study, we may find a comparative analysis of the different leisure infrastructures from the main spa resorts of the country, Sângeorz-Băi among them, and we can observe the rather modest diversity of such facilities in the resort in question. And its situation has worsened in recent years.

Still, when compared to the other resorts of national importance from the region, the first striking observation is that *the existing capacity of tourists' accommodation establishments* in Sângeorz-Băi is higher than that of other resorts in the same category (in spite of its highly seasonal character – National Authority for Tourism). We must mention at this point that we are not, however, trying to establish a comparison between Sângeorz-Băi, or any other resort in the region, and Felix resort, because of the great differences in size and complexity of the tourist phenomenon, and the fact that we only have the data regarding Sânmartin commune, which also includes 1 Mai resort.

In establishing a comparison between Sângeorz-Băi and Ocna Șugatag, Borșa or Tășnad, we note that the latter resorts, despite their lower accommodation capacity, were still registering many more incoming tourists than Sângeorz-Băi. In 2019, Tășnad, for example, did not even possess half of the available beds that Sângeorz-Băi had (339 places in Tășnad vs. 758 places in Sângeorz-Băi) but was registering over 4 times more incoming tourists that year. In 2020, when the existing capacity of Tășnad increased, the resort welcomed ten times more tourists than Sângeorz-Băi. In the same year, Borșa welcomed 12 times more tourists, and Ocna Șugatag almost 5 times more tourists than Sângeorz-Băi, in spite of their lower existing capacities. In 2021, we could see some changes in terms of existing capacity, with the existing capacity of Borșa and Ocna Șugatag surpassing that of Sângeorz-Băi. Needless to say, these resorts continued to register higher numbers of incoming tourists (8 times more in Borșa and 4 times more in Ocna Șugatag) than Sângeorz-Băi.

One might assume that Sângeorz-Băi registers a longer overall stay and has a slightly different touristic profile than the other resorts, hence a lower value of incoming tourists' indicator. Indeed, in 2019 the duration of stay in Sângeorz-Băi had the highest value registered among the resorts of the North-West Region (of approximately 9.5 days). However, the 2020 drop in the numbers of tourists was also proportionally represented by the dramatic decrease in the stay duration in this resort, to under 2 days.

Moreover, when referring to the *tourist accommodation capacity in use*, among the four compared resorts, Sângeorz-Băi had, yet again, the lowest degree of used capacity, 84,000 places-days in 2019, while in Tășnad there were 119,000 places-days, in Ocna Șugatag – 180,000 places-days, and in Borșa – 265,000 places-days.

In trying to explain the differences noted between the four resorts, we also assumed that the distribution of beds on different categories of accommodation units might be a determining factor, including the hypothesis that due to the new pandemic context and for their own safety, tourists preferred smaller accommodation units, with fewer beds. However, our assumption was not fully validated, since we could later note that both in the case of Sângeorz-Băi, as well as the Tășnad resort, the available beds are located in large accommodation units (hotels, motels, school and pre-school camps): 91% of available beds in Sângeorz-Băi and 82% in Tășnad. On the other hand, most beds in Borșa and Ocna Șugatag are located in smaller accommodation units (boarding houses, chalets, villas): 54% and 79%, respectively.

However, Borșa and Tășnad were the least impacted among the resorts of national importance in the region, with a decrease in tourist arrivals of 34% and 40.2%, respectively for the year 2020 in comparison to 2019 (Fig. 2B). Furthermore, Tășnad resort has been on a rising trend in these past years, with an increase in tourist arrivals in 2021 when compared to 2019 (which was already registering higher values than the previous years, 2018 and 2017).

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One observation to be made is that it appears that the pandemic has amplified pre-existing trends, making the situation worse for resorts that already found themselves in a difficult situation, such as Sângeorz-Băi, while highlighting the higher resilience of the more dynamic resorts that were registering rising evolutions before the pandemic started.

Among the 26 resorts of local importance we analysed (due to incomplete data concerning all the resorts in the region), the vast majority registered a significant decline in the numbers of tourist arrivals. 10 resorts have registered decreases of 17% to 48% and 14 resorts have registered decreases by over 50% in terms of tourist arrivals in 2020 in comparison to 2019. Among these latter, five resorts registered decreases by 72% to 80% (Borș in Bihor County, Jucu and Ocna Dej in Cluj County, and Bârsana and Cavnic in Maramureș County).

However, there are two resorts of local importance that have registered an increased number of tourist arrivals: Salonta (Bihor) and Colibița (in Bistrița Bârgăului commune, part of Bistrița-Năsăud County). While the increase in the number of tourist arrivals in Salonta was rather low, 3.7%, and registered a generally downward trend (in 2019 the number of arrivals was already lower than in 2018), Colibița has seen a gradual, continuous increase in past years, with the surprising evolution of 2020, when 10% more tourists arrived in Bistrița Bârgăului commune, as opposed to 2019. One explanation may also be that, in the COVID and post-COVID context, tourists may have chosen accommodation units with a smaller number of rooms (that would better comply with the safety and social distancing norms) located in remote places.

The 2021 recovery is generally present in the regional resorts of local importance, with only six resorts continuing to register declines of over 50%, again, in comparison to 2019 (Borș and Beiuș in Bihor County, Băile Băița (Gherla), Jucu and Ocna Dej in Cluj County and Cavnic in Maramureș County). One may easily note the presence on the list, yet again, of Borș and Ocna Dej, while the situation is most worrisome in the case of Jucu and Băile Băița, in which the number of incoming tourists in 2021 was even lower than in 2020, despite the relative relaxation of travel restrictions.

On the other hand, six resorts had higher numbers of incoming tourists in 2021 than in 2019: Salonta and Colibița had increases of over 100% (+169% and +102%, respectively), Vama (an increase of 27%), Rodna, Boghiș and Carei (with more moderate increases – under 10%).

As to the three new resorts of local importance, we note that Marghita and Săpânța registered similar percentual decreases in 2020, of 59%–63%, whereas Vadu Crișului registered values comparable to those of the previous year. In 2021, however, Vadu Crișului stands out with a substantial increase in the number of incoming tourists, an increase of 81.2% in relation to 2019, while Săpânța registered a number of tourists similar to that of 2019, and Marghita actually welcomed fewer tourists (by 30.4%).

4.2. The overnight stay and duration of overall stay

The analysis of the *overnight stay* in the North-West Region outlines some interesting observations. Circling back to the case of Sângeorz-Băi, where the value of the overnight stay dropped in 2020 to only 5% of the previous year's value. This is quite a unique case, since all the other resorts stayed above the 15% threshold of the previously recorded value, while most resorts ranged between 30% and 50%. Only six resorts maintained an overnight stay value above those figures: Tășnad (61.12%), Borșa (61.45%), Carei (64.66%), Mădăraș (68.77%), Băile Figa-Beclean (81.66%) and Colibița (110.75%), the one exception among the resorts in the region where there were even more overnight stays recorded in 2020 rather than in 2019. A similar variation in the pandemic's impact on tourism was described by Bănică *et al.* (2021) in a study done at the national level, including all tourist destinations. Aside from the widespread decline, they also found an upward trend in terms of the number of overnight stays in 14% of the Romanian destinations.

Concerning the *duration of the overall stay*, the regional and county fluctuations are not entirely telling, not even for the 2019-2020 period. We may notice a general decline in the number of overall

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stays, although this trend is not shared by all the analysed counties. In fact, Maramureș and Sălaj counties are the exception, registering slight increases in 2020, in comparison to 2019. However, almost all counties registered even lower values in the number of overall stays in 2021, with the exception of Bistrița-Năsăud (Table 1).

Table 1

The duration of the overall stay in the six counties of the North-West Region

County	2018	2019	2020	2021
Bihor	2.77	2.86	2.76	2.73
Bistrița-Năsăud	1.68	1.86	1.80	1.88
Cluj	1.86	1.87	1.78	1.77
Maramureș	1.83	1.88	***1.89***	1.81
Satu Mare	1.30	1.30	1.28	1.27
Sălaj	2.23	2.20	***2.21***	2.08

There are, however, some situations worth mentioning. The first would be the case of Sângeorz-Băi, where a record decline in the overall duration of stay stands out, from 9.48 days in 2019 to 1.66 days in 2020; later, in 2021, the numbers increase back up to 9.35, a surprisingly fast recovery. Secondly, there are some cases where the duration of stay actually increased in 2020 in comparison to 2019: Oradea, Borș, Colibița, Sighetu Marmației, Vișeu de Sus and Carei.

At the other end of the spectrum, there are some other resorts where the steep decline of 2020 was followed by a continuous decrease in 2021: Sânmartin (Băile Felix and 1 Mai), Mădăraș, Rodna, Turda (Băile Turda), Cavnic and Ocna Șugatag.

4.3. The tourists' accommodation capacity in use

Although the numbers of *establishments of tourists' reception functioning as tourists' accommodation* in the analysed region have continued to grow in the recent years, from 1,124 in 2019 to 1,225 in 2020 and 1,405 in 2021, and the *existing capacity* has also grown from 40,154 beds in 2019 to 42,451 beds in 2020 and 44,007 beds in 2021, *the tourists' accommodation capacity in use* in the region has followed the same decreasing trend of the previously analysed indicators: from 11,766,476 beds-days in 2019 to 8,350,780 beds-days in 2020 and 11,135,200 in 2021.

For the detailed analysis of the regional *tourists' accommodation capacity in use*, we have only analysed the major cities of the region, the resorts of national importance and some of the resorts of local importance; we have excluded those local resorts that have not reached over 1000 tourist arrivals in the past three years (in total, Romanian tourists and foreigners) or do not have an *existing accommodation capacity* of over 100 beds. By applying this criterion, we have excluded the following resorts: Beiuș, Fântânele Beliș (Râșca commune), Jucu, Livada, Salonta, Săcueni, Ștei, Tăuții Măgheruș and Vama.

The general trend of the tourism sector can also be observed in the case of this indicator, the majority of analysed resorts registering decreases of up to 40% in 2020, in relation to 2019. There were only four resorts that registered steeper drops: Sângeorz-Băi (–77%), Băișoara (–59%), Cavnic and Băile Ocna Dej (approx. –55%).

Conversely, the least steep decrease was registered in Colibița, Oncești, Oradea and Băile Figa-Beclean. The latter is a most surprising example, given the fact that the *tourist arrivals in the establishments of tourists' reception* indicator has been on a decreasing trend, as well as the overall duration of stay, which has recorded a severe drop in recent years, from 5 days in 2017 to 1.8 days in 2021.

Vadu Crișului is also a very interesting example, since its functioning accommodation capacity grew considerably in the analysed timeframe, from 6,656 beds-days in 2019 to 8,916 beds-days in 2020 and 14,119 beds-days in 2021 (more than double, in two years' time and in spite of the overall

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complicated context). Vadu Crișului has a tourist offer mostly based on its natural potential for outdoor activities, such as rafting, hiking, climbing (including via ferrata trails), or for ecotourism (given also its location at the perimeter of the Pădurea Craiului ecotourist destination). All this could have made up its comparative advantage in the pandemic context. Besides, the numerous caves in the commune (the best-known being Vadu Crișului) and its historic heritage were additional factors that supported the naming of Vadu Crișului a resort of local importance in 2022 (sgg.gov.ro).

In 2021, most resorts registered a somewhat contracted decrease (yet again, in comparison to 2019) than the one from 2020. There is an exception, however, in the form of Botiza Resort in Maramureș, where the decline seems to still be ongoing. Moreover, there are some cases where the accommodation capacity in use in 2021 was higher than in 2019, Moisei, Vișeu de Sus, Oncești, Rodna and Colibița resorts being stand-out cases. While Moisei and Vișeu de Sus resorts registered an increase of over 40% in reference to 2019, Colibița registered the highest increase, of 58%, also in reference to 2019.

An interesting observation refers to the types of units that are prevalent in these locations: in the case of Moisei and Oncești, the total accommodation capacity in use is located in agro-tourist boarding houses, and in Rodna – in agro-tourist boarding houses, as well as tourist chalets. Moreover, an interesting trend could be observed in Vișeu de Sus: while the capacity in use was on a downward trend in local hotels, it rose in tourist and agro-tourist boarding houses (a rather notable increase from 7,000 to 57,000 beds-days).

Colibița is a somewhat particular case, where sustained development has been an ongoing process since 2017, a growing trend that was maintained during the pandemic period for all kinds of establishments (agro-tourist boarding houses, House Let-type units and hotels).

However, one may note that in those resorts with a much stronger decline, most available beds are located in larger units, mainly hotels. In the town of Dej (including the Ocna Dej resort), 85% of the available beds are located in hotels, in Băișoara – 63%, and in Cavnic – 60%.

Thus, we definitely cannot rule out the idea that those resorts with a more complex accommodation offer, that included several types of establishments, and those resorts with a strong share of establishments represented by agro-tourism boarding houses have had a comparative advantage in dealing with the pandemic impact, in this region at least.

In order to validate this idea, we have directed our attention towards the working accommodation capacity for each type of accommodation unit. However, the situations of different types of establishments in the region cannot lead to any decisive conclusion, that would be valid on a regional level. For example, in what hotels are concerned, in five of the six counties, the working capacity was lower in 2021 than in 2019, but for Sălaj County it was the highest recorded in the past five years. Likewise, in the case of tourist chalets, the general decreasing trend of the functioning accommodation capacity is valid for almost all the counties, with the exception, however, of Cluj County, where the values were 4 times higher than in 2019. Still, for agro-tourist boarding houses, the increase of the capacity of tourists' accommodation in use in 2021 in relation to 2020 is obvious for all six counties. For Bihor, Bistrița-Năsăud, Cluj and Maramureș the increase was notable (as much as +22% in Maramureș), above the levels of 2019, while for Sălaj and Satu Mare, the figures came close to the values of 2019. This represents the most homogeneous and positive situation among the types of accommodation units in the region. A somewhat similar situation can be observed for tourist boarding houses, even though one may note that the 2021 recovery is slower than for agro-tourist units (the values were only getting close to the 2019 ones, in all the counties) and for tourist villas, five counties registering higher values in 2021 than in 2019, and Maramureș coming very close to that value.

Consequently, from this point of view, boarding houses and villas were the accommodation establishments that maintained their offer to the pre-pandemic standards or even managed to surpass them.

Moreover, regarding *tourist arrivals in the establishments of tourists' reception functioning as tourists' accommodation*, according to the main type of establishments, one may observe a discrete growth tendency for agro-tourist boarding houses and a slight decrease in the case of hotels and hostels (Fig. 3 A, B).

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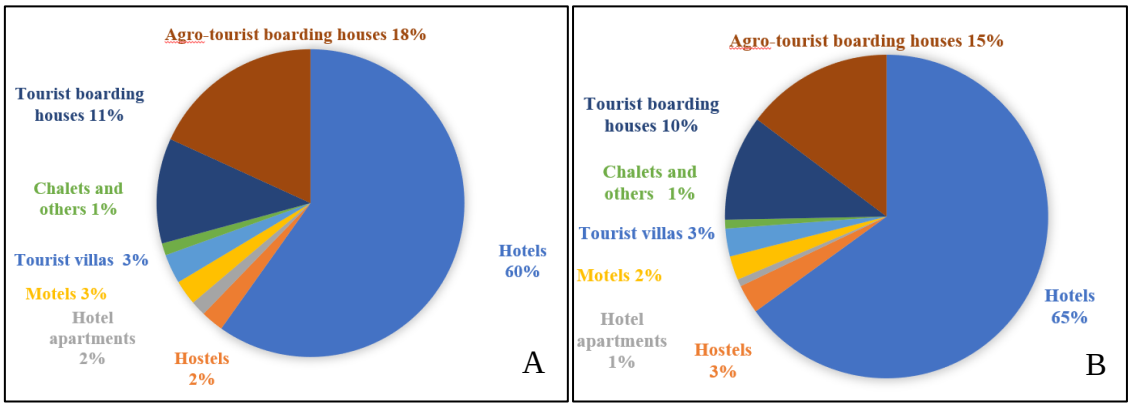

Fig. 3 – Tourist arrivals in different accommodation establishments in the North-West Region, in 2019 (A) and 2020 (B). Data source: National Institute of Statistics.

The *use index of the working touristic accommodation capacity* clearly reveals the difficult periods associated to the pandemic; on a regional level, in April-June 2020, the values were between 6 and 9.5%, in a time frame when regional values reached between 23 and 37% the previous year (Fig. 4).

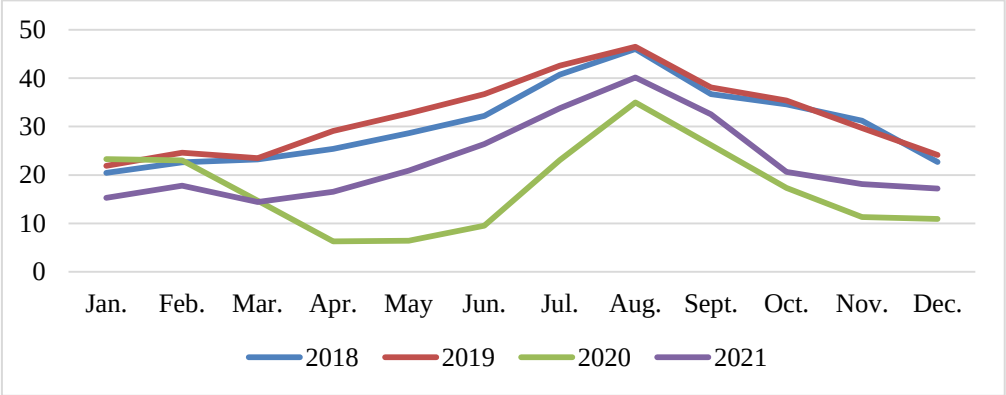

Fig. 4 – The use indices of the working tourist accommodation for the North-West Region between 2018 and 2021 (data source: National Institute of Statistics).

The situation was diverse among the analysed counties: the minimum value was recorded in Sălaj, in May 2020 – 1.5%, followed by Cluj with 3.9% in April 2020 (a dramatic decrease, in comparison to the 34% recorded the previous year) and 5.5% in May 2020, and Maramureș with 5.7% in May 2020. These lowest values overlap the lockdown period. However, in the other counties the decline was not as steep as in these cases. For example, Bistrița-Năsăud registered 14% in May 2020, in comparison to 24% in May 2019, and Satu Mare registered 10% in comparison to 18% the previous year. However, the impact of the pandemic and its successive waves was still being felt in the summer of 2020, when the indices of the tourist accommodation capacity in use were still very much below the values of previous years.

As to the *seasonality* of the tourist phenomenon in the region, one may note that in 2020 there was a higher seasonality, but that year was also marked by the lockdown and other restrictions that were mostly imposed in the colder months, and not in the summer, which is peak season in the North-West Region. In 2021 the seasonality very much follows the trends of previous, pre-pandemic years, especially in Bihor, Maramureș, Satu Mare and Sălaj. However, for Cluj and Bistrița-Năsăud we may note that seasonality remained rather pronounced in 2021 in comparison to pre-pandemic years (Fig. 5 A, B).

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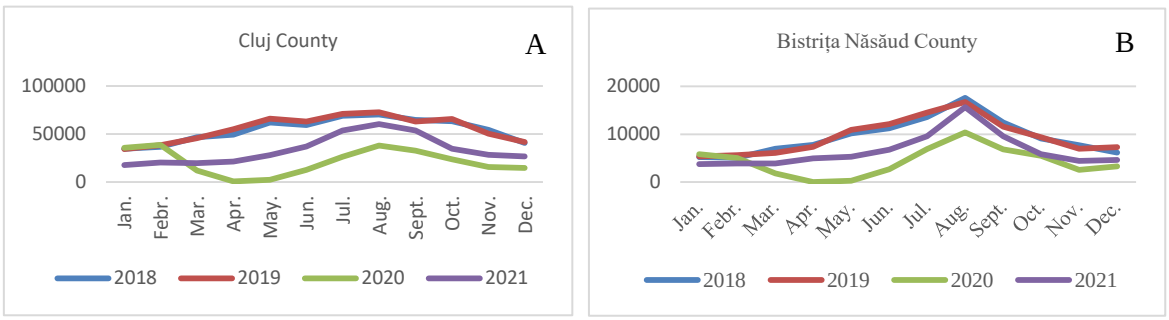

Fig. 5 – Cases of pronounced seasonality as a result of the pandemic
(A. Cluj County, B. Bistrița-Năsăud County).

While in Cluj County we were able to see a rather compact season between May–October, in the pre-pandemic years, the season was shortened to July–September in 2021. In Bistrița-Năsăud the months leading to the peak season in August registered much lower increases, and September and October much steeper decreases, thus accentuating the seasonality in the county.

5. CONCLUSIONS

We may note that the impact of the COVID-19 pandemic on the tourist activities is well represented in the statistical data. We were able to identify some regionally valid trends. However, there are so many exceptions, meaning that the extraction of general conclusions regarding the resilience of different tourist destinations or tourist units cannot be accurately outlined. However, in some cases, our findings are similar to parts of those of Bănică *et al.* (2021). They expanded on the idea that the profile of a resilient tourist destination was a small destination, with smaller accommodation units, low seasonality and located far from densely populated urban centres. This profile applies to several of the investigated destinations in the North-West Region, such as Tășnad, Colibița, Vadu Crișului etc.

Nonetheless, we also signal the presence of very mixed results, impacts and reactions. We noted many cases where similar destinations, resorts with a very similar status and tourist profile, were impacted in very different ways by the pandemic and the alterations in the tourist demand (the most striking differences appear between Sângeorz-Băi and Tășnad resorts with a similar balneological profile – while the first one experienced a dramatic loss in the number of tourists and accommodation capacity, the second managed to maintain its appeal). Consequently, we underline the need for further and more detailed studies regarding some resorts in the region, especially Sângeorz-Băi, as a most worrisome example, as well as Colibița resort, a possible new example of successful tourism development in the region.

Additionally, it appears that the context resulting from mitigating the pandemic highlighted the already present trends in the overall evolution of the older tourist resorts – it accentuated the decline of the ones already on a downward trend (like Sângeorz-Băi), while being an opportunity for newer and more dynamic ones (Tășnad, Colibița, Vadu Crișului, etc.)

Moreover, future plans for tourism development in the North-West Region must take into account the impact that the pandemic has had on the different destinations in the area. By showing the different scales of the impact felt by the analysed cities and resorts, our study can serve as a basis for the identification of the most resilient and dynamic destinations, and more importantly, of the vulnerable touristic areas that need interventions and guidance for increasing their resilience.

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Received August 5, 2022

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THE IMPACT OF THE COVID-19 PANDEMIC ON TOURISM IN THE CITY OF SARAJEVO (BOSNIA AND HERZEGOVINA)

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Key-words: tourism, pandemic, coronavirus, city of Sarajevo, tourist traffic.

Abstract. This paper examines the impact of the coronavirus pandemic on tourism in the city of Sarajevo and presents all relevant facts related to the subject. The analysis was conducted for the purpose of assessing the pandemic impact on Sarajevo as a tourist destination. The study was conducted in a timely and correct manner, and is described in all its stages, from the state of the tourist offer prior to the coronavirus pandemic to the impact itself and the consequences of the coronavirus. Based on the conducted research, it was concluded that tourism is among the most vulnerable sectors and that the impact of the pandemic on the tourist offer of Sarajevo was intensely felt, not only in economic terms, but also on the psychological state and behaviour of people working in the tourism sector. The main objective of this paper was to prove that the coronavirus pandemic has affected negatively the tourist traffic of Sarajevo.

1. INTRODUCTION

COVID-19 is a viral respiratory disease caused by the new coronavirus SARS-CoV-2.[1] The identity of the first person infected with the virus has not been officially confirmed, but it is suspected that the virus was present among the population of the Chinese city of Wuhan in November 2019. The first case in Bosnia and Herzegovina was reported on March 5, 2020.[2] The COVID-19 pandemic still takes a toll on all aspects of human life and on all sectors of the global economy without exception. Tourism has been among the hardest hit of all the economic sectors affected by the pandemic (International Labour Organization, 2022). Perhaps among its most notable effects is the impact on the tourism sector, such as travel bans and lockdowns in order to implement social exclusion measures in all efforts to prevent the further rapid spread of disease, and increase the efficiency of national health systems. By 2022, multiple highly effective vaccines had become available and had been used in countries around the world, as SARS-CoV-2 has undoubtedly become the most thoroughly studied virus in history. However, with progress, unforeseen problems have also arisen - disinformation, the anti-vaxxer movement, the refusal to wear protective masks, and the politically motivated interference disguised as knowledge (Alexandridi *et al.*, 2022). According to the United Nations World Tourism Organization (UNWTO), the global pandemic, the first of its kind in a new era of interconnectedness, has jeopardised 100 million jobs worldwide. Tourism-dependent countries are likely to feel the

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[1] https://www.cdc.gov/coronavirus/2019-ncov/your-health/about-covid-19/basics-covid-19.html?fbclid=IwAR17Jw-A87Zisdm5326W3Lxd_3QFRAruOz2P_9XlF_gdSdwIuecCzk_R1JU

[2] https://ba.n1info.com/english/news/a414110-bosnia-confirms-its-first-case-of-coronavirus/

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negative effects of the crisis much longer than other economies. The pandemic has disproportionately affected direct contact services that are crucial to the tourism sector; these services will continue to be affected for a long term (Beshudi, 2020).

The main question for this paper is what impact has the coronavirus pandemic had on the tourism sector of the City of Sarajevo? Sarajevo is the main urban, demographic and economic-geographical centre of Bosnia and Herzegovina. Administratively and territorially, it consists of four municipalities: Stari Grad, Centar, Novi Grad and Novo Sarajevo.

It lies in the central part of the Sarajevo valley, which is a naturally isolated geomorphological unit in the southeast of the Sarajevo-Zenica valley. The city of Sarajevo is located in the central part of the northern temperate zone and covers an area of 141 km².[3] The importance of tourism in Sarajevo is manifested through various types of factors such as economic, socio-cultural and environmental. The diversity of attractions, be they environmental resources, cultural or historical monuments, contribute the most value to tourism in Sarajevo.

Visiting these sites brings in significant capital to the budget of Sarajevo, thus enhancing the role of Sarajevo as a tourist destination (Brkić, Klopić, Goga, 2014). COVID-19 has had a limited effect on tourism in Bosnia and Herzegovina, due to its relatively limited economic relevance as compared to some other Western Balkan economies (European Commission, 2020a). "…the drop in economic activity was mainly the result of a lower output in the trading an" (European Commission, 2020b).

In December 2020, the Government of the Federation of Bosnia and Herzegovina assigned 30,000,000 KM (15,268,538.56 €) to the support of the tourism and catering sector in the Federation of Bosnia and Herzegovina.[4] In September 2021, following the proposal of the Federal Ministry of the Environment and Tourism, they adopted a 500,000 KM (254,475.64 €) expenditure program based on a criteria for the allocation of funds around the idea of "Current transfers to other levels of government and funds – Transfer for the development of tourism in the Federation of Bosnia and Herzegovina".[5] In May 2020, the Tourism Association of the Canton of Sarajevo published a public call for the distribution of funds to hoteliers/accommodation facilities (800,000 KM/407,161.03 €), incoming travel agencies (150,000 KM/76,342.69 €) and tour guides (50,000 KM/25,447.56 €).[6] In December 2021, the Tourism Association of the Canton of Sarajevo announced two public calls for co-financing and supporting projects that would contribute to the development and improvement of the tourist offer and potential, provide additional content for the local community, tourists and citizens, and ensure the extension of the winter tourism season in the Canton of Sarajevo. The total value of funds reached 807,000 KM (410,723.69).[7]

Many countries and their economic development are marked by different crises, but for the first time in decades, they are facing a common foe – the "COVID-19 crisis". This kind of crisis has taken the entire world by storm, precisely because it has been a global event. So far, pandemics have usually been regional and of a predicted duration.[8] Therefore, many questions remain unanswered about the survival of certain sectors and activities, their recovery, sustainable development, the transformation of the economy and society, and all possible development scenarios.

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[7] https://www.klix.ba/biznis/privreda/turisticka-zajednica-ks-osigurala-vise-od-800-000-km-za-oporavak-turizma/211203129

[8] https://www.publichealth.columbia.edu/public-health-now/news/epidemic-endemic-pandemic-what-are-differences

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2. METHODOLOGY

For the purposes of this analysis, exploratory research was conducted aimed at business entities – tourism workers in the city of Sarajevo in the August 27 – September 10, 2021 period. The research was conducted through an online survey and a structured questionnaire created by the authors. The advantages of the online survey are reflected in a wide geographical coverage (whereas in this research the survey is limited only to city limits), fast accessibility, the possibility of respondents remaining anonymous, the speed of implementation, the unification of procedures for collecting, entering, controlling, correcting data, and cost rationalisation. The purpose of the survey is to better understand how the COVID-19 pandemic has affected tourism and the touristic offer of Sarajevo. In addition to the survey, annual and monthly tourist arrivals and overnight stays were analysed in the pre- and post-COVID-19 era. A comparison of arrivals and overnight stays of foreign tourists was also done for the Canton of Sarajevo (the city of Sarajevo and the municipalities of Hadžići, Ilidža, Ilijaš, Trnovo and Vogošća). Employers and executives in the tourism industry in Sarajevo were interviewed. Twenty tourism facilities were chosen as respondents, as they can provide the clearest picture of tourist traffic in Sarajevo.

3. RESULTS AND DISCUSSION

Tourist traffic, as an unavoidable component of tourism development, provides data on the movement of tourists within an area (Omerović, 2014). For the processing of tourist traffic and the impact of the COVID-19 pandemic on tourism in Sarajevo, pre-crisis statistical data was first considered. In 2019, Sarajevo was visited by 395,845 tourists, while the total number of overnight stays was 770,472. This year was a record year in terms of tourist traffic, when the largest number of tourist arrivals and overnight stays was confirmed. Sarajevo experienced the greatest increase during the monitored period from 2016 to 2019. Compared to 2018, the arrival of tourists increased by 16.8%, and the number of overnight stays by 22.8% (*Zavod za planiranje razvoja Kantona Sarajevo*, 2019). In terms of monthly analysis, April was the least populated month, when only 168 tourist arrivals in City of Sarajevo were recorded (Table 1). This situation is related to the beginning of the pandemic when the first cases of COVID-19 appeared in Bosnia and Herzegovina.

Table 1

Monthly total tourist traffic in the city of Sarajevo for 2019 and 2020

Month	2019		2020	
	Arrivals	Overnight stays	Arrivals	Overnight stays
January	12,493	26,308	16,670	33,325
February	16,028	30,808	21,239	29,607
March	21,572	43,067	6,546	12,931
April	34,628	68,651	168	1,390
May	34,674	62,062	410	1,012
June	40,312	75,863	2,595	4,104
July	53,697	109,014	3,046	4,920
August	55,645	118,318	6,101	10,422
September	40,971	75,974	6,550	12,099
October	39,932	75,619	7,067	12,996
November	22,581	41,201	4,667	9,138
December	23,312	43,587	6,756	13,616
Total:	395,845	770,472	81,815	145,560

(*Source*: *Zavod za informatiku i statistiku Kantona Sarajevo*, 2021a).

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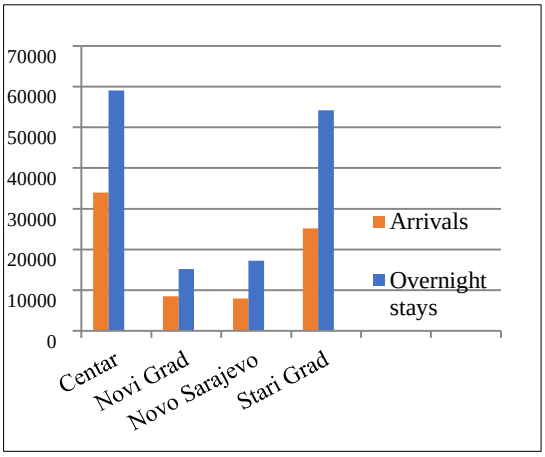

As for tourist traffic, according to the municipalities of the city of Sarajevo, most arrivals and overnight stays were recorded in the Municipality of Centar. The total number of tourist arrivals was 33,944, while the number of overnight stays was 59,046. The municipality of Stari Grad was the second-most visited, with 25,157 total tourist arrivals and 54,154 overnight stays. Novi Grad was visited by 8,484 tourists who spent 15,154 nights there. Novo Sarajevo was visited by 7,968 who spent there 17,233 nights (Fig. 1).

Fig. 1 – Tourist traffic by municipality in 2020 (*Source: Zavod za informatiku i statistiku Kantona Sarajevo*, 2021a).

Due to epidemiological decisions, a higher number of tourist arrivals from neighbouring countries was recorded in contrast to distant countries. For comparison purposes, we took the arrivals and overnight stays of tourists from China, which in 2019 (before the pandemic) ranked first, with the highest number of arrivals (63,627), while in 2020 they ranked fifth, with 3,318 arrivals (Table 2). There was also an extreme decline in the total number of tourist arrivals and overnight stays compared to previous years. Foreign visitors accounted for 85,518 arrivals and 188,610 overnight stays in the total tourist traffic of the Canton of Sarajevo.

Table 2

Tourist traffic by the arrival of foreign visitors to the Canton of Sarajevo

		Overnight stays	Arrivals	Overnight stays
	2019	**2019**	**2020**	**2020**
Croatia	59,161	104,312	18,590	37,669
Serbia	25,507	45,845	12,503	23,863
U.A.E.	26,158	83,960	8,750	24,643
Turkey	47,080	80,440	4,984	9,802
China	63,627	78,732	3,318	5,603
Montenegro	9,226	16,073	3,289	6,123
USA	23,484	50,388	3,163	6,217
Slovenia	26,767	44,850	3,057	6,009
Germany	23,566	48,644	2,758	5,732
Austria	12,037	22,356	1,612	3,342
Kuwait	7,216	26,904	1,450	6,719
Saudi Arabia	47,538	124,662	1,306	4,444
Italia	16,679	39,132	1,229	2,564
Great Britain	9,550	22,438	1,198	3,005
Netherlands	7,004	14,812	1,193	2,608
Sweden	7,415	16,717	947	2,130
France	6,222	12,822	829	1,976
Oman	7,441	19,644	584	1,543
Hungary	8,592	14,388	429	835
Poland	7,886	12,551	375	998
Spain	7,736	12,692	368	888
Japan	3,950	5,532	351	605
South Korea	3,198	3,703	64	116
Rest of the world	120,798	259,707	13,171	31,176
TOTAL	577,838	1,161,304	85,518	188,610

(*Source: Zavod za informatiku i statistiku Kantona Sarajevo*, 2021b).

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With the spread of the coronavirus on a global level, the Crisis Staff of the Federal Ministry of Health issued orders and decisions in accordance with the epidemiological situation we were faced with. In order to prevent the spread of the coronavirus, they implemented important decisions for the benefit of human health in the Federation of Bosnia and Herzegovina, which negatively affected the tourist traffic of the state and the city of Sarajevo for the past two years, as shown in Figure 2.

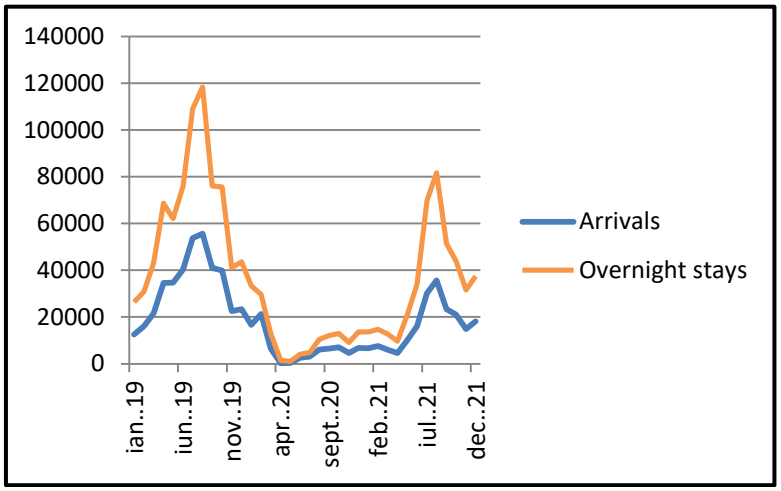

Fig. 2 – Tourist arrivals and overnight stays in the City of Sarajevo for 2019, 2020 and 2021 (*Source*: authors adapted according to the *Zavod za informatiku i statistiku Kantona Sarajevo*).

Some of these decisions were: a mandatory 14-day quarantine for all people wishing to enter the country, suspended public transport, meaning no trams, trolleybuses and buses, no outdoor movement for people under 18 and over 65 years of age.

With the introduction of the "curfew", the movement of all people was prohibited and foreign citizens were forbidden from entering the country through the Sarajevo International Airport (Federalno ministarstvo zdravstva, 2021).

During July, citizens of EU member states and Schengen member states, as well as foreigners who had a multiple Schengen visa or a visa of the European Union, or a corresponding residence permit in the European Union and the Schengen area, were allowed to enter and stay in Bosnia and Herzegovina. The only condition was to have a negative coronavirus test, no older than 48 hours at the moment of entry into Bosnia and Herzegovina. Only citizens of the Republic of Croatia, the Republic of Serbia and Montenegro were able to enter Bosnia and Herzegovina just with their passports, without any additional testing, since May 2020.[9]

These decisions affected tourism workers, restaurants, cafes, nightclubs and discos the most, and their working hours were shortened because of the limited number of guests, and some were completely shut down during this problematic period. Wearing masks has been mandatory since the start of the pandemic, both in closed public spaces, and in the open if maintaining a distance of 2 meters between people is not possible (Krizni stožer/štab Federalnog ministarstva zdravstva, 2021). In 2021, the distribution of the COVID-19 vaccine began to combat the spread of the virus and reduce the mortality rate in infected people. The mass vaccination of the population in Bosnia and Herzegovina began on April 21, 2021[10]. The VTO rule (vaccinated, tested, overcome) was introduced, with the help of institutions in various sectors, mostly in the tourism industry. For the tourism industry, vaccines have been one of the most important aids for easier and safer travel.

[9] https://granpol.gov.ba/Content/Read/74?title=Covid-19
[10] https://vlada.ks.gov.ba/aktuelnosti/novosti/od-srijede-u-zetri-pocinje-vakcinacija-stanovnika

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The recovery of tourism in Sarajevo occurred in early 2021. There is a noticeable increase in the number of tourists in the first three months with a small decline in April. The largest number of visitors since the beginning of the pandemic was recorded during the summer months. In August, Sarajevo was visited by 81,695 tourists. The biggest contribution to that was made by the Sarajevo Film Festival, when the accommodation capacities were overbooked. The impact of the COVID-19 pandemic resulted in a large increase in the index in August 2021, compared to August 2020, when most accommodation facilities were closed.

The survey was created on the Google Docs platform and distributed via email and social media profiles. It was sent to tour operators in Sarajevo via e-mail, together with a request for further distribution and sharing of the survey. The answers from the survey were used exclusively for scientific purposes. Anonymity was guaranteed, unless the respondent chose otherwise. Respondents were asked to answer the questions by circling the answer provided, writing in the blank field or answering the question asked. The survey took approximately five minutes to complete.

The key questions for this research were: "Did you register a reduced number of reservations and cancelled reservations?", "Did you suffer financial damage to your business since the emergence of COVID-19?","Did the authorities help you in any way during the COVID-19 pandemic?", "How much has the number of employees in your company decreased?" and "During the COVID-19 period, did you lower the prices of services compared to the previous season, and by how much (%)". With the help of the answers to these questions, one may have concluded how much the pandemic negatively impacted tourism and the work of tourism entities in Sarajevo. The tourism entities surveyed through this questionnaire were hotels, hostels, travel agencies, boarding houses and Air B&B rooms/apartments/studio apartments. Of the twenty respondents, eight were travel agencies, six were hotels, three were hostels and four were landlords of rooms/apartments/studio apartments. No answers were recorded for boarding houses (Fig. 3).

Tourism is an industry that reacts quickly to crisis events, and the pandemic triggered a decrease in tourism activities after 10 years of consistent growth. Some tourism entities managed to overcome the obstacles posed by the pandemic, such as staff reductions, price decreases and the like, while others failed to cope with the pressure and had to close their branches. In the next segment of this paper, a survey is presented that contains the survey questions, as well as the answers provided by the people involved in the tourism industry.

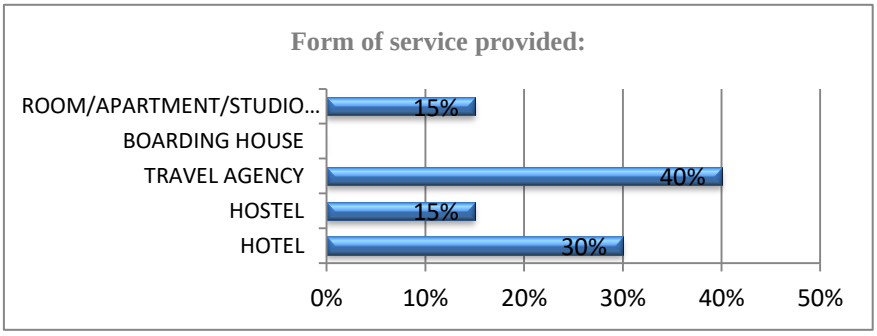

Fig. 3 – Tourism entities surveyed through the questionnaire (%).

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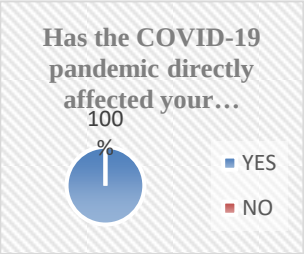
1. Has the COVID-19 pandemic directly affected your business?



The same answer to this question was received from all respondents, namely “YES”. The COVID-19 pandemic has affected all spheres of our lives, not just the tourism industry.

Fig. 4 – The direct impact of the coronavirus pandemic on the business of tourism entities (%).

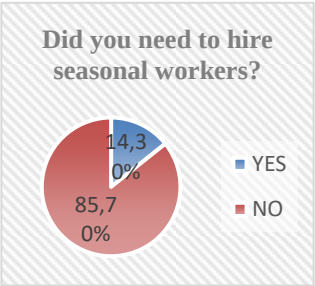
2. How has this affected your finances?

Regarding the COVID-19 pandemic, some of the answers were:

- ✓ “Tourism has completely stopped with the beginning of coronavirus”
- ✓ “The drop in revenue in 2020 was 90%”
- ✓ “The drop in traffic was 98%”
- ✓ “Loss of jobs and the closure of the agency”

As expected, respondents did not have positive answers to this question. With the restrictions came the significant devaluation of interest, inquiries, and the volume of work itself. Most respondents faced crippling financial losses, causing them to lay off their workers and eventually even close down their businesses.

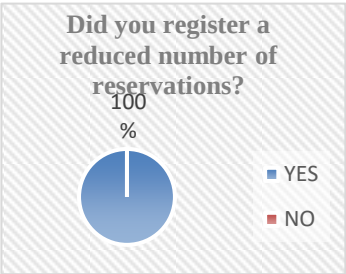
3. Did you need to hire seasonal workers?



The vast majority of surveyed tourism workers did not need to hire additional labour, which is a negative consequence of the pandemic – 85.7% of answers were NO, while 14.3% of answers were YES.

Fig. 5 – Employment of seasonal workers (%).

4. Did you register a reduced number of reservations?



The expected answers were obtained. The same answer to this question was received from all respondents, namely "YES". In 2021, the number of tourist reservations dropped two-fold.

Fig. 6 – A reduced number of reservations (%).

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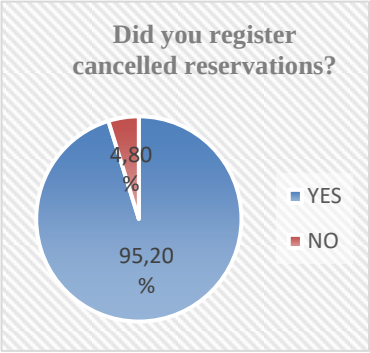
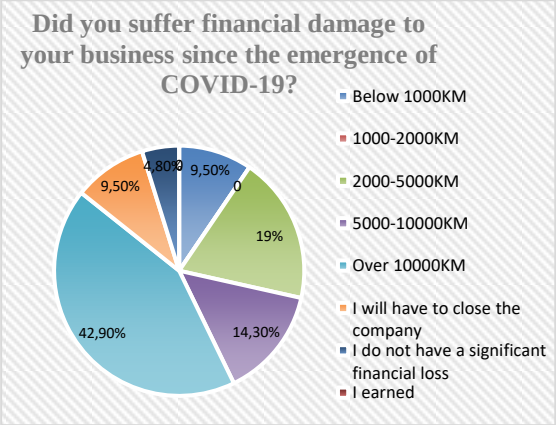
5. Did you register cancelled reservations?



The cancellation of reservations was registered by 95.2% of respondents, while 4.8% of respondents did not register cancelled reservations. This year's holidays were booked "last minute", because people were probably deciding whether or not to go on vacation at the last minute and depending on the epidemiological situation.

Fig. 7 – Cancelled reservations (%).

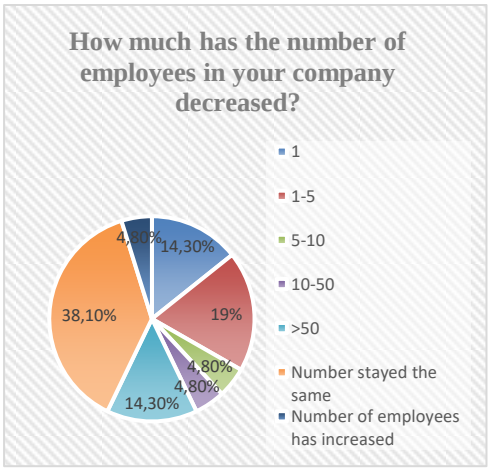
6. Did you suffer financial damage to your business since the emergence of COVID-19?



Different answers were obtained. The degree of financial loss ranged from under 1,000 KM (508.95€) to over 10,000 KM (5,089.51€). The highest percentage of responses was "more than 10,000 KM" (42.9%). None of the respondents answered that they earned more. However, 4.8% of them reported that they didn't have a significant financial loss.

Fig. 8 – Financial damage to business (%).

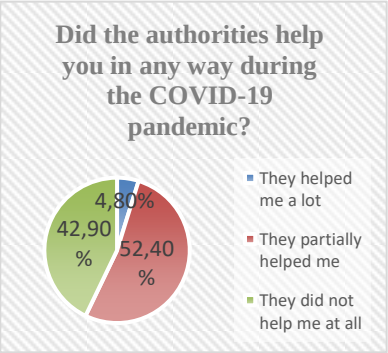
7. How much has the number of employees in your company decreased?



According to 38.10% of the answers, the number of workers remained the same. On the other hand, 4.8% of respondents said that their number of employees had increased. Due to the diversity of tourism entities and their volume of work, varying responses were registered.

Fig. 9 – The decrease in employed workers (%).

8. Did the authorities help you in any way during the COVID-19 pandemic?



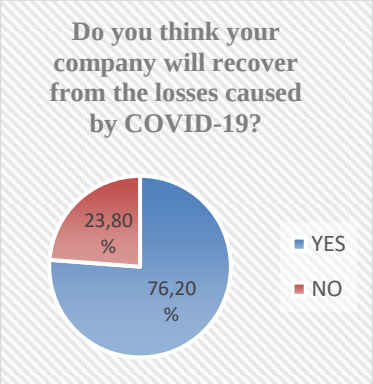
The graph shows that 52.4% of respondents answered that the authorities partially helped them, 42.9% of respondents answered that the authorities did not help them at all, while 4.8% of respondents answered that the authorities helped them significantly.

Fig. 10 – Government assistance for tourism entities during the pandemic period (%).

9. During the COVID-19 period, did you lower the prices of services compared to the previous season, and by how much (%)?

The query shows that 28.6% of respondents lowered their prices by 30 to 40%, 23.8% of respondents lowered said prices by 10 to 20%, 23.8% of respondents did not lower their prices, 19% of respondents lowered their prices by 20 to 30%, 4.8% of respondents dropped their prices by 40 to 50%. No response was recorded for "10%", or for "We increased them". Given these lower prices, some tourism workers have not been able to sell travel arrangements or rent out accommodation units.

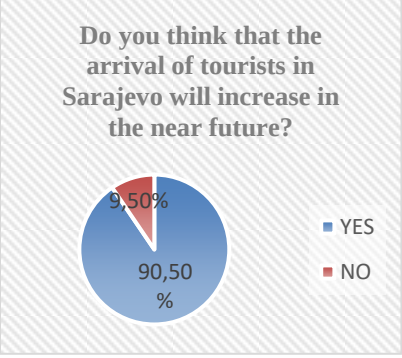
10. Do you think your company will recover from the losses caused by COVID-19?



The vast majority, 76.2% of respondents, believe that their company will recover from the losses caused by COVID-19, while 23.8% disagree.

Fig. 11 – Recovery (or lack thereof) from the losses caused by the pandemic (%).

11. Do you think that the arrival of tourists in Sarajevo will increase in the near future?



The majority of respondents, 90.5%, believe that the situation will improve, while 9.5% of respondents disagree.

Fig. 12 – Tourist arrival in Sarajevo (%).

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Once the analysis was performed, the following conclusion may be reached: the coronavirus pandemic directly affected the business of tourism workers. This can be attested by the employment of seasonal workers where only 14.3% of respondents answered they needed to hire seasonal workers, while the other 87.5% did not. The cancellation of reservations and their decrease in numbers was registered by 95.2% of respondents. Additionally, 42.9% of respondents suffered financial damage in the amount of over 10,000 KM, while a large number of respondents said that they did not receive any help from the authorities, with some owners having to close down their company. The majority of respondents, 76.2% to be exact, lowered their prices compared to the previous season, prior to COVID-19. Although the data is not promising, 90.5% of respondents have hope for the improvement of the tourism sector. in order for it to bounce back, it is necessary to adopt sectoral development strategies and thus create the conditions for the most urgent start of economic recovery.

4. CONCLUSIONS

Based on the overall analysis, the authors conclude that the impact of the pandemic on the tourist offer of Sarajevo was very much felt, not only in economic terms, but also when it comes to the psychological state and the behaviour of people working in the tourism sector. The implications of the pandemic are not limited to only human life and health, as it also affects people's livelihoods, causing the loss of jobs, as seen throughout the research, sparking enormous damage to all the sectors of the global economy, among which tourism is the most vulnerable. The reason for this is the measures taken to suppress the spread of the virus by banning flights, closing hotels almost all over the world and restricting the travel of non-fully vaccinated persons. This sector has encountered an incomparable number of cancellations and a sharp drop in demand due to government instructions to implement social distancing and quarantine.

There are many variants of the COVID-19 virus. The Alpha, Beta and Delta variants are the most well-known. However, according to the latest information, this may not be the end. That is, in December 2021, much time was dedicated to identifying whether the Omicron strain had reached Bosnia and Herzegovina, which was subsequently confirmed. Therefore, the following question arises: is the pandemic coming to an end? Experts predict that the mass vaccination of the population will reduce mortality and the spread of the pandemic. Already in some parts of the world, as well as in Bosnia and Herzegovina, there is an improvement in the tourism sector where the number of tourists visiting the capital is increasing every day, and their participation in tourist traffic increases the budget of the Canton of Sarajevo. This research identified the impact of the coronavirus pandemic on the tourism sector taking as example the City of Sarajevo, where it was concluded that the spread of COVID-19 had substantial, possibly long-term consequences. The data in this scientific paper were obtained directly from the subjects most affected by the current global situation. Taking into account the example of positive world practice, Sarajevo should implement similar activities in order to revive cultural, entertainment and sports life, as well as tourism in general. Tourism in Bosnia and Herzegovina has the potential to alter the entire narrative when it comes to the country's economy. Sarajevo, as the capital of Bosnia and Herzegovina that has a large tourist offer and ranks high in terms of providing tourist services, can significantly contribute to strengthening the country's tourism sector.

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Received July 16, 2022

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QUALITÉ DE VIE ET DURABILITÉ DANS LES QUARTIERS RÉSIDENTIELS ALGÉRIENS ENTRE LA MÉTHODOLOGIE DE PLANIFICATION ET LA RÉALITÉ DE MISE EN ŒUVRE. LE CAS DE LA VILLE D'OUM EL-BOUAGHI, ALGÉRIE

FATIMA DAHDOUH [*], SOUMEYA HOUMER [**]

Key-words: quality of life, sustainable development, residential neighbourhoods, Oum El-Bouaghi city.

Quality of life and sustainability in Algerian residential neighbourhoods between the planning methodology and the reality of implementation. The case of the city of Oum El-Bouaghi, Algeria. Algeria is one of the important countries that has a race track in line with the trend of quality of life and sustainable development, through the enactment of many laws and legislation that direct the residential production process and the sustainability of the urban environment, and urge directing the production process towards quality after the long approach towards the quantitative path that had previously prevented access to it. This research paper intends to assess the quality of life, as well as its repercussions on the population, in the medium-sized city of Oum El-Bouaghi, an area fit for implementing national and urban policies. Here, housing is considered one of the most important elements of urban development, and the paper proposes various recommendations that would help achieve the continuity of life within residential neighbourhoods and improve the relationship of residents with said neighbourhoods, as well as the latter's sustainability, together with everything related to framing the field, where the results showed the presence of several urban problems in the constituent elements of the neighbourhoods and a lack of efficiency in the housing field. This has a negative impact on the quality of life and triggers a division in the reactions of the residential community within these neighbourhoods.

1. INTRODUCTION

L'Algérie, comme tant de pays dans le monde, s'est engagée à prendre en considération la qualité de vie dans ses programmes d'urbanisation future. En effet, la constitution de 1989, dans un souci de rétablir l'équilibre entre les villes et les centres urbains dans le pays par la répartition équitable des richesses, est venue corriger les déséquilibres du système centralisé en simplifiant les procédures par la promulgation de lois permettant de garantir la production de logements et d'entités urbaines qui assurent la qualité de vie urbaine, architecturale et sociale. L'Algérie a commencé à promulguer des lois et des législations qui orientent l'opération de la production des logements et qui illustrent l'approbation tacite de l'importance de la qualité de la vie urbaine au sein des villes Algériennes et des quartiers à partir de l'année 1990. Parmi eux: la loi 90–20 du 01-12-1990, relative à l'aménagement et l'urbanisme dont l'article 2 a pour objet d'édicter les règles générales visant a organiser la production du sol urbanisable, et pour base le respect des principes et objectifs de la politique nationale d'aménagement du territoire. Quant à la loi 01–20 du 12-12-2001, relative à l'aménagement et au développement durable du territoire à l'article 4, elle vise un développement harmonieux de l'ensemble du territoire national selon les spécificités et les atouts de chaque espace régional. L'ensemble est achevé à travers l'égalité des chances entre les régions, les territoires et zones en difficulté, pour la stabilisation de leurs populations, ainsi que le rééquilibrage de l'armature urbaine et la promotion des fonctions régionales, nationales et internationales, avec la protection des espaces,

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Rev. Roum. Géogr./Rom. Journ. Geogr., **66**, (2), p. 179–195, 2022, Bucureşti.

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des territoires et des populations contre les risques naturels, et l'utilisation rationnelle des ressources patrimoniales, naturelles et culturelles et leur préservation pour les générations futures. De même, la loi 02–08 du 08-05-2002, relative aux conditions de création des villes nouvelles et de leur aménagement à l'article 1, fixe les conditions de création des villes nouvelles et celles de leur aménagement. Et l'article 2 ajoute qu'ils constituent des centres d'équilibre social, économique et humain, grâce aux possibilités d'emploi, de logement et d'équipement.

Ensuite, la loi 03–10 du 19-07-2003, relative à la protection de l'environnement dans le cadre du développement durable dans l'article 2, améliorant les conditions de vie et en œuvrant à garantir un cadre de vie sain, ainsi que l'usage de technologies plus propres, renforcer l'information, la sensibilisation et la participation du public et des différents intervenants aux mesures de protection de l'environnement. Article 2 de la loi 07–06 du 13-05-2007, relative à la gestion, concerne la protection et le développement des espaces verts. Celui a pour but d'améliorer le cadre de vie urbain, "et d'améliorer la qualité des espaces verts urbains existants avec de promouvoir la création d'espaces verts de toute nature par rapport aux espaces bâtis de faire de l'introduction des espaces verts, dans tout projet de construction, une obligation prise en charge par les études urbanistiques et architecturales publiques et privées" (loi 07–06 du 2007). Finalement, la loi 06–06 du 20-02-2006 portant loi d'orientation de la ville, dans l'article 1 , a "pour objet de fixer les dispositions particulières dans le cadre de la politique de l'aménagement du territoire et du développement durable" et dans l'article 6 de coordonner toutes les interventions particulièrement parmi eux: "la réduction des disparités inter-quartiers et la promotion de la cohésion sociale, la résorption de l'habitat précaire ou insalubre, la maîtrise des plans de transport, de déplacement et de circulation dans et autour des villes, la garantie et la généralisation des services publics, la promotion du partenariat et de la coopération entre les villes, l'intégration des grandes villes aux réseaux régionaux et internationaux". La définition du quartier dans cette loi a été énoncée à l'article 4, elle est: "partie de la ville délimitée sur la base d'une combinaison de données relatives à l'état du tissu urbain, de sa structure, de sa composition et du nombre d'habitants y résidant", l'article 26 de la même loi ajoute un observatoire national de la ville qui est rattaché au ministère chargé de la ville réalisant des différentes tâches dans: "le suivi de la mise en œuvre de la politique de la ville, l'élaboration d'études sur le développement des villes dans le cadre de la politique nationale d'aménagement du territoire, la production et la tenue à jour d'une nomenclature des villes, la participation à la promotion de la coopération internationale dans le domaine de la ville, la proposition, au Gouvernement, d'un cadre d'actions permettant de promouvoir la participation et la consultation des citoyens, le suivi de toute mesure prise par le Gouvernement dans le cadre de la promotion de la politique nationale de la ville". Dans ce cas, la constitution, l'organisation et le fonctionnement de l'Observatoire national sont déterminés par le décret exécutif 17–94 du 26 -02-2017 complétant le décret exécutif 07–05 du 08-01-2007 portant sur la création, organisation et fonctionnement de l'Observatoire national de la ville, qui en raison de sa nouveauté, n'a pas encore commencé à s'acquitter des tâches qui lui ont été confiées.

Malgré cette batterie de lois en matière d'aménagement, d'urbanisme et de construction (Production de logements sociaux), ainsi que la tendance à faire de nombreux efforts dans le domaine de la planification et de l'urbanisation et diverses formes de programmes et projets de logement visant à améliorer les environnements urbains et la qualité de vie et à les orienter vers la durabilité, les résultats restent très en deçà des attentes des populations surtout en matière de qualité. En effet, les quartiers d'habitat ainsi créés sont pour la majorité dépourvus de viabilité bien réalisée, d'équipements d'accompagnement et de services; l'objectif de la durabilité et de la qualité de vie semble être loin d'être atteint. La législation algérienne essaye tant bien que mal à répondre aux exigences de la qualité de vie dans les quartiers sauf que le nombre de logements qu'il faut toujours construire fait que la quantité devient la priorité, reléguant ainsi la qualité a une moindre importance.

"*La qualité d'un lieu ou d'un emplacement à différents niveaux de l'échelle (zone, ville dans son ensemble, quartier, logement) est certainement un phénomène subjectif et chaque personne dans cette situation peut différer dans ses opinions sur le sujet*" (Dehimi, Hadjab, 2019). Soit, l'importance des quartiers consiste à l'optimisation de la vie des habitants; "*Le quartier est donc une unité essentielle*

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dans la structure physique de la ville car ses quartiers se complètent pour former un tissu continu et non pas des unités séparées. Par conséquent, le développement du quartier reflète le développement de la ville" (Sanaa Satie, 2019).

A partir de ce qui précède, on peut se poser la question suivante: Quelle est la qualité de la vie urbaine et son impact sur la communauté dans les quartiers résidentiels de la ville d'Oum El-Bouaghi?

L'objectif que nous visons à travers cette recherche est de comprendre ce qu'est la bonne qualité de la vie urbaine dans les quartiers et mettre sous lumière son rôle dans les études d'urbanisme, aussi que d'essayer de comprendre les sociétés urbaines en Algérie, en prenant la ville d'Oum El-Bouaghi comme cas d'étude. À cette fin, nous avons retenu des indicateurs d'innocuité de l'environnement urbain et de confidentialité sociale à partir des indicateurs de la bonne qualité de vie urbaine internationale.

2. LE CADRE CONCEPTUEL DE LA QUALITÉ DE VIE URBAINE ET LA DURABILITÉ

À la lumière des multiples tendances dans l'étude du concept de qualité de vie, l'Organisation mondiale de la santé (WHOQOL) a présenté une définition implicite de la qualité de vie en tant que perceptions des individus de leur statut dans la vie dans le contexte de la culture et des systèmes de valeurs dans lesquels ils vivent et par rapport à leurs objectifs, attentes, normes et intérêts. Par conséquent, cette définition reflète que la qualité de vie renvoie à l'évaluation subjective de la vie de l'individu (THE WHOQOL GROUP 1998). Ensuite, la qualité de vie s'est orientée "pour exprimer la qualité et l'efficacité du logement, car son amélioration est devenue l'objectif des plans de développement" (Loubna Abdulaziz Al Barsali, Noha Muhammad Effat, 2020).

Le concept de qualité de vie urbaine peut être un liant dynamique entre les dimensions fondamentales de la qualité de la vie physique, la mobilité urbaine, les politiques sociales, psychologiques, économiques et urbaines, qui sont déterminées selon les lieux et les communautés, car il est difficile de comprendre la qualité de vie urbaine d'une communauté dans un lieu particulier, en étudiant une seule dimension. (El Ariane, 2012). Si certains considéraient "la qualité de vie urbaine comme la qualité de vie, elle est globale, car elle contient les conditions de vie qui représentent une dimension objective et inclut également la satisfaction de vivre en ville, donc elle se définit comme une expression de la satisfaction de vivre dans la ville" (František, Františe, 2021).

La qualité de vie aide l'urbaniste à surveiller et prendre soin des communautés locales tout en formulant de nouveaux plans qui tiennent compte des besoins humains et en aidant aux études futures. Le développement de l'environnement doit inclure la durabilité sociale qui contribue à la réalisation et à l'évolution de la qualité de vie (Sayed, Idid, 2004).

Par conséquent, nous constatons que le concept de qualité de vie fait partie des concepts qui sont complets, bifurqués, se chevauchent, interagissent et même complètent de nombreuses sciences et disciplines différentes, étant donné qu'ils incluent les sciences de psychologie, de littérature, de l'éducation, de santé, de l'ingénierie et des sciences sociales, du milieu urbain et même rural, et d'autres sciences, qu'elles soient théoriques, techniques ou appliquées. Le rapport de la Commission mondiale pour l'environnement et le développement Brundtland des Nations Unies (WCED en 1987) ont fourni la définition la plus largement utilisée et la plus fiable du développement durable en tant que "*développement qui répond aux besoins du présent, sans compromettre la capacité des générations futures à répondre à leurs propres besoins*" (Our *Common Future*, 1987). L'Union mondiale pour la nature (Programme des Nations Unies pour l'environnement, 1991) a défini le développement durable comme "*Il maintient et améliore la qualité de la vie humaine en termes sociaux, économiques et environnementaux et soutient les ressources existantes*" (Baher, 2006). Patrizia Gazzola Elena Querci a décrit la relation entre qualité de vie et durabilité, que on pense que la qualité de vie est le résultat de l'interaction entre les composantes matérielles et sociales, cette relation étant largement liée à "*ici et maintenant*", et que la durabilité est considérée comme étant davantage influencée par les composants matériaux, sociaux et économiques et généralement liée au futur où l'on peut montrer l'interaction à l'aide des trois substrats

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selon des critères de durabilité idéaux (Patrizia, 2017). Alors que le Royaume-Uni a récemment utilisé l'expression *qualité de vie* en tant que synonyme de *durabilité* et de *développement durable*, il a pris meilleure qualité de vie comme titre de sa stratégie de développement durable et explique qu'au cœur du développement durable se trouve l'idée simple d'assurer une meilleure qualité de vie pour tous, pour les générations présentes et futures, là où la difficulté n'est pas de voir la relation entre durabilité et qualité de vie (David et Gabriel, 2005). En outre, "la durabilité est liée à la qualité de vie des gens dans le présent et dans le futur, et elle combine également la conception de l'environnement physique et les modes de vie des gens dans cet environnement et la façon d'utiliser leurs espaces urbains et la qualité de leur communication en tant que société" (Yasmine Bkir Abd el-Hamid, Amrou Bahgat *et al.*, 2021).

Ainsi, on peut considérer que "*la qualité de la vie urbaine se réfère à un urbanisme qui vise à réaliser la durabilité du développement tout en tenant compte de la qualité de vie*" (Omar Mohamed, 2015). Philip Sutton a ajouté qu'il est possible d'identifier trois niveaux de durabilité liés à la qualité de vie, représentés dans ce qui suit (Sutton, 2000):

– **Durabilité de la survie**: il est considéré comme le niveau de base de la durabilité, où les trois exigences doivent être satisfaites simultanément.
– **Maintien de la qualité de vie attendue**: dans certaines régions, cette qualité de vie dépasse de loin le niveau requis pour la survie de base. La recherche de la durabilité peut être incompatible avec la préservation de la qualité de vie attendue.
– **Améliorer la qualité de vie**: où la durabilité est un modèle de réflexion sur l'avenir et dans lequel les considérations environnementales, sociétales et économiques sont équilibrées dans la poursuite du développement et l'amélioration de la qualité de vie.

Cela signifie que le développement durable a réalisé la justice entre les besoins des générations du présent et du futur et a élevé la qualité de leur vie pour le mieux en l'améliorant à divers aspects (environnementaux, sociaux, économiques et urbains).

Ainsi que la nécessité de maintenir le niveau de cette qualité de vie pour qu'elle soit durable, à la fois pour les générations actuelles et celles du futur, étant donné que la satisfaction de leurs besoins reste le facteur commun et conventionnel entre la condition de durabilité et le bien-être de l'individu; et de ce fait, une durabilité élevée de la qualité de vie que nous la représentons à travers la Figure 1.

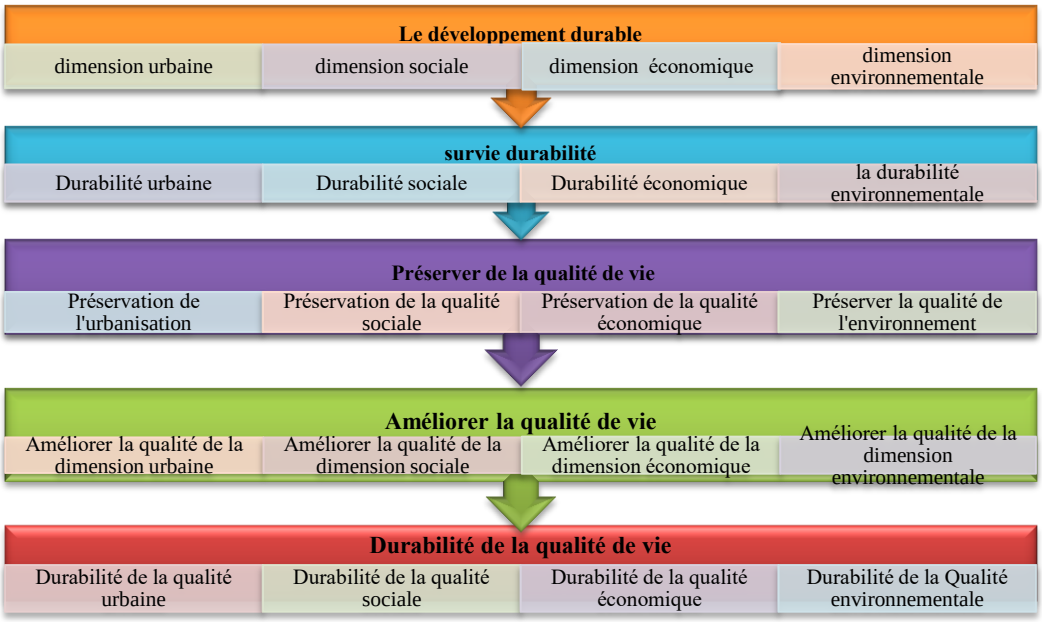

Fig. 1 – Développement durable et qualité de vie durable à travers ce qui précède (les auteures, 2020).

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3. INDICATEURS DE LA QUALITÉ DE VIE URBAINE DANS LES QUARTIERS RESIDENTIELS

A travers le tableau suivant, nous passons en revue de nombreux indicateurs au niveau des villes dans le monde parmi des études et quelques avis, différentes méthodologies et méthodes de leurs applications en fonction de la nature et des priorités de chaque société, car chaque indicateur contient de nombreux domaines d'influence (Hassan Ahmed Hassan, 2017) comme suit (Tableau 1):

Tableau 1

Indicateurs de qualité de vie au niveau des villes dans le monde

	Premièrement: les indicateurs des organisations et institutions mondiales					
Entité	Indicateurs approuvés					
UNESCO	Indicateurs normaux Les caractéristiques géographiques comprennent, Les ressources naturelles, le milieu environnant.	Indicateurs économiques incluant le marché, Activités économiques, des biens et des services.	Indicateurs sociaux Cela comprend les relations sociales, l'amour, les sentiments, la solitude, les coutumes et les traditions, les caractéristiques générales de la société.	Les indicateurs de santé et de personnalité comprennent l'état de santé général, la motivation des gens, la confiance en soi		
Le comité PPC traitant de la crise démographique Centre de Protection Environnementale Américain.	Sécurité publique - alimentation en termes de coût de la vie – logement standardisé – communications – éducation – santé publique – calme et tranquillité – circulation – air pur.					
Centre d'études politiques du Colorado	Indicateurs économiques – Indicateurs environnementaux et investissement foncier – Indicateurs de qualité de vie urbaine – Indicateurs culturels et éducatifs – Indicateurs sanitaires.					
Centre de développement communautaire de Floride	Sécurité publique, gouvernement, logement, environnement, éducation, santé, culture, littérature et divertissement, transports et économie.					
Magazine économique	Bien -être maté riel	Santé et stabilité politique	Vie de famille et égalité des sexes	Géographie et climat	Liberté politique	La sécurité d'emploi
	Deuxièmement : Indicateurs des villes mondiales					
Francfort	Qualité du travail, participation communautaire, qualité du logement, capital humain, ampleur du stress sociétal, infrastructure, vie sociale de la communauté.					
État de Boston	Ville, santé, économie, éducation, environnement, logement, santé publique, technologie, vie culturelle et arts.					
Japan	Indicateurs de santé: taux de mortalité, espérance de vie à la naissance, dépenses publiques de santé, taux de risque, maladies infectieuses. Indicateurs sociaux: performance du gouvernement, liberté de la presse, taux de criminalité et satisfaction dans la vie générale. Indicateurs économiques: coût du logement, taux d'investissement, taux de chômage, conditions économiques, marché du travail, revenu national, salaires réels. Indicateurs environnementaux: pollution de l'air, qualité de l'eau, bruit, pollution, santé publique, déchets locaux, maladies endémiques.					
Indicateurs de la qualité de vie au Royaume-Uni	La liste des indicateurs contient dix domaines principaux, sous chaque domaine un groupe d'indicateurs est le suivant: Les personnes et la population, la consistance et la cohésion communautaires, la sécurité communautaire, la culture et les loisirs, le bien-être économique, l'éducation et l'apprentissage tout au long de la vie, l'environnement, la santé et le bien-être social, le logement, les transports et la mobilité.					

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Tableau 1 (continué)

Projet d'indicateurs de la qualité de vie à Jacksonville, Floride	Économie – Santé – Sécurité communautaire – Éducation – Environnement naturel – Environnement social – Politique, mouvement et transport – Culture et divertissement Les indicateurs de société en Amérique du Nord et dans le monde ont modifié un modèle de plusieurs manières pour obtenir des indicateurs adaptés à chaque région: un indice annuel est publié qui montre la qualité de vie.
Indicateurs de qualité de vie dans les six plus grandes villes de Nouvelle-Zélande	Neuf domaines, et chaque domaine couvre un certain nombre d'indicateurs de qualité de vie, comme suit Etudes démographiques – logement – santé – éducation – économie et emploi – sûreté et sécurité – .environnement urbain – cohésion communautaire – démographie

(Hassan, 2017).

4. MÉTHODOLOGIE

La nature de l'étude, qui tourne autour de la qualité de vie et durabilité dans les quartiers résidentiels, a nécessité l'utilisation de l'approche inductive afin de revoir les études théoriques et ses connaissances et s'appuyer sur l'approche descriptive pour collecter des faits, des données et des informations sur le cadre du champ de recherche (plans, cartes, photos) et les analyser s'appuyer sur l'approche appliquée de manière convient à la communauté en effectuant plusieurs visites afin de réviser et déterminer dans quelle mesure les indicateurs sélectionnés sont compatibles avec les caractéristiques de la communauté résidentielle et leur applicabilité, fait de s'appuyer à la fois sur les approches subjectives et objectives et combinant les indicateurs d'économiques (la propriété du logement) et les indicateurs de qualité de vie urbaine (la dimension urbaine), des indicateurs de qualité de vie sociale et des indicateurs de l'environnement urbain des quartiers résidentiels, et compléter l'étude de terrain à l'aide d'un questionnaire distribué aux résidents du quartier résidentiel, sélectionnant la taille de l'échantillon de l'étude à 5% de la population au niveau des quartiers résidentiels situés dans le pôle urbain Macomades dans la ville d'Oum El-Bouaghi. L'échantillon était de 273 questionnaires adressés aux familles, sur un total de 5.464 familles, en appliquant le modèle d'échantillonnage aléatoire régulier en distribution, à partir de laquelle 239 questionnaires ont été récupérés, dont 202 ont été acceptés. Par application, les indicateurs à l'échantillon d'étude représenté par le pôle urbain Macomades sont représentés dans le tableau 2:

Tableau 2

Indicateurs utilisés pour évaluer la qualité de vie dans les quartiers résidentiels du pôle urbain, Macomades

	Indicateurs objectifs
Indicateurs urbains au sein du quartier résidentiel et du logement	– L'adéquation de la conception urbaine du quartier avec les exigences individuelles des habitants. – Éléments d'aménagement urbain au sein du quartier résidentiel, services. – L'accessibilité des différents réseaux au sein du quartier résidentiel. Durabilité des matériaux de construction et maîtrise des travaux de construction. Violations urbaines temporaires et permanentes. Taille de la pièce, ventilation, humidité et solarisation. – L'adéquation de l'aménagement intérieur du logement aux exigences de la famille.
Indicateurs environnementaux.	– Flexibilité de l'environnement résidentiel. – Gérer les différentes techniques urbaines dans le quartier, y compris la gestion des déchets solides urbains dans le quartier résidentiel. – L'image visuelle et esthétique des façades urbaines des habitations.
Indicateurs économiques	Le coût du logement et la propriété du logement.

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Tableau 1 (continué)

	Indicateurs subjectifs
Indicateurs sociaux	– Taille de la famille. – Cohésion sociale appartenant à la communauté résidentielle. – Adaptation sociale et participation communautaire. – Sûreté et sécurité à l'intérieur du quartier résidentiel et de la résidence. – Moyens de transport et connectivité du quartier avec la ville et les zones voisines. – Satisfaction des résidents à l'égard du voisinage dans le quartier et de leur vie.

(Les auteures, 2020).

5. PRÉSENTATION DE L'AIRE D'ÉTUDE

La ville d'Oum El-Bouaghi est le chef-lieu de la wilaya. Issue du découpage administratif de 1974, elle se situe au nord-est des hauts plateaux avec une altitude variant entre 700 et 1.000 m par rapport au niveau de la mer, sa superficie est de 432,31 km^2 soit 6,98% de la superficie totale de la wilaya. Le nombre d'habitants est estimé à 590.195 (monographie wilaya O.E.B 2020). La ville est structurée par deux axes importants, soit la R.N10 (reliant O.E.B. à Constantine) vers l'est et la R.N 32 (O.E.B. - Khenchela-Tebessa) au sud. La wilaya a bénéficié d'un important programme de logements sociaux dont la majorité par la ville de Oum El-Bouaghi sur le site MACOMADES.

6. DESCRIPTION DU CAS D'ÉTUDE

Le pôle urbain "Macomades" constitue un champ d'étude idéal dans la ville d'Oum El-Bouaghi, car il représente la zone d'expansion de la ville du côté Ouest et est considéré comme le plus grand projet urbain que la ville ait connu. Macomades est le résultat d'un grand programme de logements (logements sociaux; logements participatifs et promotionnels) s'étalant sur une surface de près couvertes par deux plans d'occupation de sol POS A (125 Ha) et POS B (175 Ha) (PDAU, 2017).

Le pôle Macomades, par sa situation stratégique, devient la porte d'entrée Ouest de la ville et relie les deux axes routiers important, soit la R.N 10 et la R.N 32, sa proximité de l'université Larbi ben M'hidi fait un pôle urbain dynamique au vu des services qui s'y trouvent.

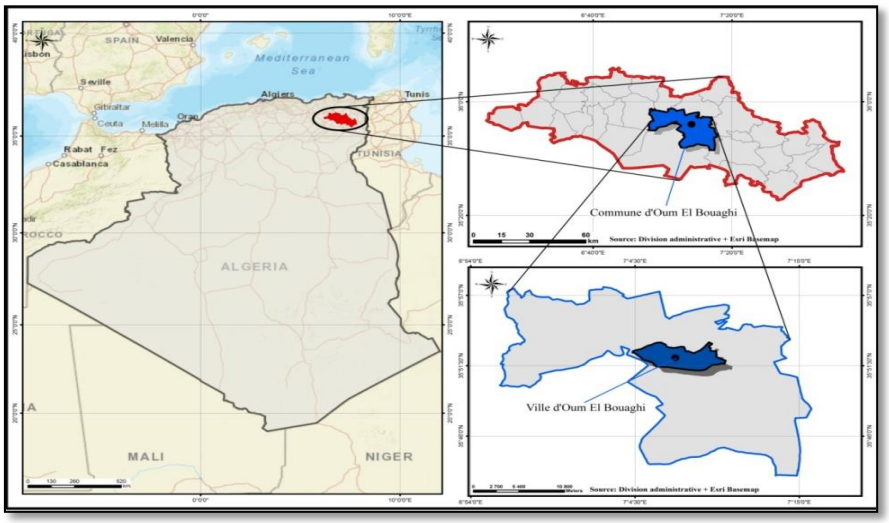

Fig. 2 – Carte montre la situation de la ville d'Oum El-Bouaghi (Dahdouh, **2020**).

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Tableau 3

La fiche urbaine du cas d'étude

Date de construction	2005–2009
Date de livraison	2010–2011
Superficie	200 hectares
Type d'hébergement	Logement collectif participatif promotionnel
Surface totale bâtie	91,46 hectares
La superficie totale non construite	108,54 hectares
L'espace destiné à la fonction résidentielle	53,97 hectares
Zone destinée aux équipements et services	33,65 hectares
Zone destinée aux espaces verts et aux espaces publics	3,84 hectares
Nombre de logements	5464 logements
Le nombre de familles du cas d'étude	2400 familles.
Le nombre de familles d'échantillons	273 familles

S'appuyant sur la Révision du PDAU de la ville d'Oum El-Bouaghi, 2017 (Dahdouh, 2020)

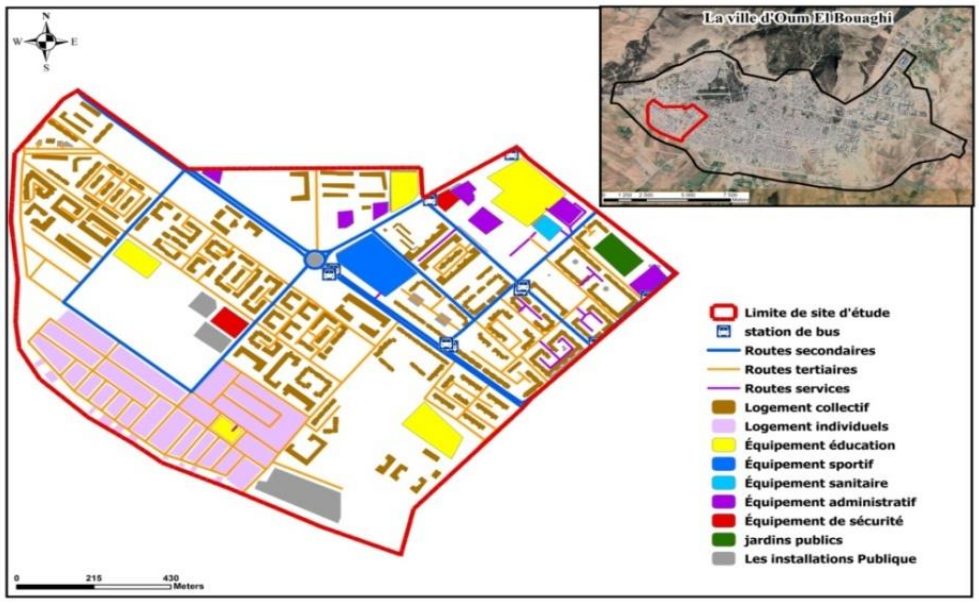

Fig. 3 – Le cas d'étude à travers la Révision du PDAU de la ville d'Oum El-Bouaghi, 2017 (Dahdouh, 2020).

7. DISCUSSION DES RESULTATS

7.1. Sur l'évaluation et la propriété du logement

À travers les données de la (Fig. 4), nous constatons que le pourcentage de propriété du logement constitue 86,13%, ce qui est le pourcentage le plus élevé, et exprime la vraie formule du logement, car il s'agit d'un logement collectif participatif aidé portant le titre de propriété de son propriétaire d'origine ou du nouveau propriétaire en cas de vente, suivi du taux d'hébergement par le loyer 13,86%, c'est à dire le pourcentage qui reflète la catégorie qui n'acquiert pas de logement, que ce soit venant de l'intérieur ou de l'extérieur de la ville.

Alors que la Figure 5 représente le pourcentage du lieu de résidence précédent pour l'échantillon de la communauté de recherche, où le pourcentage de résidence de la même ville était de 58,41%, le

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pourcentage le plus élevé qui exprime l'importance de la production de logements dans la ville d'Oum El-Bouaghi et la crise du logement dont elle a souffert et continue d'en souffrir. Suivie par la proportion de la population provenant des agglomérations urbaines voisines de 30,69% et des zones rurales de 6,4%. Quant à la proportion des arrivées d'autres villes, elle est de 4,45%. Cela met en évidence la diversité du milieu social dans le secteur résidentiel entre les zones rurales et urbaines et la nature de la cohésion sociale.

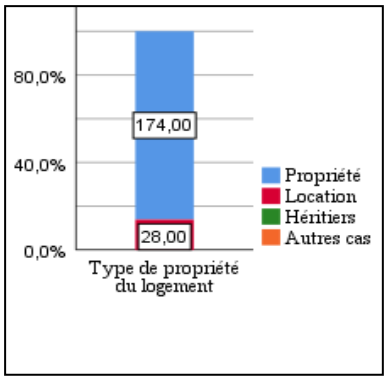

Fig. 4 – Type de propriété du logement.

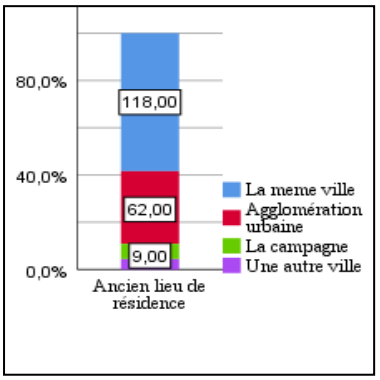

Fig. 5 – Ancien lieu de residence (Les auteures, 2020).

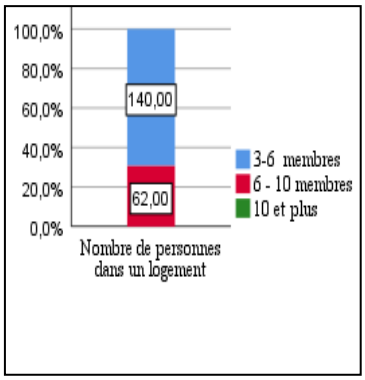

Fig. 6 – Le nombre de personnes dans un logement.

Quant à la Figure 6, nous constatons que les familles de 3-6 membres, à 69,30%, résident dans un logement collectif avec trois chambres, tandis que le nombre de familles composé de 6 à 10 personnes est estimé à 30,69%, ce qui est un pourcentage important qui exprime également le taux d'augmentation du nombre d'individus à l'intérieur de la maison. Cela entraîne un impact négatif sur la qualité de vie à l'intérieur du logement et un surpeuplement, un manque de confort et d'intimité dans les chambres et l'espace résidentiel, en plus des répercussions négatives sur l'utilisation des espaces extérieurs et des équipements divers.

7.2. Sur l'évaluation de la connectivité du quartier avec la ville

Quant à la connexion du quartier résidentiel, de l'échantillon d'étude, avec la ville et les environs par les moyens de transport, nous constatons que les taux de corrélation sont élevés, représentés par l'utilisation des transports en commun avec 58,41%, la possibilité d'atteindre les différentes zones de la ville avec 78,41%, et la disponibilité de postes d'attente au niveau des quartiers avec 92,57%, (Fig. 7).

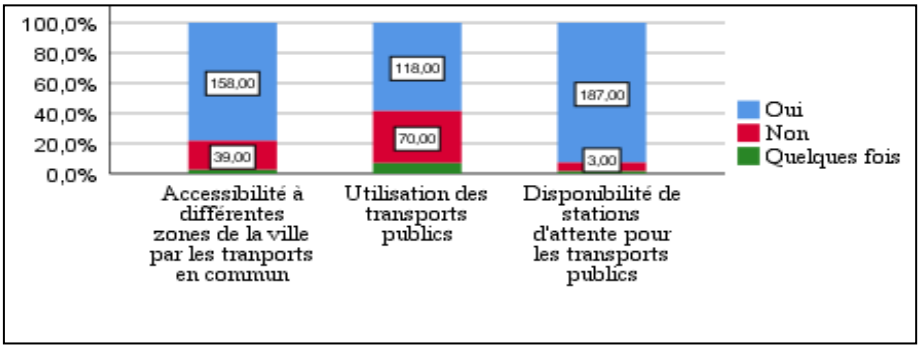

Fig. 7 – Connectivité du quartier avec les zones voisines et la ville (Les auteures, 2020).

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7.3. Sur l'évaluation des services et de la participation sociale

Les services et la participation sociale des résidents du quartier ont exprimé une baisse, car les pourcentages les plus élevés ont été enregistrés pour ceux liés aux réponses négatives, comme le montre la Figure 8, où l'on retrouve le pourcentage de refus de faire plus d'actions collectives avec les voisins pour les quartier à 70,29% et le pourcentage de demandes d'aide et de soutien des voisins en cas de besoin ou d'exposition à des blessures de 54,45% contre 85,14%, ce qui traduit le refus de participer à des activités sportives et culturelles.

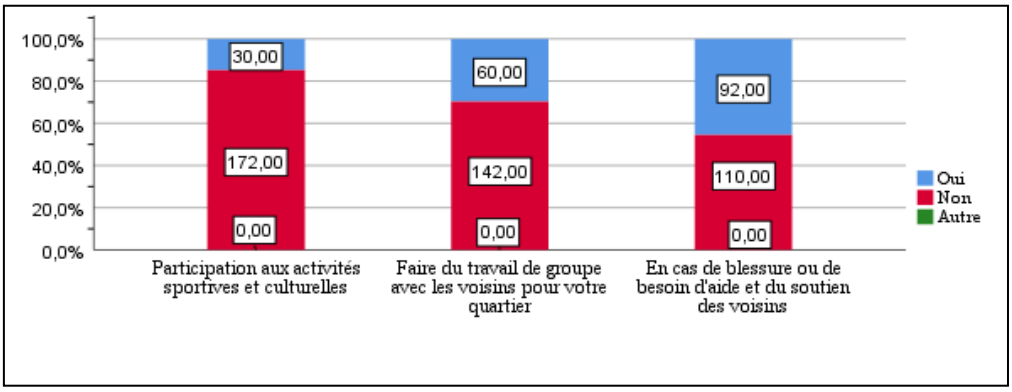

Fig. 8 – L'étendue de la participation et de l'interaction avec la communauté du quartier (Les auteures, 2020).

Figs. 9, 10 – L'espace vert à l'intérieur du quartier. (Dahdouh, 2020).

Fig. 11 – Les façades du quartier.

7.4. Sur l'évaluation de la sûreté et de la sécurité

On remarque à travers la Figure 12 que la disponibilité de la sécurité à l'intérieur du logement représente 69,30%, ce qui est considéré comme élevé par rapport au pourcentage de manque de sécurité, tandis que le pourcentage d'insécurité dans le quartier résidentiel est le plus élevé (49,00%), suivi du pourcentage de sa présence à 39,60%, malgré l'activation du rôle de la sécurité urbaine dans le quartier résidentiel, représenté par le taux prédominant estimé à 69,30%. On retrouve les réponses liées au pourcentage le plus élevé lié à la présence de violences urbaines envers l'environnement urbain et aux différents actes de sabotage (59,40%) tels que l'écriture sur les façades et l'écrasement du mobilier urbain.

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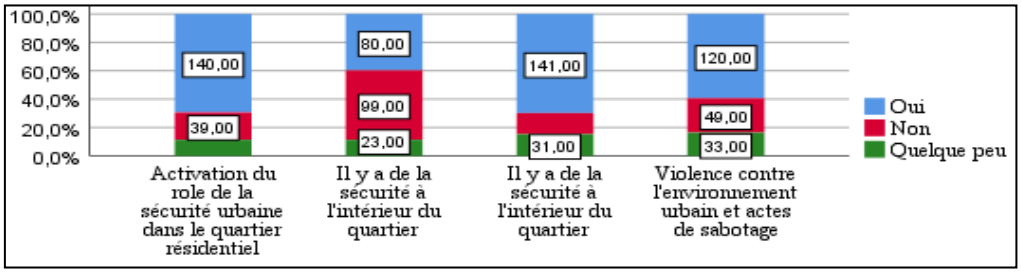

Fig. 12 – Sécurité et sûreté à l'intérieur du logement et du quartier résidentiel (Les auteures, 2020).

Figs. 13, 14, 15 – La culture de la clôture ou de la fermeture de quartiers (Dahdouh, 2020).

7.5. Sur l'évaluation de la résilience de l'environnement résidentiel

À travers la Figure 16, nous constatons que la communauté de l'échantillon de recherche a exprimé la difficulté de développer l'environnement résidentiel du quartier avec l'évolution des besoins changeants, avec un taux le plus élevé étant estimé à 59,60% en échange d'imposer l'environnement résidentiel, effectuer des violations urbaines temporaires et permanentes de 56,93% et de 57,42% respectivement, qui sont convergentes et représentent la majorité. Par conséquent, nous constatons que la communauté de recherche a exprimé sa relation avec l'environnement résidentiel dans le quartier par obligatoire de 65,34% et appropriée de 34,65% (Fig. 17).

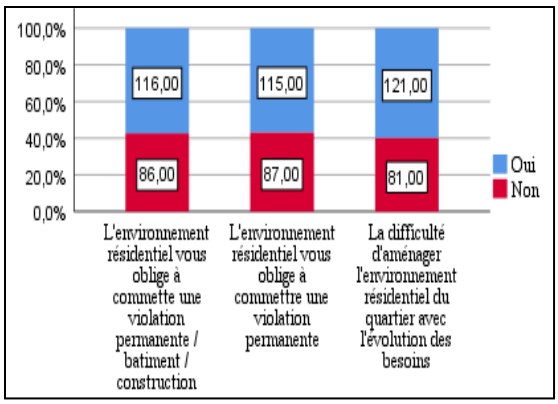

Fig. 16 – L'ampleur de la flexibilité de l'environnement résidentiel du quartier.

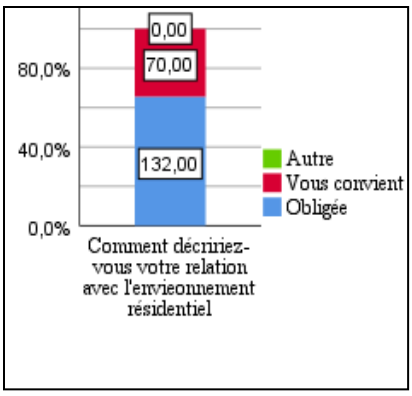

Fig. 17 – La relation d'une communauté à son environnement.

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7.6. Sur la cohésion sociale et l'appartenance à la communauté résidentielle

L'appartenance à des quartiers résidentiels est l'un des indicateurs les plus importants qui sont évalués dans la qualité de vie résidentielle, car il exprime l'étendue du lien et de la fidélité aux lieux et à la communauté de leur résidence. Nous constatons que la communauté de l'échantillon de recherche a été exprimée comme faible avec 62,37% et 70,79%, respectivement (Fig. 18).

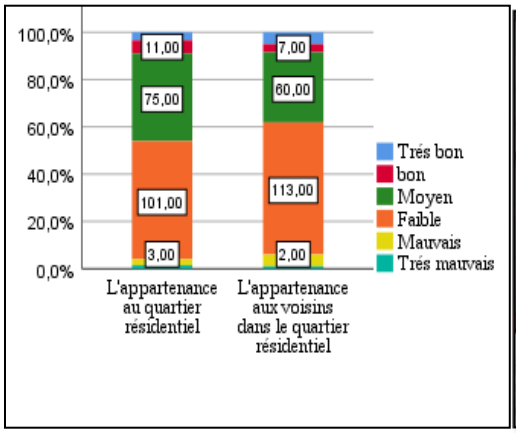

Fig. 18 – L'étendue de l'appartenance au quartier et à la communauté du quartier (Les auteures, 2020).

Figs. 19, 20 – L'état des façades du quartier (Dahdouh, 2020).

(Les auteures, 2020).

7.7. Sur l'évaluation de la satisfaction à l'égard du voisinage

On remarque à travers la Figure 21 la description qu'ont les résidents d'eux-mêmes avec insatisfaction à l'égard du quartier résidentiel en général et des voisins en particulier, respectivement de 71,78% et 59,40%. À travers les résultats de la Figure 22 on constate que le taux d'insatisfaction à l'égard de la vie est le plus élevé, estimé à 54,45%, suivi du pourcentage de groupes satisfaits à 33,16%, tandis que le pourcentage de satisfaction représente quelque peu 12%.

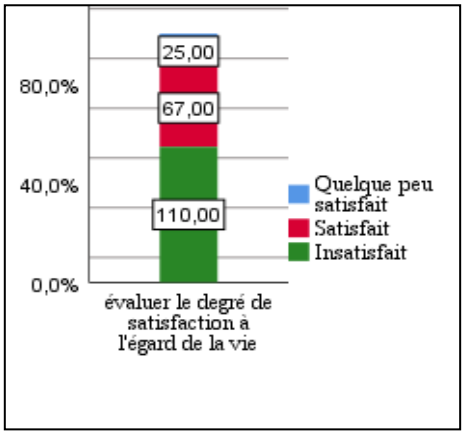

Fig. 21- Le degré de satisfaction à l'égard des voisins.

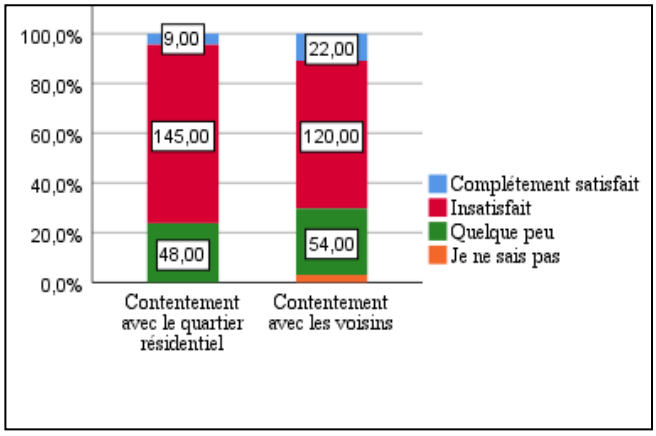

Fig. 22 – Evaluation de la satisfaction des habitants.

(Les auteures, 2020).

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Figs. 23, 24 – Espaces extérieurs dans le quartier (Dahdouh, 2020).

7.8. Sur l'évaluation de l'adéquation de l'aménagement urbain du quartier

Le pourcentage de mauvaise adéquation des lieux publics du quartier à diverses activités de la part de ses habitants est le plus élevé (Fig. 25), estimé à 97,52%. En revanche, le manque de possibilité de réaliser diverses activités dans le quartier est de 88,61%, ce qui reflète le faible niveau et l'adéquation de la conception urbaine des lieux publics du quartier (Fig. 26).

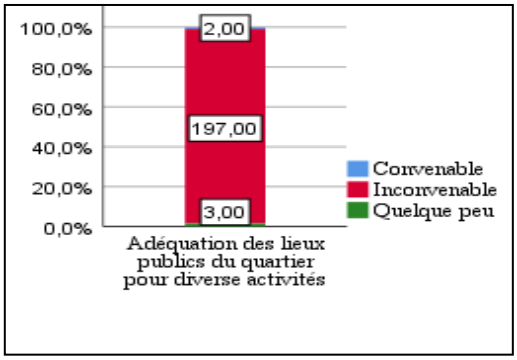

Fig. 25 – Adéquation des lieux publics du quartier pour diverses activités.

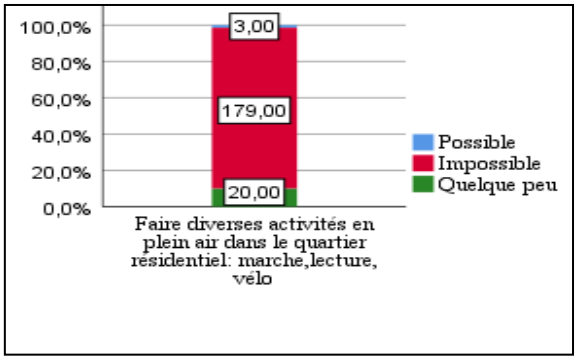

Fig. 26 – L'étendue de la réalisation de diverses activités dans le quartier.

(Les auteures, 2020).

7.9. Sur l'évaluation de gestion urbaine dans le quartier

A travers la Figure 27, nous constatons que le processus de gestion de chacun des éléments urbains et des différentes techniques urbaines utilisées pour aménager le quartier résidentiel et sa gestion est totalement absent et inexistant pour la gestion des bâtiments résidentiels, espaces publics et espaces verts, et les éléments du mobilier urbain dans le quartier résidentiel, alors que l'absence de processus de gestion des routes au niveau du quartier résidentiel représente un taux élevé estimé à 84,15%, suivi de 50,99% pour l'absence de gestion des installations publics et services, alors que l'on retrouve des pourcentages importants liés à l'existence d'un processus de gestion des différents réseaux (eau potable, assainissement, électricité, gaz, téléphonie) avec 70,92 %, et la gestion des déchets solides urbains et travaux d'assainissement de 67,82 %.

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7.10. Sur l'évaluation de la qualité de vie résidentielle

L'évaluation de la qualité au sein du quartier résidentiel a été exprimée du point de vue de la population et des conditions de vie dans le quartier résidentiel à des taux allant du moyen à très mauvais, où l'on retrouve les taux moyens en évaluant la qualité de la vie privée au sein du quartier résidentiel à 79,70% et la qualité de l'urbanisme du quartier résidentiel à 50,99% tandis que l'évaluation de la qualité de la sécurité et de la sûreté à l'intérieur de la résidence et du quartier résidentiel de 36,13%, quant à la mauvaise qualité de l'intimité dans les espaces extérieurs du quartier résidentiel de 47,02%, la qualité des services et de la participation sociale au sein du quartier résidentiel de 49,50%, la qualité de l'image visuelle du quartier résidentiel à 49,00%, la qualité de l'environnement résidentiel et de l'adaptation sociale de 72,27%. La qualité de la cohésion sociale et de l'appartenance à la communauté résidentielle est de 79,20%, tandis que l'évaluation de la qualité de l'aménagement urbain et de la gestion dans le quartier résidentiel est très mauvaise, de 94,05%, et la qualité de vie résidentielle, nous la trouvons moyenne, de 45,54% (Fig. 31).

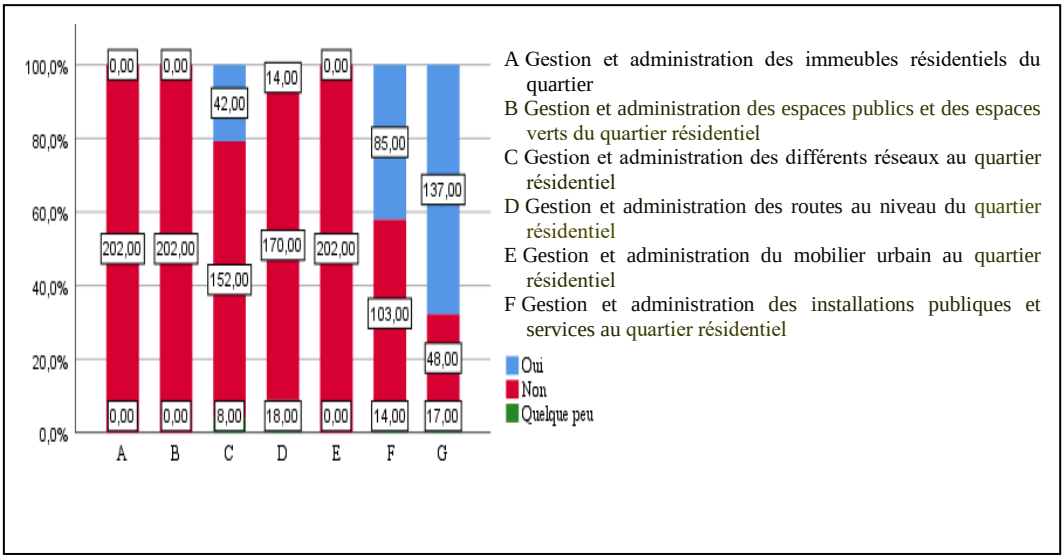

Fig. 27 – Problèmes au niveau du quartier résidentiel (Les auteures, 2020)

Figs. 28, 29, 30 – État général des voiries dans les quartiers (Dahdouh, 2020).

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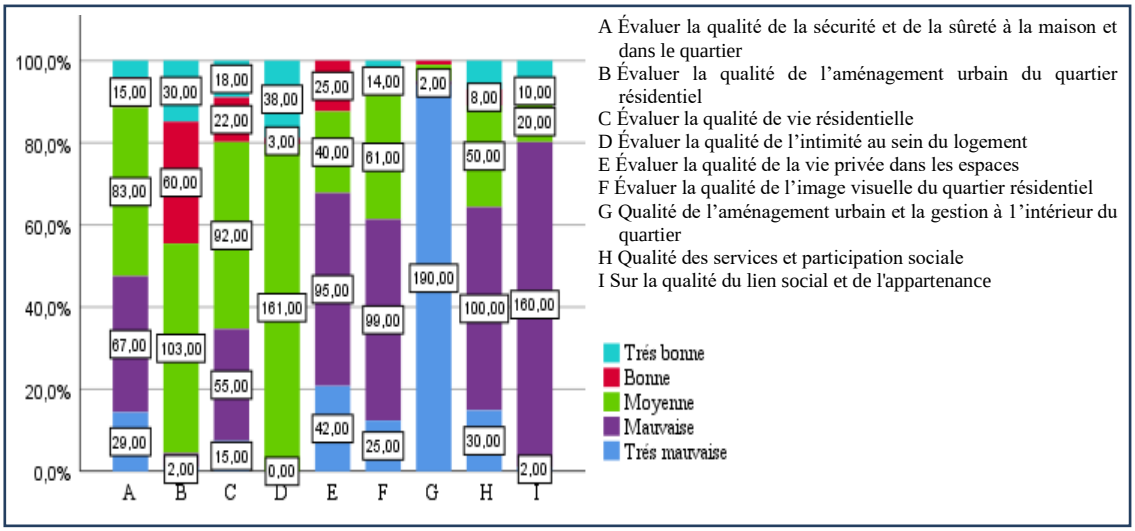

Fig. 31 – Évaluation de la qualité de vie résidentielle dans le pôle urbain de Macomades (Les auteures, 2020).

8. CONCLUSIONS

A partir de cette étude, l'analyse des données (observations et graphiques) et les résultats obtenus nous permettent de conclure comme suit:

– Il y a la difficulté à adopter une définition précise de la qualité de vie en raison de ses ramifications dans de nombreuses sciences et disciplines, qu'elles soient théoriques ou appliquées, en plus de son exhaustivité et de la multiplicité de ses approches et de ses courants intellectuelles et idéologiques selon les différents pays et leurs lois législatives, ainsi que leurs politiques de développement.
– Alors que la qualité de vie peut être définie à travers cette étude comme la bonne relation et la satisfaction totale de la population résultant de l'intégration, de la coopération et de l'influence de diverses dimensions entre elles, car elle ne peut être séparée; elle est le produit de l'interaction d'indicateurs objectifs et subjectifs entre eux et entre les éléments fixes, variables, influents et affectés qui peuvent être mesurés et représentés graphiquement.

Également, les indicateurs de la qualité de vie ont montré que:

– Il existe des problèmes urbains car les éléments urbains qui composent le quartier résidentiel manquent d'efficacité. Il y a aussi un manque d'éléments d'aménagement urbain au sein de la zone résidentielle.
– Les quartiers résidentiels au niveau du pôle urbain Macomades présentent une forte densité urbaine avec un manque d'espaces ouverts, non aménagés et inefficaces, en plus d'une image urbaine incohérente qui contient des matériaux et éléments de mauvaise qualité et mise en œuvre malgré la modernité du quartier.
– D'ailleurs, les indicateurs de la qualité de vie nous permettent de dire que:
– Les constituants essentielles d'un quartier résidentiel ne sont pas réunis, ainsi les aménagements ne répondent nullement aux attentes des populations.
– Les quartiers résidentiels au niveau du pôle urbain Macomades présentent une forte densité urbaine avec un manque d'espaces ouverts, non aménagés et inefficaces, en plus d'une image urbaine incohérente, résultat de matériaux et éléments de mauvaise qualité et d'une mise en œuvre non faite dans les règles de l'art.
– Il a également été observé que la culture de la clôture ou de la fermeture de quartiers, en construisant des murs de clôture, est largement répandue au niveau du pôle urbain de

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Macomades, ainsi des ilots fermés se sont formés pour des raisons de sécurité beaucoup plus se sont formés majoritairement pour des raisons de sécurité.

– L'analyse de proximité nous a permis de constater que les habitants ne sont pas constitués en association ou groupe de voisinage, de manière que les espaces aménagés ne sont pas entretenus, seuls quelques initiatives individuelles sont à noter.

Les habitants trouvent solution à leurs besoins d'une maniéré individuelle, chacun intervient selon ses soucis et ses manques et selon les moyens dont il dispose alors que les problèmes urbains ne peuvent être résolus que par l'ensemble des habitants, c'est ce que l'on appelle le « modèle de déterminisme environnemental », ils font face aux situations actuelles en adoptant leurs visions individuelles.

– Dans cette étude, nous avons constaté une faible satisfaction et une diminution du niveau de cohésion sociale, d'où une diminution du pourcentage de jouissance de la vie privée par les habitants, la mauvaise relation des habitants les uns avec les autres, qui fait qu'il y ait le sentiment de non appartenance à la communauté de voisinage, ce qui induit à la faible cohésion sociale.
– S'il existe une relation entre les indicateurs de qualité de vie et celle de la qualité sociale et environnementale, elle doit être objective, la construction de l'environnement urbain doit être efficace par l'implication de tous.
– On déduit de ce qui précède que: l'évaluation de la qualité de vie dans les quartiers résidentiels permet de connaître les implications des politiques adoptées, aussi que leur impact sur la répartition spatiale de la population et les besoins de logement.

En effet, les programmes d'aménagement et les éléments d'urbanisme et de conception des quartiers résidentiels ont un rôle important et influencent la qualité de vie urbaine par les infrastructures et différents réseaux ou services divers. Où tous les besoins des résidents doivent être fournis, tels que la sécurité et le respect des vies privées, cela allégerait la pression sur la politique de la ville au regard d'une demande continue de logements en adéquation avec les aspirations de la population et la taille de la jeune famille algérienne, afin de répondre à leurs demandes actuelles et aspirations futures.

En conséquence de ce qui précède, il peut être recommandé:

– Les programmes résidentiels dans la ville d'Oum El-Bouaghi peuvent être orientés et rendus attractifs pour les résidents s'ils répondent aux normes de qualité à la hauteur de ses habitants, car ils regorgent encore d'opportunités d'expansion urbaine et incubent de nombreux projets et programmes de logement dans le futur.
– Faire prendre conscience des notions de rationalisation, de qualité et d'entretien dans de nombreuses composantes urbaines et services au sein des quartiers résidentiels est devenu un impératif afin de préserver l'environnement urbain au sein des quartiers résidentiels algériens et de rationaliser les ressources pour éviter la dégradation du niveau de sécurité dans les bâtiments.
– La nécessité d'orienter la politique du logement par l'État algérien, les urbanistes et les architectes vers la qualité dans la production des programmes d'habitat et d'aménagement de la ville, et d'activer le rôle de la participation communautaire en bénéficiant de la recherche académique et de la sensibilisation de la population de leurs besoins particuliers dans la ville en général et les quartiers résidentiels en particulier, à se caractériser par la flexibilité et la capacité de s'adapter aux transformations urbaines rapides, tout en conservant les caractéristiques et les constantes locales propres à la ville. En plus de mettre l'accent sur le développement du modèle de services et prendre en considération toutes les catégories de la population dans la planification des quartiers résidentiels et la répartition des usages, en particulier la fourniture d'espaces publics, verts et récréatifs, et l'élévation du niveau de sécurité et de sûreté pour les la population.

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Reçu 28 avril 2021

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URBAN REGENERATION AND REUSE OF URBAN SPACES. THE CASE OF METROPOLITAN TABRIZ, IRAN

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Key-words: urban planning, sustainable development, urban regeneration, Tabriz City.

Abstract. The regeneration of historical and deteriorated areas of cities has been observed in the recent urban planning literature worldwide. Inefficiency is one of the main issues in deteriorated urban areas where the possibility of updating and spontaneous change has all but disappeared. Similar to many other countries, the current process of extension of the deteriorated urban area in Iran indicates that problems will be complicated, if we do not apply any precautionary measures, suitable policies, planning and action plans. In this regard, one solution has been the implementation of flagship developments. One of the main objectives of flagship developments is to achieve urban regeneration goals; an approach that is used as a comprehensive strategy for applying some positive changes in a place showing signs of decay. It takes into account the idea of quality improvement, with integrated goals of economic, social and physical topics. This study aims at investigating the necessity of regenerating the old and historical texture of Tabriz. This is a descriptive–analytical study where GIS software was used. Results indicate that Tabriz is the second city in Iran with a worn-out texture; more specifically, about 25% of its texture is worn out and approximately 500,000 inhabitants live there. There are also several important historical monuments found in such texture. Given that the texture is located near the northern fault line of Tabriz, any earthquake may cause serious economic and human loss. The final result of the SWOT analysis shows that the best strategy for Tabriz city is an aggressive one that would exploit the strengths and opportunities. Therefore, in order to reduce human and economic losses, the best approach would not be to build near the fault line, but to regenerate the old and worn-out texture of Tabriz city.

1. INTRODUCTION

Before the industrial revolution, cities did not go through many physical changes. After the industrial revolution, and due to the increase in population and economic, social and cultural changes and new technology, the texture of cities changed (Zangiabadi, 1990). Following rapid urbanization, especially in developing countries, the growth pattern of many cities was changed from a centralized pattern to a sprawl standard, and the sprawl growth pattern led to an increase in barren lands and the wearing out of the old texture of cities (Mohammadi *et al.*, 2012). Additionally, urban sprawl growth has caused environmental, economic and social challenges in developed and developing countries. In fact, since 1970, the world's large cities have been plagued by worn-out texture (Liu *et al.*, 2017). Urban regeneration and the reuse of urban space is a new strategy in urban development, a strategy which reduces the challenges of the sprawl growth pattern (Xie *et al.*, 2021; Perez *et al.*, 2018). Urban regeneration can effectively promote urban economic growth, improve the urban physical environment and protect cultural heritage (Forouhar & Hasankhani, 2018; Berta *et al.*, 2018; Zhang *et al.*, 2017). In fact, urban regeneration entails the reuse of urban spaces, and comprises the reconstruction of old residential buildings, land reutilization, commercial area renewal, redevelopment of brownfields, and social and cultural improvements (Wang *et al.*, 2021; Zhu *et al.*, 2020; Martin *et al.*, 2018; Mehana *et*

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Rev. Roum. Géogr./Rom. Journ. Geogr., **66**, (2), p. 197–213, 2022, Bucureşti.

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al., 2019; Xie *et al.*, 2021). Urban land and land resources are a basic factor for production and socioeconomic activities in cities, and due to urban sprawl, urban land is constrained (Wu *et al.*, 2014;). Nowadays, the central areas of cities, especially in developing countries, are not desirable areas for habitation, so that the majority of the inhabitants of these areas make up the lower classes of societies. Therefore, to solve issues of the central areas of cities, urban planners and managers have turned their attention to sustainable planning using urban regeneration (Pourahmad, 2010). The goals of urban regeneration projects and the reusing of urban spaces being pursued by local governments, revolve around the following: to shrink the city and halt unnecessary urban sprawl, to attract investments, and reenergize urban economy, and to enhance the city's competitiveness, to redevelop or substantially upgrade a dilapidated area, to assign new functions and make the best possible use of urban land, and to assist in place branding and/or reshaping of the urban image (Robert, 2000; Cochrane, 1999; Pervic *et al.*, 2019; Neducin *et al.*, 2021). Between 1966 and 1990, the average growth of urban population was 4.4% and the average growth of urban area was 6.9%, the reason being the social, political and economic changes in Iran (Majedi, 2012; Pourmohammadi & Jam Kasra, 2011). In fact, in recent years, Iranian cities, especially large cities, have grown rapidly, which has created many issues. One of the main issues is worn-out texture. The old and worn-out texture has formed and developed as part of a lengthy process and today is surrounded by modern technology. Although this texture previously had a proper and hierarchal function, today, with the advancement of technology, the cities have been weakened in terms of structure and function. Urban planners believe that today's cities have no identity without old textures, and if the old and worn-out textures are not regenerated, we will see the death of the only witnesses of history of civilization (Habibi *et al.*, 2012). The existence of worn-out textures in cities, especially large cities, is a major challenge for urban planners and managers. The worn-out textures have caused economic, social, environmental, security and infrastructural problems in cities (Rasouli *et al.*, 2016; Bouchani, 2004). At present, more than 25% of the urban population in Iran lives in worn-out textures (Pourahmad *et al.*, 2017). Moreover, according to the estimation of the housing and urban development organization, there are 50,000 hectares of worn-out texture in 100 of the cities of Iran. The characteristics of the worn-out textures of Iranian cities include the following: physical worn-out, improper streets, improper passages, lack of green space, worn-out infrastructure, high vulnerability and low economic, social, environmental value. Actions taken to regenerate worn-out textures in Iranian cities consist of the restorative operation on the physical aspects of these textures. Urban regeneration included social revitalization, economic prosperity, environmental sustainability and physical reconstruction (Gadami *et al.*, 2020; Majedi, 2008). Metropolitan Tabriz, after Tehran, has the most worn-out texture in Iran. It is surrounded from the north and south by mountains, while the land in this city is limited for urban use. Tabriz is a historical city with a strategic position in Iran. It is an old city that has a lot of political and social value. It has 2,600 hectares of worn-out texture. In fact, about 25% of the city of Tabriz is made up of a worn-out texture. The issues such as the irregular expansion of the city, the lack of per-capita services used, the lack of hierarchy in road networks, the narrow streets and passages, the inconsistent uses, the poor quality of buildings and the lack of proper urban facilities and equipment are the main problems of the worn-out and old texture of the city of Tabriz. While Tabriz city centre has high capabilities due to its geographical centrality, the existence of a bazaar and adjacent commercial activities, historical and cultural identity and tourist attractions, the historical context and historical monuments of Tabriz city are located inside the worn-out texture of the city, as well as the many people who live in the worn-out texture area. The urban infrastructure in this sector is severely worn out. In fact, the worn-out texture has caused economic, social, infrastructure and environmental challenges, and has led to unsustainable development in this part of the city.

This research is the first to deal with the city of Tabriz. The current paper aims at putting forward the importance of urban regeneration and the reuse of urban spaces in the big cities of Iran,

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including Tabriz and the fact that a large part of the city has worn-out texture and is inhabited by large populations. The city is located near the fault line; therefore, in order to preserve people and historical monuments and to resolve economic, social and environmental problems, and finally to achieve sustainable development, it is necessary to regenerate the worn-out texture in the city of Tabriz.

2. LITERATURE REVIEW

The term *urban regeneration* means revitalization, renewed life, modernization and regrowth (Christelle & Damidaviciute, 2016; Alpopi & Manole, 2013; Gadami *et al.*, 2020). Urban regeneration is a comprehensive action that seeks to solve urban problems and improve the economic, social, physical and environmental situation of the city (Robert, 2000; Korkmaz & Balaban, 2019). In fact, urban regeneration has a complex and multi-dimensional nature (Donnison, 1993; Korkmaz & Balaban, 2019). Today, the concept of urban regeneration has shifted from physical transformation to a comprehensive approach to economic, social, physical and environmental transformation (Guzey, 2009). The key attitude in regeneration is to improve the situation of the people and the city, alike (Safaeipour & Zarei, 2017). The sustainable urban regeneration approach is one of the newest universally accepted approaches in the face of worn-out urban textures (Vilaplana, 1998). This approach emphasizes the optimal use of urban potential to obviate new needs; it also prioritizes reviving the old texture and restoring social life and economic prosperity (Izadi, 2006). The regeneration of the old texture of cities is touched upon in the oeuvre of John Ruskin and Friedrich Engels. It took almost four decades – covering the era of the Athens Charter (1933) and Amsterdam Charter (1975) – for developed countries to intervene in the valuable historic sites in order to regenerate them. In 1868, Thomsen proposed to settle 10,000 workers' families in the dense fabric of downtown Glasco. High density was, he thought, necessary to revive commercial units and public spaces and restore the economic value of possessions. The plan appears to be one of the earliest manifestos of urban regeneration. Kamil (1843-1903) was looking to organize urban spaces and revive the old urban texture, proposing ways to decorate cities (Habibi & Maghsoodi, 2007). Karir (1922) thinks it necessary to conceive an interrelationship between the old and new spaces. He rejects the notion of separating urban functions. Lichfield highlights the necessity of a better appreciation of the erosion process and the agreement over the issues an individual tries to achieve. Working on how to encounter new solutions for old textures, Danison believes that one should emphasize the districts with interrelated, similar problems (Roberts, 2001). Lynch and Jacobs take a humanist approach to city building. According to them, in regenerating the city, planning should happen with the participation of people and following the advice of experts (Shamaei, 2006). Jacobs (1961) emphasizes the principle of human interactions, self-repair, and the people's participation in regenerating the city by drawing on the chronic problematic texture (Pakzad, 2007). In worn-out textures and historic sites, Alexander (1936) highlights the organic order and the population (Pourjaafar, 2009), believing in principles such as sustainable stability and acting in keeping with the economic, social, and environmental organization (Habibi and Maghsoodi, 2007). Palumbo et al., in an article entitled "Strategies for an Urban Renewal in Rome: Massimina Co_Goal", conclude that this project relies on a combined top-down/bottom-up strategy. In fact, this project promotes a set of retrofitting actions for a defined number of private houses to be involved in a co-financed refurbishment program. Furthermore, the main goal of the project is to achieve sustainable development, economic prosperity and social revival (Palumbo *et al.*, 2017). Andrew and Jonas, in a paper entitled "Urban Management and Regeneration in the United States: State Intervention or Redevelopment at All Coast", conclude that urban regeneration in the United States is built around a narrowly economistic model of redevelopment rather than around a socially inclusive or participatory 'new regionalist' model. Additionally, urban regeneration tools used in the US include special purpose districts, public-private partnerships, the tax-increment financing of redevelopment, revenue and general obligation bonds, and community activism

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and engagement (Andrew and Jonas, 2009). Korkmaz & Balaban, in the research entitled "Sustainability of Urban Regeneration in Turkey: Assessing the Performance of the North Ankara Urban Regeneration Project", conclude that, in recent years, urban regeneration in Turkish cities has gained momentum due to the increasing number of activities in private and public sectors. Additionally, this research shows that the project's contribution to urban development sustainability has been minimal and thus, many efforts are required to improvement the sustainability performance of urban regeneration projects in Turkey (Korkmaz & Balaban, 2019). In the article entitled "Urban Regeneration in China: Policy, Development, and Issues", Ye discusses China's recent urban regeneration policies, including how residents are affected and how they protect their economic and social rights, the role of developers and governments, and the interaction between the main participants in a broad Chinese social, economic and political context. This research introduces the urban regeneration of Guangdong Province and examines how it intends to engage the government, developers, and communities in this urban regeneration (Ye, 2011). Consequently, over the nearly five decades when urban regeneration policies were pursued, their objectives have varied not only because of the varying nature of the problems associated with urban decline. The variation is also the result of different understandings of how multiple dimensions of regeneration relate to one another and how that relationship could be mobilized towards the desired aims of different ideological perspectives from successive governments and the varying balance of power of the potential beneficiaries and losers of regeneration policies. Across countries, different policy and institutional contexts have also shaped variations in urban regeneration policy objectives. Current regeneration practice accepts that interventions need to go beyond physical redevelopment, and while this remains an important component, the main objectives tend to refer to the stimulation of economic growth, together with the decrease in social inequality and the increase in community cohesion. More recently, environmental sustainability and climate change issues have gained considerable prominence as objectives of regeneration policy (Jones and Evans, 2013). Those objectives are still quite broad and admit several different conceptions as to the manner of attaining them. As the public sector in most countries no longer has the capability or the appetite for a large-scale direct intervention in the urban environment, achieving the economic goals of urban regeneration has come to largely depend on the performance of the property market. The stimulation of economic growth has often meant the provision of accommodation for businesses, or even just the employment-generating and economic multiplier potential of the development industry (Turok, 1992). In both cases, the success of the intervention relies on altering the dynamics of local property markets. New buildings in renovated surroundings with a buoyant property market can change investors' perception of a locality and lead to more investment in the local economy. There is a well-explored connection between urban regeneration and city marketing, with physical changes in a locality (often through flagship developments) being used to boost the competitiveness of a location in attracting businesses, dwellers and investment (Evans, 2005). In many cases, the reintegration of a derelict area into the mainstream property market has been seen as a regeneration objective in itself. The objective of stimulating the economy has also translated into investment in urban infrastructure, especially as a way of increasing the competitiveness of urban regions (e.g., improvements in public transport networks), although much of the multiplier effect of this investment also tends to depend on the stimulation of property markets. However, since the 1990s, the principle that regeneration should not be circumscribed to physical redevelopment has gained wide acceptance in theory, if not always in practice (Imrie, Lees and Raco, 2009). However, although urban regeneration is often regarded as a comprehensive, holistic discipline, encompassing all the aspects described (physical, economic, social and environmental), in practice it is rarely, if ever, truly comprehensive. The complexity of the problems it tries to address, together with the nature of the government machinery available to implement the policies and the balance of interests associated with each objective means that most urban regeneration practices are steered towards either physical/ environmental objectives, or economic growth and competitiveness, or social inclusion.

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3. STUDY AREA

The city of Tabriz, one of the most ancient cities in Iran, is the capital of the East Azerbaijan Province. Tabriz city, located in the northwest of Iran, is in a mountainous area at an altitude of 1,350 meters at the junction of the Aji River and Quri River and is surrounded by mountains from the north to the south. This city with a population of 1,612,000 people in 2020 and an area of 237 km^2 is the fourth largest city in the country after Tehran, Mashhad and Isfahan. Like other populated cities in Iran, Tabriz city has experienced the phenomenon of rapid urban growth leading to the formation of urban sprawl growth, an increase in the area of the worn-out texture, informal and slum settlements in peripheral areas of the city. During recent years, due to high numbers of immigrants and a high population growth rate, Tabriz city has undergone an irregular and rapid growth and has experienced incredible population and spatial change. This city has a strategic position in Iran, acts as a connection point between Iran and Europe and has always been considered to be one of the major cultural, political and economic poles of Iran (Rahimi, 2016; Moosavi, 2011) (Fig. 1).

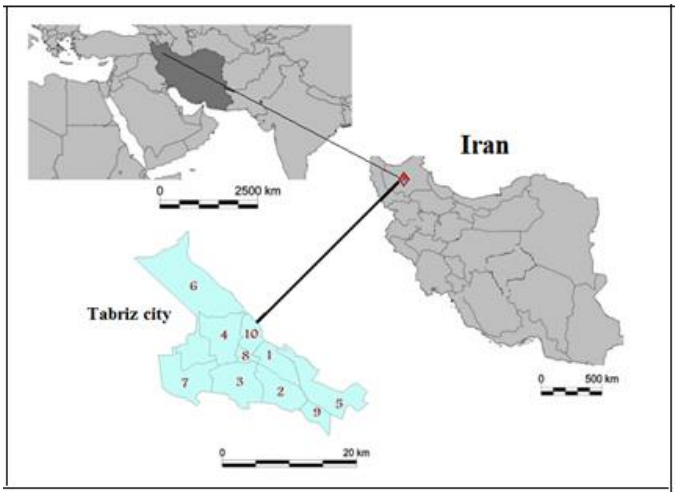

Fig. 1 – Location of the study area.

4. METHODOLOGY

This study is a practical one and the methods of investigation are both descriptive and analytical. The information and data are collected through the library method, referring to organizations, departments and field observations. The GIS software and SWOT method were used for data analysis. The SWOT matrix is one of the most suitable techniques for planning and analysing the strategy, so much so that today it is used as a new tool for performance analysis by strategy planners (Saraei & Shamshiri, 2013). The SWOT technique or matrix is sometimes called TOWS. It is a tool for recognizing existing threats and opportunities as external factors and recognizing its internal strengths and weaknesses in order to assess the situation and formulate a guiding strategy (Ebrahimzadeh & Aghasizadeh, 2009). The SWOT analysis aims to increase strengths and opportunities and reduce weaknesses and threats. In this technique, the organization can design and formulate strategies by identifying strengths, weaknesses, opportunities and threats. Based on this, strengths eliminate weakness and seize opportunities, or use them to deal with threats (Dincer, 2004). Finally, the SWOT technique defines what may help the organization achieve its objectives, and what obstacles must be overcome or minimized in order to reach the desired results (Fig. 2).

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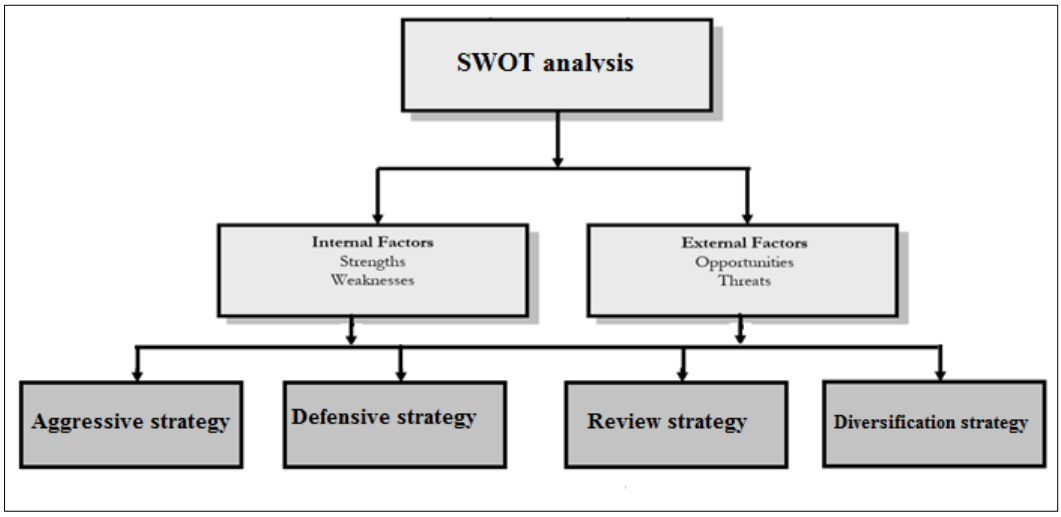

Fig. 2 – SWOT analysis.

5. RESULTS AND DISCUSSIONS

5.1. Territorial dynamics of the City of Tabriz

The fast growth of the metropolitan centres of Iran, as is the case of Tabriz in recent decades has transformed the urban organization and the system of neighbourhoods, exposing them to extensive physical expansion. Physical space is, therefore, devoted to a variety of urban functions. The city's population has grown 7.2 times in 76 years. The population grew from 213,542 in 1930 to 1,558,693 in 2016. That said, the growth rate of the population during the period was not consistent. The highest rate was registered between 1976-1986, amounting to almost 5 percent. This rate is attributed to a high birth rate and to waves of migration from the villages to the city in the first decades following the Islamic Revolution. Reasons contributing to the slow growth in recent years are, however, population control, the rise in literacy rate and economic conditions. At the beginning of the 1986-2006 period, the city of Tabriz had 31.56 percent of the whole population of East Azerbaijan but the share soared to 38.55 percent at the end of the period. The city settled almost 40 percent of the population of the province (Gorbani, 2012). An examination of the trajectory of the physical expansion of Tabriz indicates that it has experienced an increasing territorial dynamic from mid-1951 and especially from the 1960s, preceded by population growth and the expansion of economic activities. The area of the city grew from 1,770 in 1946 to 2,127 hectares in 1966, 4,580 in 1976 to 9,647 hectares in 1991, and from 10,257 in 1996 to above 13,000 in 2006. The population grew almost five times and the physical expansion almost twelve times between 1956 and 2006. A great part of the expansion pertains to the 1956-86 period, during which the physical structure of the city was on the brink of collapse due to the socio-political developments of society, overshadowing the natural setting of the city. The urban space has grown 2.4 times higher than the population. The worn-out textures, newly-built areas in the city – either built in a planned or unplanned way – which could not settle people include a sizable number of unoccupied lands. The factors contributing to the predicament of the city's structure include: The northern and southern margins of the city having a density of 400 persons per hectare, problematic land use (such as Tabriz Airport, the industrial areas to the west, military bases, and Tabriz University), farms, gardens, uncultivable lands within the remit of the city which have become part of the inner city, a negligence of the relative balance in land use under the urbanization model (Fig. 3).

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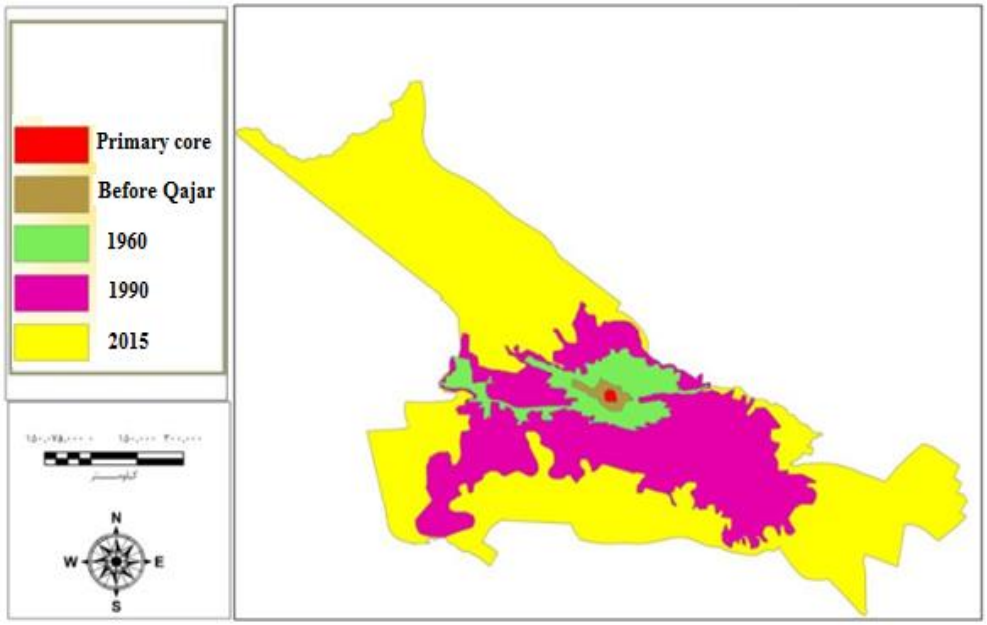

Fig. 3 – Periods of territorial dynamics in Tabriz.

The proportion between the population growth and the settling capacity of various districts is not, we might add, well-balanced. The quarters of the city in the eastern districts, such as Baghmisheh and Yaghchiyan, or Laleh and Taleqani in southwestern Tabriz can settle a higher number of people. In the case of the former, it is possible because of residential areas and being on the route to urban expansion, while for the latter it is due to having good lands prone to development, accessibility to the commercial centres, and having the appropriate communication infrastructure. The average settling, however, occurs in townships – Andisheh, Rajaei-Shahr, and Zafaraniyyeh – which are still going through the process. The same phenomenon occurs in marginal areas in the northern parts. The lowest growth rate belongs to the historical parts surrounding the Great Bazaar and agricultural-industrial districts to the city's western part. The regions where land is put up for construction are the ones that bear the brunt. All districts of Tabriz – save for districts 4 and 8, the central and historical ones, and district 5, which includes the marginal areas marked by a density of over 400 persons – have the space required for settling more people for at least 6 years. Given the population growth, even district 8 can settle the population for the next 64 years. Moreover, the whole city can settle a population for the next 21 years if this growth rate and area of residence are kept. There is no need, therefore, to sprawl-expand the city; instead, the internal development capacities of the city – i.e., uncultivable lands and a worn-out texture – can be used for infill development.

5.2. Criteria for identifying worn-out texture

The worn-out texture is a district of the city that, due to physical worn-out, facilities and infrastructure, together with unsuitable and narrow streets and passages, was vulnerable and had low spatial, environmental, economic and social value (Robert *et al.*, 1997). Worn-out textures cannot be regenerated by owners due to the poverty of residents and their owners, and investors have no incentive to invest in these textures. The desire to migrate increases among its inhabitants (Ebrahimzadeh & Maleki, 2012). Types of worn-out textures can be divided into the following: historically valuable, disorganized and problematic, inefficient, with/without cultural heritage, marginal rural areas located in the urban zone; therefore, worn-out textures can encompass marginal and rural areas at the outskirts

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of cities (Babaei *et al.*, 2018). The criteria for identifying Worn-out textures comprise the following: 1) The age of the buildings: More than 80% of buildings are over 50 years old, or if they were built during the past 50 years, do not have a technical standard, nor a resilience to moderate earthquake; 2) Micro-residential blocks: In worn-out textures residential buildings are smaller, and their average area is less than 120 square meters; 3) Buildings materials: The materials of worn-out textures are more than brick, wood and iron, and do not have a standard structural system; 4) The number of storeys in each building: In worn-out textures most buildings are 1 to 2 storeys high; 5) The access status: worn-out textures have an irregular form and narrow streets and passages, so that most streets are less than 6 meters wide; 6) Economical: Low cost housing, low-income population and unemployment destroy the economic structure of the past; the high cost of renovating buildings and the inability to attract the population's participation; 7) Social: the large-size family, insecurity, high density population, non-indigenous residents, the high rate of illiteracy and the negative growth rate, as well as the exit of old residents from the worn-out texture, the migration of primary social strata from the old and worn-out texture, increasing of types of social violation (Samiei, Sayafzadeh, 2016; Jamal, 2007); 8) The status of services: worn-out textures have many problems in terms of public services and equipment, the improper distribution of municipal services, the division of texture lands into smaller sectors, the lack of infrastructure, such as parking, green spaces and the vulnerability during earthquakes; 9) Environmental: environmental pollution, caused by the amassment of commercial and employment centres, as well as the existence of terminals and storerooms, car traffic within the texture, the noise and air pollution, the reduced green space, the substandard buildings, the unsanitary conditions (garbage and sewage), and debris and demolition waste (Habibi *et al.*, 2007). All these cases together with pollution reduce the spatial value of the old and worn-out texture, and increase migration to these areas, while ultimately hindering the social, economic and territorial dynamics of the old and worn-out texture.

5.3. The worn-out texture of Tabriz city

In Iran, there are about 132,000 hectares of worn-out urban texture, and about 21 million people inhabiting these worn-out textures. The city of Tehran, together with its 3,270 hectares, has the most worn-out texture, that 18% of the population of Tehran resides in worn-out textures (the Municipality of Tehran, 2018). The worn-out texture of the city of Tabriz – 2,530 hectares – has occupied about 25% of the total area of Tabriz (The Municipality of Tabriz, 2019). The city of Tabriz has the most worn-out texture in Iran, after Tehran. The worn-out texture of Tabriz city includes four types of texture: historically valuable worn-out texture, middle worn-out texture, rural-urban worn-out texture, and marginal worn-out texture. Approximately 500,000 people live there. Two major population groups can be identified in the worn-out texture of Tabriz (Fig. 4).

The first group inhabits the worn-out texture of the central core of Tabriz and is originally from Tabriz. The second group mostly inhabits the unsuitable and worn-out texture on the outskirts of Tabriz and are immigrants that have migrated to Tabriz from the surrounding towns and villages over the past four decades and who have settled in small, non-standard buildings. The worn-out texture of Tabriz has many problems, such as micro-residential blocks, which in some cases are under 30 meters; the high density of the population inhabiting these areas has caused disturbances in the neighbourhoods and has impacted social relations in these areas; the lack or weakness of municipal services such as green spaces, a library, a clinic and a mosque, having reduced the social interactions of residents. Additionally, the lack of health services, urban facilities and infrastructure, coupled with the air and noise pollution, the increasing urban poverty, the increasing social anomalies and crime rate, the unplanned and illegal construction, and the instability of buildings have reduced the spatial, social and economic value of the worn-out texture of Tabriz city (Fig. 4).

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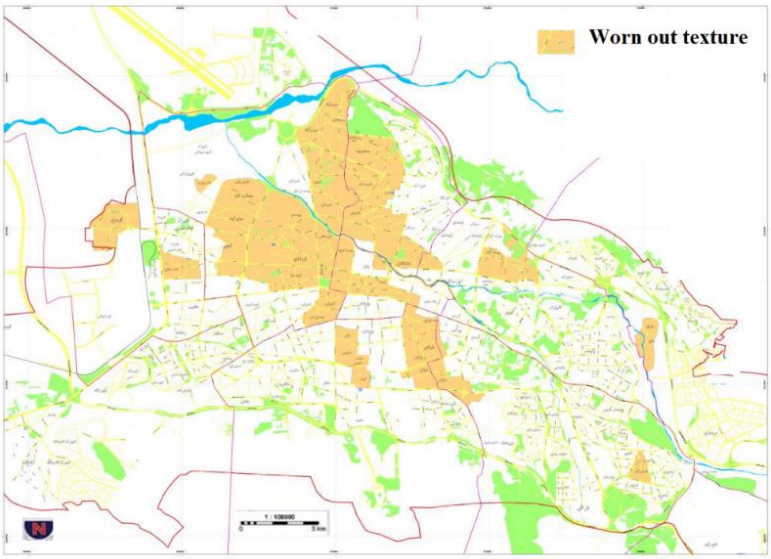

Fig. 4 – The worn-out texture of Tabriz city (source: Tabriz Municipality, 2019).

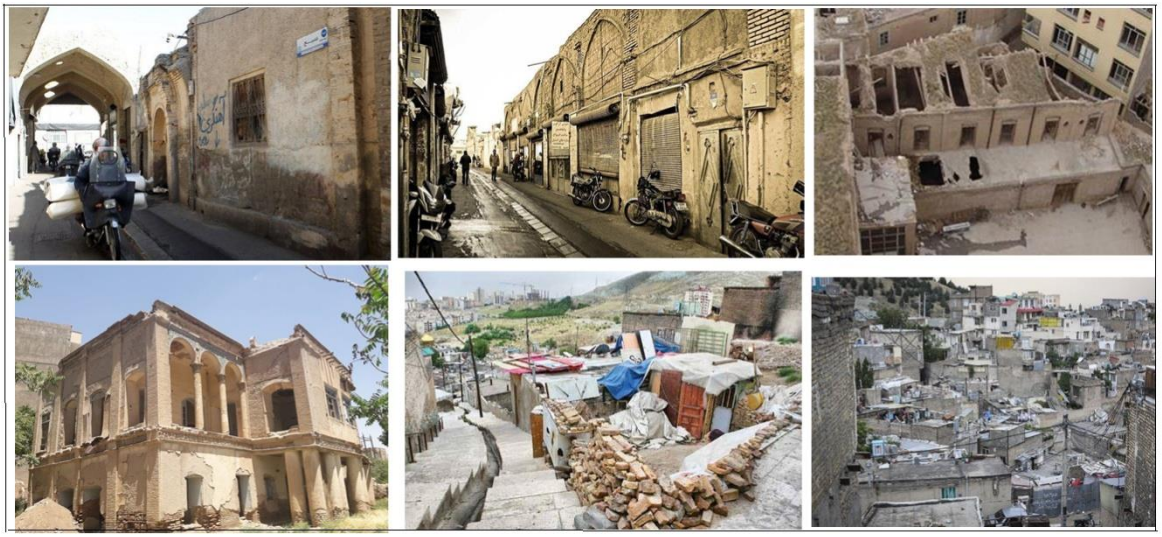

Fig. 5 – The worn-out texture of Tabriz.

The instability of buildings is a serious threat to the residents of the affected areas. In fact, the necessity of paying attention to the worn-out texture in the city of Tabriz is represented by the potential dangers posed by a natural crisis, especially earthquakes. Tabriz city is located a short distance from the famous fault to the north of Tabriz and, in some areas, it is completely expanded over the fault. Moreover, most of the worn-out texture, especially in the north of the city, is adjacent to the fault. According to the division of earthquake risk zones in Iran, the city of Tabriz is one of the high-risk areas. The impermeability and inadequacies of the road and access network, narrow roads, the delayed access to services and emergency vehicles, such as fire engines and ambulances, have led to inefficiency and disorder in most worn-out textures within the city limits. All these factors have rendered the city of Tabriz, especially its worn-out textures, vulnerable, since any earthquake may cause serious economic and human loss (Figs. 5, 6).

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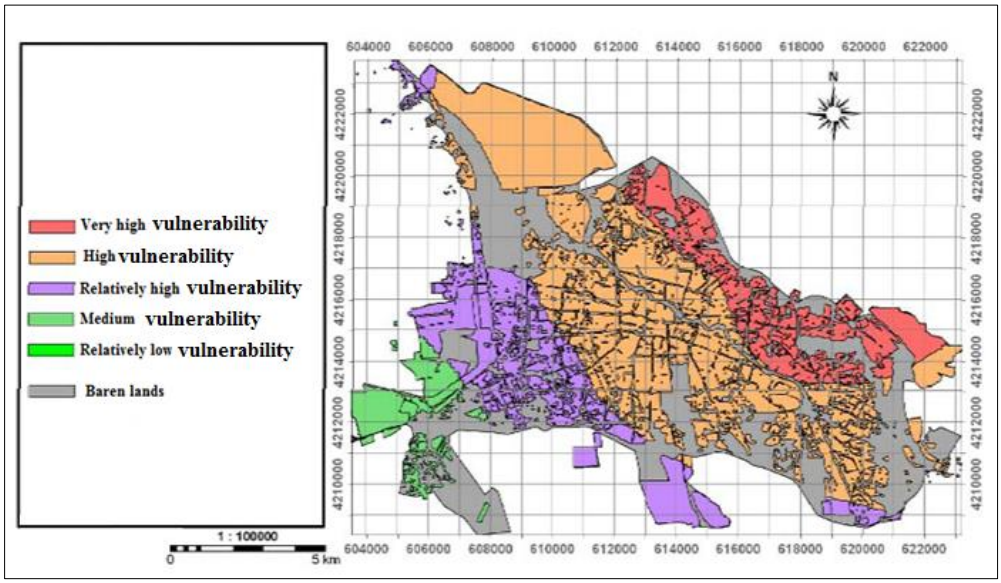

Fig. 6 – Earthquake vulnerability zoning in Tabriz city (source: Rostaei, 2011).

5.4. The necessity of regenerating the worn-out texture of Tabriz

The worn-out historical textures of Tabriz show the history, identity and culture of the city. These textures are very valuable in terms of architecture and urban planning. Regarding the importance and value of historical texture, the following can be mentioned:

1) Architectural values: the harmony between buildings and nature, the observance of climate when building, homogeneity in physical environment and inhabitants, the coordination of urban functions and the attention to aesthetics. The historical monuments of Tabriz are as follows: Alishah Arg or Arg of Tabriz, Rab'-e Rashidi, the Firefighting Tower, the Bazaar of Tabriz, Shams ol Emareh, the Constitution House of Tabriz, the Blue Mosque and the Tabriz mosques, in general (Fig. 7).
2) Cultural values: historical textures have an important role in connecting people to their cultural background. In fact, old textures are places of accumulation of memories, and play a special role in preserving cultural values. Therefore, the historical textures of cities are a good place to understand the different aspects of indigenous and local culture and how it affects different aspects of urban life.
3) Social values: the historical and old textures have, due to a previously existing social cohesion, the potential to strengthen social relations and increase social cohesion. The pattern and concept of the neighbourhood and the centre of the neighbourhood is a good opportunity to experience popular participation and strength solidarity between citizens (Alizadehganat & Mabhout, 2015).
4) Urban design values: these textures play an important role in recognizing the style and pattern of urban design in previous periods, while also having an important role in times of housing shortages. In addition to the fact that housing within historical textures is a sort of capital, it also saves in terms of urban facilities and infrastructures.
5) Economical values: in historical and old textures, there are monuments of cultural value called historical resources, symbols of past civilizations and urban life, as well as a sustainable economic resource, one of the major products of cultural economy.
6) The prevention of sprawl growth and the use of the infill development capacity, especially in barren lands and in the old and worn-out textures of Tabriz.

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7) The high vulnerability of worn-out historical textures caused by the fault line north of Tabriz.
8) The importance and necessity of providing services in a natural and human crisis: the insufficiency in the design and construction of residential units with congestion zoning, the inefficiency of the road network, especially in the area around the bazaar, the severe shortage of urban facilities and equipment, such as fire brigades, emergency and rescue services, and relief centres.
9) Traffic issues: the lack of public and private parking, the interference between pedestrians and drivers, the lack of a road network hierarchy, the instant concentration of services used with urban and regional performance in these textures.
10) The disharmony of worn-out textures displaying new needs.
11) The regeneration of worn-out textures triggers the organization of land use and the elimination of incompatible or troublesome uses.
12) The residence of a high number of people within the worn-out textures of Tabriz and the prevention of population movement from worn-out textures to the suburbs of Tabriz city.
13) The regeneration of the worn-out texture enhances efficiency, social justice, security, health, comfort and environmental quality, and ultimately promotes community, economic and spatial values.

Fig. 7 – The historical texture of Tabriz and its historical and cultural monuments.

5.5. The evolution of intervention in the old and worn-out texture of Iranian cities

1) Before the Islamic Revolution of Iran in 1978, the extensive demolition and reconstruction process, which relied on the general governmental budget and neglected residents and owners, was the Government's main approach when dealing with the old textures, which led to the uncontrolled expansion of the city and the isolation of the old centres of the cities. This demolition and reconstruction showed the prevalence of the modernist approach dependant on western models at that time.
2) After the revolution and until the end of the war, improvement plans were the main policy in the historical old textures of Iranian cities during this period, and were implemented in the form of a government program related to public revenues with very limited participatory and a purely physical approach to environmental challenges. The economic conditions of the country prevented the extension of this policy to other cities, leading to it being implemented only in the cities of Isfahan, Yazd, Semnan, Shiraz and Gorgan.

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3) Between 1989 and 1993, detailed plans for historic cities, especially those affected by the war, followed by the plan of cultural and historical axes were the Government's main plans in the early post-war years. According to these plans, the textures of urban centres, which had always been a separate part of the city, were regarded together with the structural comprehensiveness of the city. The prevailing policy during that time was improvement and reconstruction with the participation of the people. The lack of necessary infrastructure in the old textures, the lack of economic capacity and incentive policies, and the lack of capability and capacity in the municipalities, have all led to the non-realization of these programs.
4) Between 1993 and 1997, the integrated policy was the Government's main approach to improving and renovating urban textures, through the acquisition, clearance and integration of existing real estate assets within urban centres. These policies were implemented with an emphasis on the physical aspects and with the Government's intervention.
5) Between 1997 and 2009, the main goal was achieving a balanced and sustainable development by identifying and using the existing physical, economic and social capacities within the legal limits of cities, and balancing the population settlement while preventing the irregular expansion of cities. Moreover, in this period, the strategy of the infill development of cities was introduced to meet the challenges of the dysfunctional texture. In the meantime, regeneration projects were implemented with the participation of investors and the private sector (Izadi, 2006; Mirzakhani, 2021).
6) Between 2009 and 2013, the importance was acknowledged for the participation of urban renewal stakeholders, residents and owners for the success of urban regeneration and rehabilitation. In addition, the necessary conditions were provided for the presence of investors and the private sector as residents in the regeneration of the old texture.
7) Starting 2013 and up to present-day, at the beginning of this period, a review of the set of policies and actions for urban improvement and renovation was on the agenda. In fact, after reviewing previous actions, the urban regeneration policy was seen as the main approach and criterion of action in historical old textures. The urban regeneration approach is regarded as being able to serve as a framework for guiding urban planners in order to improve the quality of life and the viability of existing urban textures.

5.6. SWOT analysis

5.6.1. The internal factor evaluation matrix

Internal factors include weaknesses and strengths. In fact, for weaknesses and strengths, there are many factors defined. The internal factor evaluation matrix includes the following steps; the most important strengths and weaknesses are listed, these factors are weighted from 0 to 1, so that the sum is equal to 1. Then, each factor is assigned a score of 1 to 4, score 1 for factors which are too weak, score 2 for weak factors, score 3 for strong factors, and score 4 for too strong factors. To determine the final score, the weight of each factor is multiplied by its score. Finally, the sum of the final scores is calculated to determine the final score of the internal factors. In the internal factors evaluation matrix, if the final score is higher than 2.5 (average 1 and 4), it indicates that the strengths are superior to the weaknesses, and if it is less than 2.5, it indicates that the weaknesses are superior to the strengths (Tab. 1).

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Table 1

The Strategic Internal Factors Evaluation Matrix

	Strengths	**Weight**	**Score**	**Weighted score**
S1	The existence of the largest roofed bazaar in the world within the historical texture of Tabriz	0.065	4	**0.26**
S2	The existence of buildings with excellent architecture in the historical texture of Tabriz	0.051	2	**0.102**
S3	Historical monuments and cultural heritage such as: Shams al Emareh, Firefighting Tower, Rab'-e Rashidi, Alishah Arg, the blue mosque and the municipality building	0.054	4	**0.216**
S4	Security and social–cultural solidarity	0.04	2	**0.08**
S5	Located in the centre of Tabriz city	0.045	3	**0.135**
S6	The proximity and access to the city's commercial services	0.025	2	**0.05**
S7	The easy access to public transport	0.041	3	**0.123**
S8	The location of services, commercial and production uses in the historical texture (mixed land use)	.040	2	**0.08**
S9	Low housing and rental prices	0.042	2	**0.084**
S10	The existence of urban spaces with their own identity	0.04	2	**0.08**
	Weaknesses	Weight	Score	**Weighted score**
W1	In the historical texture of Tabriz, many buildings are worn out	0.090	4	**0.36**
W2	Th lack of public and private parking	0.051	3	**0.153**
W3	The inadequate and weak infrastructure	0.054	2	**0.108**
W4	The lack of a road network hierarchy, narrow streets and passages	0.051	3	**0.153**
W5	High population density in the old texture Tabriz city	0.026	3	**0.78**
W6	Low security especially at nights	0.015	2	**0.03**
W7	Air and noise pollution in old texture Tabriz city	0.050	3	**0.15**
W8	Weak services uses	0.051	3	**0.153**
W9	The lack of proper urban facilities and equipment	0.051	3	**0.153**
W10	The existence of abnormal visual landscapes	0.025	2	**0.05**
W11	The existence of incompatible uses in the old texture	0.036	2	**0.072**
W12	The high unemployment rate	0.061	3	**0.183**
	Total internal factors	1		**3.555**

The strategic internal factors evaluation matrix shows that the total weight score of strengths is 1.21 and the total weight score of weaknesses is 2.345, which makes the total final weight score of internal factors 3.555.

5.6.2. The External Factor Evaluation Matrix

The External Factor Evaluation (EFE) matrix, a strategy tool, is used to examine a company's external environment and to identify the available opportunities and threats (David, 1999). External factors encompass opportunities and threats. Accordingly, all the stages are similar to the IFE matrix (Tab. 2).

Table 2

The Strategic Evaluation of External Factors Matrix

	Opportunities	**Weight**	**Score**	**Weighted score**
O1	The high capacity for investment of old texture	0.081	3	**0.243**
O2	The existence of abandoned buildings to create the required uses	0.093	3	**0.279**
O3	The Government providing financial facilities to the residents of the old texture	0.085	4	**0.34**
O4	The decision of city managers to regenerate the old texture	0.074	3	**0.222**

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Table 2 (continued)

O5	**Increasing the people's tendency towards historical and cultural tourism**	**0.052**	**2**	**0.104**
O6	The ability to turn the historical texture into an important tourist area	0.054	3	**0.162**
O7	Located on the silk road	0.061	3	**0.183**
O8	Increasing public transportation and walking in the old texture	0.053	3	**0.159**
	Treats	Weight	Score	**Weighted score**
T1	Proximity to the north fault line of Tabriz	0.1	4	**0.4**
T2	The people's deficient knowledge regarding the values of historical texture	0.065	3	**0.195**
T3	The migration of residents from the old texture	0.061	2	**0.122**
T4	The damage to historical monuments by tourists	0.035	2	**0.07**
T5	The lack of public participation in the regeneration of the old texture	0.062	3	**0.186**
T6	The desire of low-income groups to inhabit the old texture	0.043	2	**0.086**
T7	The perpetuated separation of the old texture from the new texture	0.042	3	**0.084**
T8	The gradual demolition of local buildings	0.039	3	**0.117**
Total		1		**2.952**

The matrix of strategic external factors' evaluation shows a total weight score of opportunity of 1.692 and the total weight score of threats as 1.26, which makes the total final weight score of external factors 2.952.

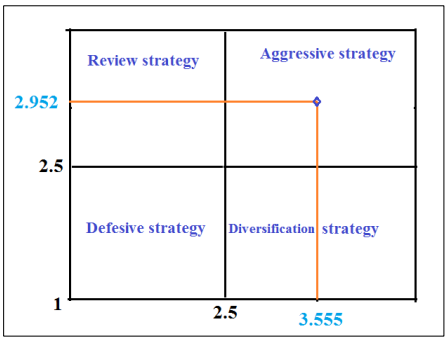

Fig. 8 – Diagram of SWOT analysis strategies.

The final result of the SWOT analysis shows that the best strategy for Tabriz city is an aggressive one, which utilizes the strengths and seeks to take advantage of opportunities. ST Strategies (diversification) use strengths to avoid threats. WO Strategies (review strategies) take advantage of opportunities to reduce weaknesses and WT Strategies (defensive strategies) reduce vulnerabilities and stay away from threats. Figure 7 shows that the best strategy for Tabriz city is an aggressive strategy that exploits strengths and opportunities (Fig. 8).

6. CONCLUSIONS

In recent decades, the rapid growth of cities in Iran has engendered many issues. Hence, these issues and problems have affected all aspects of the city and disrupted the lives of urban inhabitants. One of the major problems of Iranian cities is worn-out textures, the root cause of many other issues. In fact, worn-out textures are the result of excluding old and historical textures of cities from the urban planning process. Due to economic, social, physical and environmental issues, such as micro-buildings, abandoned buildings, unemployment, the lack of green spaces and infrastructure, the narrow

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streets and passages, the lack of open spaces, air and noise population, low security, worn-out textures have caused unsustainable development in Iranian cities. These textures cover a large area of cities and comprise a large population. Worn-out textures have high capacities for infill development. Urban regeneration is a process that leads to the creation of a new urban space while preserving the main spatial features (physical and functional). Consequently, a new urban space is created that, while having fundamental similarities with the old urban space, and substantial and semantic differences. In other words, regeneration means creating a new spatial organization in accordance with the new conditions, that all are effective in creating new urban relations. In this approach, the preservation of cultural and historical monuments is very important. Sustainable development and social justice are important goals of urban regeneration. In fact, regeneration improves the social, economic and environmental conditions of the city. The old and historical texture of cities is an embodiment of civilization and the culture of societies. If these textures are not regenerated, they will become worn-out textures. The historical texture of Tabriz, despite the historical and cultural monuments and the potential for infill development, unfortunately faces problems such as population density, heavy traffic, incompatible uses and a lack of infrastructure and equipment. About 25% of the texture of Tabriz is worn-out and there are more people who reside in the worn-out textures. So, in addition to the physical structure, the cultural and historical identity of Tabriz is also destroyed. Furthermore, according to the northern fault line of Tabriz and the high density of population in the worn-out and old texture, in the event of a natural crisis (an earthquake) or human crises, serious economic and human loss may occur. Therefore, providing attention to the old and worn-out texture of the city of Tabriz and its regeneration will improve the quality of life for citizens, and increase the vitality of urban spaces, as well as reduce causalities of natural and human crises. Finally, using the SWOT analysis, we conclude that the best strategy for the regeneration of the worn-out texture in Tabriz is an aggressive strategy, that is, the use of strengths and opportunities to reduce weaknesses and threats. In general, according the results of this research, the following recommendations may be put forward:

1) Using the participation of citizens in regenerating the worn-out texture of Tabriz.
2) Using demolished and abandoned spaces for service uses.
3) Constructing elements and symbols to revive urban identity and create suitable urban furniture that would render the environment pleasant.
4) Paying attention to the local architecture and design, and constructing buildings based on their capacity to adapt to the natural conditions of the region.
5) Creating open and green spaces for a sustainable environment in the worn-out texture of Tabriz.
6) Creating a road network hierarchy for convenient access.
7) Providing financial facilities to residents for housing reconstruction by the Government.
8) Encouraging private investors to invest in the worn-out texture.
9) Strengthening the sense of spatial belonging in the worn-out texture.
10) Creating service uses and their just distribution so as to obviate the needs of residents.

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Received June 3, 2022

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THE EXPANSION OF OLIVE GROWING AREAS IN THE HIGH PLAINS OF EASTERN ALGERIA. DRIVING FACTORS, SOCIO-ECONOMIC IMPACTS AND CHALLENGES

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Key-words: Olive growing, Agriculture system, Rural development, Algerian high plains.

Abstract. The present study focuses on the emergence of olive trees cultivation and its expansion within the surveyed area (i.e., the high plains of north-east Algeria). It is presumed that the Algerian government evidently favoured the olive oil sector by encouraging the semi-intensive systems through different plans and policies. In addition, the Socio-economic and climatic conditions were the main factors behind this emergence. This particular activity has improved the quality of life for several rural families. On the other hand, it has led to a marked change in agriculture land use and landscapes in several target regions, from a cereal monoculture to polycultures. The findings have revealed some challenges to ensure the future sustainability of olive orchards and to reach the objectives related to guaranteeing food security and, hence, to promoting rural development. The current agriculture trend can be followed up by relevant surveys for a better understanding of the process of growing olive trees from a socio-economic and environmental perspective.

1. INTRODUCTION

Olive cultivation has existed since ancient times in the Mediterranean Basin (Angles, 2000). In fact, it took up a significant part of its mountains and hills (Loumou and Giourga, 2003). According to the Food and Agriculture Organization of the United Nations (FAO, 2001), 95% of the total olive oil production in the world comes from the Mediterranean. In same vein, the International Olive Council (IOC, 2017) stated that, in the 2016/2017 season, about 2.33 million tons of olive oil were produced in the region, making up more than 90% of the global yield. Therefore, olive oil production is essentially an important economic sector for the Mediterranean region, which dominates the global olive oil production. Regarding the olive cultivation systems in the Mediterranean, it should be noted that several factors threaten traditional olive cultivation, as the activity is being transferred from the most fragile areas toward irrigated plains, due to the intensive scheme practice of olive orchards (Loumou and Giourga, 2003). Additionally, Duarte *et al.*, 2008, identified that the abandonment of traditional olive growing is principally caused by low productivity. In this context, for example, Sánchez-Martínez and Cabrera, 2015 analysed the olive cultivation expansion in plain regions (Southern Spain). Likewise, in North Africa, new modern olive orchards are planted in plains with higher densities (Gregoriou, 2009). On the other hand, several studies discussed the future of olive grove development on sloping areas, such as the works of de Graaff *et al.*, 2010 and Fleskens and Graaff, 2007, in addition to Fernandez Escobar *et al.*, 2013 who reviewed the evolution of olive growing from traditional to intensive systems, and Xiloyannis *et al.*, 2008, who focused on the constraints of a semi-intensive system on sloping land.

Algeria is part of the Mediterranean countries, and for a very long time it has been an agricultural and rural country (Côte, 1996a), where olives are a traditional crop, and the most dominant of the Algerian

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Rev. Roum. Géogr./Rom. Journ. Geogr., **66**, (2), p. 215–224, 2022, Bucureşti.

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arboreal orchards; in the 2000–2009 decade, 39% of the arboreal surface was dedicated to olive orchards (MARD, 2018). In fact, in the past two decades, Algeria has focused intensely on agricultural and rural areas, especially with regards to the cultivation of olives as a strategic activity that contributes to the development of rural areas. Indeed, the policy adopted in the country has yielded positive results in this vital agricultural branch; the area assigned for planting olive trees increased from 168,080 hectares in 2000 to 432,961 hectares in 2017. Consequently, the production nearly tripled from 217,112 to 684,461 tons for the same timeframe (FAO, 2017). It should be noted that the olive tree orchards have taken over significant areas, not only in mountainous areas, but also in high plains such as in the north-east of Algeria, which is known for its long favourable region for cereals cultivation and livestock farming. Moreover, the olive oil cultivation appeared in the southern part of the country under totally different conditions from those of its region of cultivation, whereas, the olive trees have been located in the Tell region (Bord, 1981) and are only planted in mountain areas (Côte, 1996a).

In fact, agricultural landscapes mutation is a topic discussed in many studies, such as the works of Hafiza, 2013, in addition to those of Rouabhi *et al.*, 2014 and Rouabhi *et al.*, 2016, that showed a variety of changes in agriculture typology in north-eastern Algeria. Therefore, the start of the olive cultivation spatial dynamic that has been recently observed regarding our study area needs to be assessed, since developing and managing the quality of rural areas and the quality of their products is of great significance (CENEAP, 2003b). On the other hand, research focusing on the olive growing survey is limited with regards to the north-east of Algeria.

This study focuses on a selected area from the plains of north-eastern Algeria. This area was chosen because it is made up mainly of cereals, in addition to the recent emergence of olive cultivation. The focus of the present study is to survey the spatial dynamics of olive groves, by identifying the main reasons that influenced their expansion and understanding their impact on agricultural systems and landscape. The findings are followed by a set of recommendations that can be proposed for rural areas in terms of local and sustainable development.

2. MATERIALS AND METHODS

2.1. Methods

In order for this research to achieve its goals, we have adopted the following methodology: (i) the general presentation of the olive groves' status and their spatial expansion, using the spatial statistics analysis, a detailed analysis of the different driving factors that have influenced the olive cultivation emergence in the study area, (ii) the exploration of the spatial impact resulting from the marked progress of olive cultivation, and discussing the possible spatial challenges related to the activity.

For accurate results, the analysis is based on the reports issued by the International Olive Oil Council (**OOC**), and the Food and Agriculture Organization of the United Nations **(FAO)**. Furthermore, the review of the different relevant reports and studies of the Algerian Ministry of Agricultural and Rural Development (**M.A.D.R**), the National Office for Rural Development Studies (**B.N.E.D.E.R**), and the National Centre for Studies and Analyses of Population and Development (**C.E.N.E.A.P**).

In addition, field surveys and practical experiences were conducted over the last years in several rural areas for a better understanding of the spatial patterns of olive trees and the identification of their dynamics. As for the mapping process, the authors used scientific and methodological materials such as Professional Google Earth, the ArcGIS software, in addition to the Trimble eCognition software.

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2.2. Study Area

The Algerian high plains area is located in a semi-arid climate, between the Tellian Atlas and the Saharan Atlas, at an average altitude of 800 meters (Côte, 1996a). In fact, our study area is part of the high plains in north-eastern Algeria (Fig. 1), and according to The National Office for Rural Development Studies (BNEDER, 2008), it is situated in the Bordj Bou Arreridj (**BBA)** territory, between 35.87° and 36.31° North latitude, and between 4.56° and 5.18° East longitude. The study area covers an expanse of 1,577.36 km², that is, 40% of the **BBA** territory, where most of it is flat lands; the altitude varies between 634 m and 1,313 m, while 86.71% of the study area is low-sloping lands (less than 9º of slope).

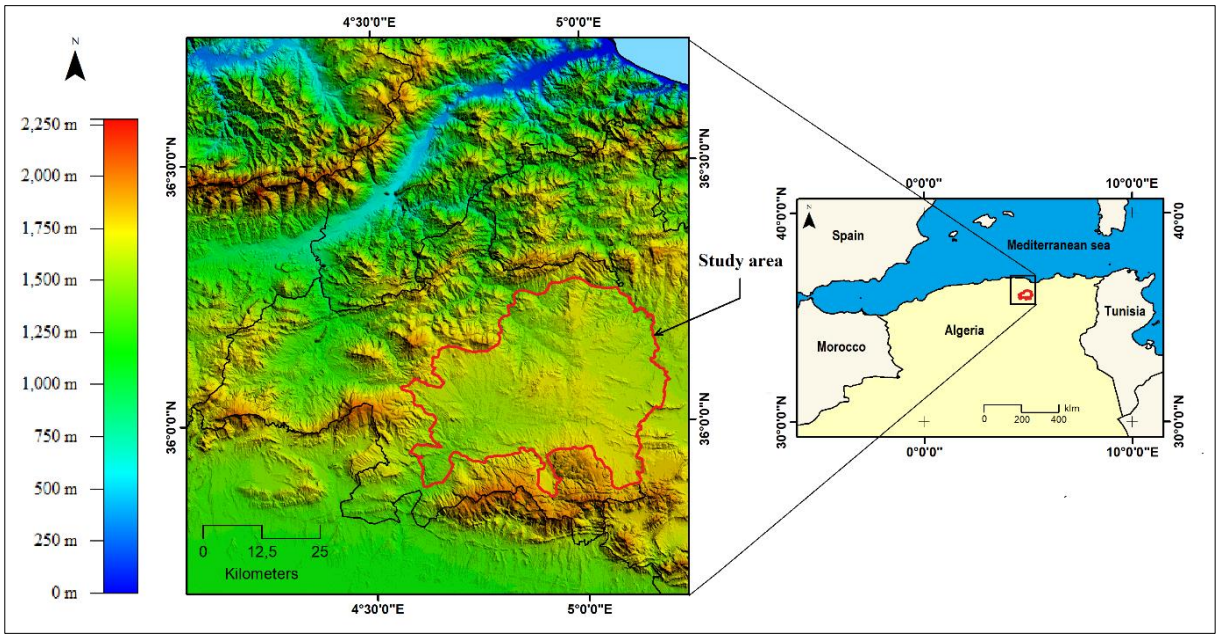

Fig. 1 – Location of Study Area in the High Land (North-East Algeria).
Note**:** Made by the Authors.

3. RESULTS

3.1. Changes in Agriculture Land-use from 2001 to 2017

According to the statistics regarding to the study area obtained from the Department of Agricultural Services of the **BBA** province, as shown in both Figure 2 and Figure 3, a significant increase in the number of olive trees was recorded between 2001 and 2017, as olive groves augmented from 478.5 hectares to 5,297 hectares, an increase of about 4818.5 hectares. It should be noted that besides this new dynamic, and in the same period, there was a small decline in large-scale farming area (fallow/cereals systems) of 8.2% of its original surface area. In this context, it should be noted that the study area is a favourable region for producing cereals, mainly barley and wheat, which are the basic products of Algeria (CENEAP, 2003a), with a rain-fed regime. As for vegetable farming in the study area, it occupies very small areas, which is only 1%.

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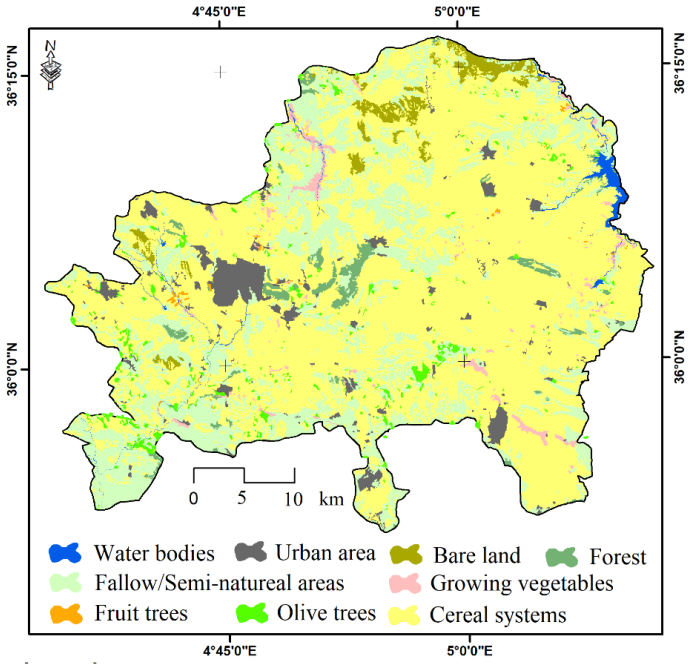

Fig. 2 – The Agriculture Land Cover /Use in the Study Area (2015)
Source: **B.N.E.D.E.R**, 2015.

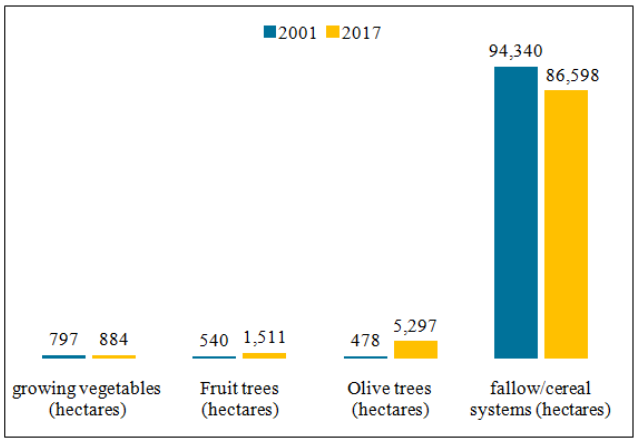

Fig. 3 – The Growth of Agricultural Activities from 2001 to 2017 in the study area
Source: Elaborated by the authors according to statistics
from the Department of Agricultural Services of the **BBA** province.

3.2. Patterns of the Olive Growing Area and its Spatial Dynamics

In the past 20 years, the olive area in the study area has multiplied nearly 10-fold due to the newly implemented olive trees, which are distributed over approximately 9,000 plots of land. In actuality, the olive area constitutes around 78% of the fruit trees in the area of study. That is to say, the initial olive areas were represented mainly by traditional plantations with medium yields, while the new ones are widely cultivated by semi-intensive production systems in small and medium-scale farms, averaging between 0.5 hectares and 5 hectares, with the presence of many olive cultivars.

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The olive-growing activity in the study area has been marked by a clear spatial movement, which extends right up from the mountains to the contact area with the plains. Olive trees have emerged in recent years in numerous small plots within the same perimeter, forming agricultural poles and creating a new transitional landscape, with a clustered pattern, especially in both the northernmost and the south-western regions of the study area. Meanwhile, some olive groves can be spotted in the centre of the region's plains (Fig. 4).

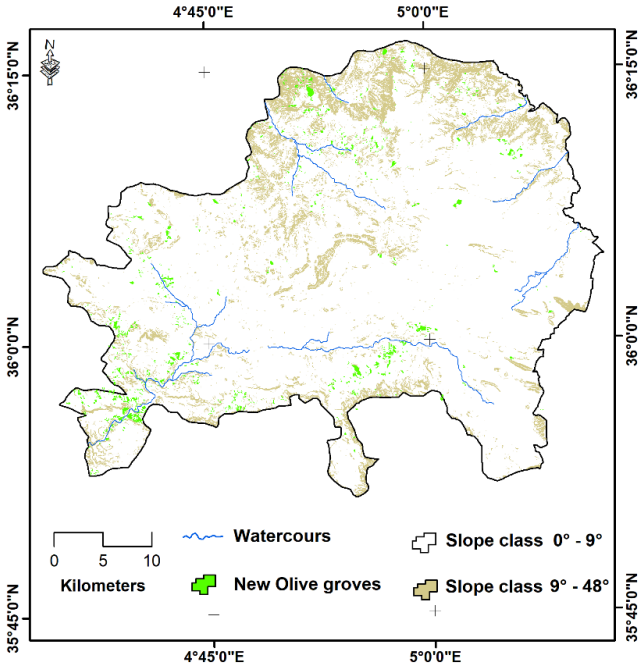

Fig. 4 – Location of the New Olive Trees Orchard in the Study Area (North-East Algeria)
Note: Localizing the olive groves was done by the authors based on the field surveys and the high-resolution aerial images generated by the free Google Earth software. Afterwards, the map was made by the ArcGIS software.

4. DISCUSSIONS

4.1. Factors of Olive Trees Emergence

The emergence of olive trees in the study area was related mainly to the following factors: the objectives of the government towards agricultural and rural development and the interest of peasants, as well as the characteristics of olive farming practices. In what follows, we present a detailed analysis of the driving factors of the emergence of olive groves in the study area.

4.1.1. The Agricultural Policy of the Government

Planting olives has become an important activity for agricultural and rural development in Algeria. The National Agricultural Development Plan (**NADP**) launched in 2000 in Algeria was a factor that has promoted the activity in rural areas, where fruit trees cultivation has strongly developed since 2000 (Bedrani, 2008). In addition to this, the Rural Renewal Policy (**RRP**), launched during the 2009–2014 period, continued to support this activity through its various agricultural programmes. In fact, the means and forms of support from the government for olive trees cultivation are mainly: offering olive trees according to the accepted requests, where some of the target areas are supported by

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opening rural roads, digging wells and providing equipment, in addition to providing financial support. It should be noted that besides these subsidies, many peasants have been offered a specific training on olive tree cultivation, which is a new activity for most of the locals.

The expansion of this activity is due to its great importance, which is mainly related to the diversification of economic practices, one of the four main objectives of the new policy in rural areas, which would create more jobs and an influx of income for the local population (Bessaoud, 2006).

4.1.2. Land Ownership and Peasants' Initiatives

According to MARD, 2002, the rural population in the study area makes up about 23.38 % of the total population of the **BBA** territory, 8,855 of whom are farmers. On the other hand, the Used Agricultural Area (**UAA**) is estimated at 102,240 hectares, which is divided into 7,129 exploitations; the private sector accounts for 56% of the **UAA**, while the rest is related to the public sector, which consists of Collective Farms known as **EAC**, Single Farms known as **EAI**, in addition to Typical Farms. In this context, it should be noted that the proportion of the public-sector land localized especially in Algerian plain regions was estimated at about 24.5% (CENEAP, 2003a). Furthermore, regarding the study area, there are almost 103 ha/exploitation for the public sector and nearly 9 ha/exploitation for the private one, where the public sector has a small number of exploitations that are characterized by a large area and concentrated in high plains, particularly in the eastern region of the study area. Conversely, the private sector has a great number of exploitations, but they are characterized by their small-scale structure (Fig. 5). Thus, the individual ownership of lands was an important factor in olive cultivation emergence in the area under study, where the private initiatives of farmers towards olive trees investment have increased, since the diversification of activities in small lands leads to a greater economic revenue.

4.1.3. Environment Conditions and Characteristics of Olive Farming Practices

The Mediterranean region is among the areas most affected by climate change (Giorgi, 2006; IPCC, 2007), where the phenomenon negatively affects agriculture, and drives farmers to seek more income by choosing the use the available water, such as planting fruit trees (Nefzaoui *et al.*, 2012). This is the case of our study area, where olive trees are preferred, given that the North of Algeria is characterized by a Mediterranean climate (UNDP, 2009). In addition to the aforementioned factors, olive trees are preferred as a new activity in view of their characteristic practices, as they are rustic trees with a long life, low-maintenance and low-cost, and which suit a wide range of soils. Moreover, peasants are taking advantage of mechanization as they are familiar with the exploitation techniques in low-sloping lands.

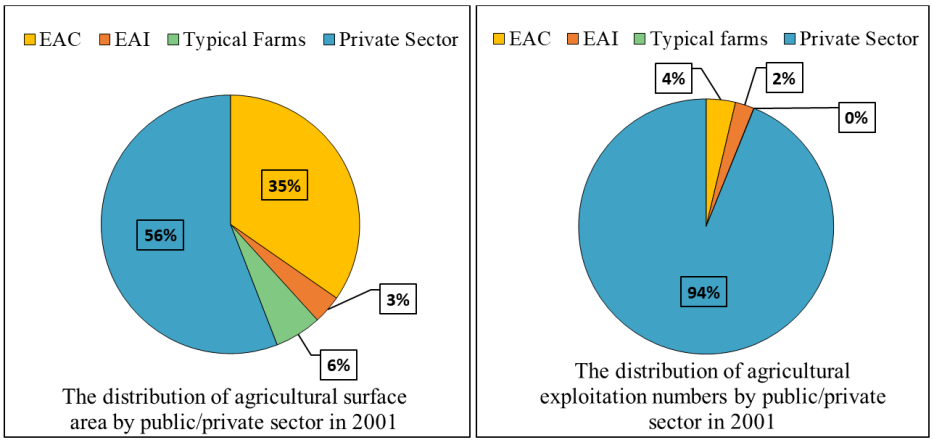

Fig. 5 – The characteristics of agricultural exploitations by public and private sectors in 2001
Source: MARD, 2002.

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4.2. The Impact of the Emergence of Olive Orchards

4.2.1. Socio-economic Impacts

Interestingly, olive cultivation has multiple uses, depending on farming practices (Marangon *et al.*, 2008). In this context, and regarding our study area, the details of the contribution of olive farms to local development, in particular from the socio-economic perspective, are taken through numerous conversations with those directly involved in this activity (local peasants and stakeholders). It is concluded that olive tree farming attracts many farmers, while for most of them it is a new experience. On another side, the rural farmers have invested plots of their own land, which are not far from their houses, in order to take better care of their olive orchards.

Farmers are interested in this type of agriculture mainly in order to increase and diversify their income, which has led them to become more engaged in farming; olive farmers ensure part of the food needs from their own production, and assign an important part of their income as well, hence the idea of bolstering their livelihood that motivates a significant number of them to be more stable in their lands.

The stability of the rural population is one of the major challenges, because the Algerian rural areas have long suffered from the phenomenon of rural exodus, especially in the past few years (Bessaoud, 2006). Given the situation, olive cultivation has, certainly, contributed to the stability of the rural populations in the countryside, as is the case of all North Africa, which encourages olive tree growing in rural areas for the same purpose (Gregoriou, 2009). In fact, the activity has proved to be successful, since it is considered a vital element of the rural economy, in addition to other local agricultural activities, by improving the living conditions of many rural people, especially in vulnerable rural areas.

4.2.2. The Impact on the Agricultural System

Indeed, about 70% of the olive trees, were planted mainly on low-sloping lands (under a 9º slope). However, there isn't a high number of olive groves in the central and eastern parts of the study area, which for a long time mainly intended for large-scale farming. On the other hand, the status of the agricultural land ownership characteristic of this part of the study area has been a factor in slowing down the expansion of olive trees. Generally, this current phenomenon is in a silent dynamic that started to make a slow transformation in agriculture practices, from monoculture to polyculture in the region of **BBA**, where the agricultural landscape is divided into two categories, as illustrated in Figure 6: (a) cereal farming in the high plain, especially in the centre of the BBA territory, and (b) mixed farming that recently appeared around it in several areas near the mountain sector. The latter generally combines three main agricultural activities: cereals, olive trees and poultry. In the midst of such heterogeneity, there is also a diversity of planting density mainly in terms of the olive orchard structures. Also, in the same plot where olive trees are grown, cereals and vegetables may be intercropped.

4.3. Challenges

In fact, Algeria is far from being self-sufficient in the production of fruit of the rustic arboriculture, including olive trees (Bedrani, 2008). Moreover, based on FAO, 2017, estimations, Algeria remains a modest producer of olive oil, ranking 10th among the top ten olive oil-producing countries in the Mediterranean. Therefore, in order to remedy this situation, important efforts are made on the development of the olive crops with the aim of contributing more to the international production of oil and of diversifying the country's economic revenue. Consequently, with respect to the study area, the activity proved its positive influence on the stability of the rural population, as it provided them with employment opportunities resulting in a higher degree of socio-economic empowerment for the farmers. However, the emergence of the olive cultivation activity in several areas of the high plains can influence the cereal landscape, which is the main agricultural activity of the

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region, especially under the high expectation of increasing new areas for the practicing of the activity in the future. In this context, it should be noted that the majority of cereal production exists in the arid and semi-arid areas of Algeria (Ramdane and Christine, 2012), and cereals adapt well to the semi-arid and continental climate (Côte, 1996b), which includes our study area. Accordingly, it is necessary to take into account the importance of the strategic agriculture typology in these areas that can play a significant role in food security and attaining a strong agricultural economy, especially when considering the year 2017, when the dependence of Algeria on imports of cereals reached 72.2% (Bessaoud *et al.*, 2019).

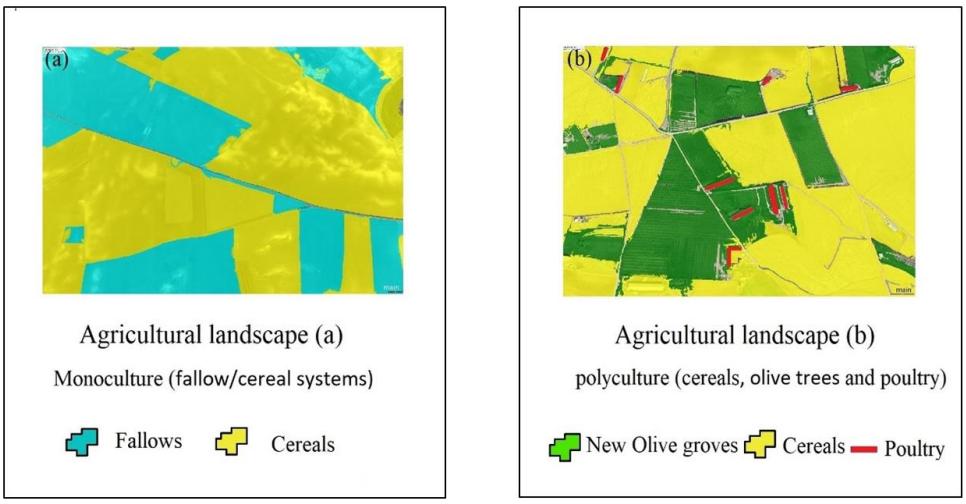

Fig. 6 – The impact of the new olive groves on the agricultural system and landscape of the study area. Note: The agricultural landscapes were identified by using the Object Based-Image Analysis **(OBIA)** method, which is proposed by Baatz and Schäpe, 2000, and is available through the Trimble eCognition software. The data used for the segmentation process were derived from High-resolution aerial images that had been generated by the free Google Earth software.

Given that the new Algerian agricultural vision is more concerned with crops that are less subject to rainfall hazards (Bedrani, 2008), the olive cultivation activity seems to be widely preferred to mitigate climate change and the water irrigation shortage. However, based on the above analysis, the new olive tree growing systems expected in the future should be controlled to ensure the crops' sustainability, by selecting appropriate lands for expansion and investment, taking into consideration the advantages of the olive trees' characteristics and practicalities pertaining to the function of preserving vulnerable soils on a sloping area, which is a factor that helps in managing natural resources.

5. CONCLUSIONS

In conclusion, planting olive trees has proven to be a strategic agricultural activity in Algeria, where it was encouraged as part of the implementation of new policies in rural areas, especially since 2000. Our area of study is a sample of olive cultivation practices that have recently emerged in the high plains of northern Algeria.

The agriculture trend towards olive tree planting is confirmed in our study area. It has been noticed for almost two decades and has become an important activity that many farmers are practicing for the first time. This tendency has created a new agricultural landscape in the high plains, where the latter have witnessed a shift from monocultures to mixed farming in several areas, as represented by a new agrarian landscape mixture between three agricultural activities: cereals, olive trees and poultry.

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This agriculture dynamic seems to be slowly expanding towards an area with a high agricultural potential, especially the area under study, where more areas can be exposed to the conversion to future olive tree growing. This is due mainly to the socio-economic context. To that end, it is necessary to set-up a comprehensive approach that establishes the areas dedicated to olive tree plantation, such as low-quality lands, which are the most suitable for future agriculture intervention, as this will truly be at the service of sustainable development by taking on the economic and food security challenges.

This paper is a modest contribution to the ongoing discussion regarding the olive cultivation that has recently emerged on high plains. However, further studies on the issues are required. For example, useful studies may focus on determining potential sites, which may be more appropriate for olive trees plantation throughout Algerian rural areas, based on an environmental and socioeconomic vision, taking advantage of remote sensing technologies and geographic information system applications in this context. Moreover, assessing the efficiency of agricultural system trends, alongside their spatial challenges, is also worth investigating.

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Received July 11, 2020

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